Cape Peninsula
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THE EFFICACY OF SANITATION ON MICROBIOLOGICAL HAZARDS IN READY-TO-EAT FOOD OUTLETS FROM SELECTED PRIMARY MANUFACTURERS IN GAUTENG PROVINCE, SOUTH AFRICA.

by

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DECLARATION

I, **ANDRÉ ALBERTUS LAMBRECHTS**, declare that the contents of this dissertation/thesis represent my own unaided work, and that the dissertation/thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

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ABSTRACT

The retail sector in South Africa is increasingly evolving into a dynamic industry, driven by changes in technology, saturating markets and globalisation. A major phenomenon in South Africa has been the evolution of hypermarkets, which sell large quantities of almost all consumer goods on a self-service basis. The South African consumers are becoming increasingly health conscious and, as such, the demand for wellness foods, health and convenience food has escalated. Convenience foods are expected to remain popular with consumers and supermarkets and will therefore increase the amount of ready-to-eat food items offered. As the retail industry has changed over the last two decades, so has the epidemiology of foodborne illnesses, with an increase in the incidence of bacterial infections caused by emerging organisms. In addition, there are certain food safety issues specifically associated with ready-to-eat foods. In recent years, incidences of enteric diseases associated with meat consumption have risen. The emergence of several new foodborne diseases has led to an increased focus attention on the issue of food safety by consumers and the industry. The most commonly implicated foods in these disease outbreaks have been meat and dairy products.

The microbial load of eight convenience food manufacturing plants was determined by firstly sampling stainless steel food contact surfaces after they had been cleaned and sanitised at the end of a day's shift. The samples were analysed for Total Plate Count (TPC), *Escherichia coli, Salmonella* species and *Staphylococcus aureus* and *Listeria*. The results showed that 59 % of the total areas sampled for TPC failed to comply with the legal requirements for food surfaces specified in the South African Health Act (< 100 cfu.cm^{-2}). *Listeria* was detected in 23 % of the samples taken and *E.coli* was found in 1.3 % of the samples, while *S. aureus* was not detected in any of the samples. Fifty percent

of the plants applied conventional cleaning methods for cleaning and sanitation and the remaining 50 % used the low-pressure foam (LPF) method.

The bacterial results of the two cleaning methods were statistically compared and a statistically significant difference ($P \leq 0.05$) was found between the TPC means of the cleaning methods after cleaning. No statistically significant difference ($P > 0.05$) was found in terms of the *Listeria* species counts after both cleaning processes. The LPF method proved to be the superior cleaning option for reducing TPC counts.

Secondly surface samples were collected from washed and sanitised dominant hands of food handlers and analysed for the presence of total plate counts, *S. aureus* and *E. coli*. The study aimed to evaluate the efficacy of hand washing practices and sanitation before commencing work. A total of 230 samples were collected, involving 100 % of the food handlers in selected convenience food outlets. The highest bacterial count taken from handswas 7.4×10^{-3} cfu.cm^{-2} and the lowest showed no detectable growth. Forty percent of the TPC analysed complied with the legal limit of < 100 cfu.cm^{-2} and only 18 % of the food handlers had no detectable bacteria present on their hands. One hand sample tested positive for *E. coli*, which is generally viewed as an indication of faecal contamination. *S. aureus* could not be detected on the hands of any of the food handlers. The results of this study indicated that hand hygiene is unsatisfactory and underlined the importance of further training to improve food handlers' knowledge of good hand washing practices.

The study also aimed to present data on the food hygiene knowledge and practices of food handlers based on a representative sample from convenience food outlets in the Gauteng area. The management, as well as food handlers, were interviewed without prior announcement and managers were interviewed prior to starting their shifts,

followed by food handlers, after they had passed through the change room and hand wash facilities. Although the majority of food handlers adhered to basic hygiene principles, the results highlighted a need for proper and continuous training in hygiene practices, not only for food handlers, but also for management. Furthermore, all food handlers should adhere to a formal cleaning schedule and specific courses should be planned for food handlers. Most training is done away from the workplace and the workers might find it difficult to translate theory into practice. Although food safety training programmes are essential, behavioural changes will not occur merely as a result of having received training but rather continuous development of food handlers.

In conclusion, the popularity of convenience food is bound to increase with the growing appeal for modern foods. Consumers in South Africa nowadays demand good quality and safe products at a reasonable cost. Due to continuous time constraints, convenience food is the food of the future for the working mother. It is clear that managing foodborne disease is a challenge and an economic problem subject to various constraints. Food safety has too often become a hit-or-miss gamble, with parents obliged to roll the dice when it comes to the safety of their children's food and consumers in general. The food industry therefore needs to improve food safety processes to prevent the contamination of foods and use methods to ensure safe food for consumers. Better training, more testing and better methods of tracking food must be utilised to verify that the processes are working. This study endeavoured to add to the understanding and improvement of hygiene processes as well as food handlers' practices in the convenience food industry in the Gauteng Province.

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CHAPTER 1: GENERAL INTRODUCTION

1.1 BACKGROUND

The South African food and beverage market is becoming increasingly sophisticated and retail outlets in South Africa offer the full spectrum of products available in the United States of America. About 90 % of inventories of consumer-ready products in these stores are domestically sourced. A major phenomenon in South Africa has been the evolution of hypermarkets, which sell large quantities of almost all consumer goods on a self-service basis. The hypermarkets, located mostly in suburban shopping centres or malls, have put significant pricing pressure on smaller scale local retailers by purchasing directly from manufacturers and bypassing the wholesaler, thereby obtaining lower margins but a higher turnover. The South African consumer is becoming increasingly health conscious and, as such, the demand for wellness foods, health and convenience food has escalated/grown. Convenience foods are expected to remain popular with consumers, and supermarkets are expected to respond to this demand by increasing the amount of ready-to-eat food items offered at their fresh food departments, delis, bakeries and home meal departments (United States Department of Agriculture Foreign Agricultural Service Report, 2010). The epidemiology of foodborne illnesses has changed over the last two decades, with a rise in bacterial infections caused by emerging organisms as well as a considerable increase in the incidence of illness from well-recognised pathogens such as *Salmonella* (Forsythe & Hayes, 2002). In addition, there are certain food safety issues specifically associated with ready-to-eat foods (Marriot & Gravani, 2006). For instance, *Listeria* spp. can become a threat if food is not prepared hygienically and kept at the sub-optimal temperature (World Health Organisation, 2004). In recent years, incidences of enteric diseases associated with meat consumption have risen. The emergence of several new foodborne diseases has focused

attention on the issue of food safety. The most commonly implicated foods in these disease outbreaks have been meat and dairy products (Gibson & Rastall, 2005). The following organisms, *Staphylococcus aureus, Salmonella* spp*, Listeria* spp and *Escherichia coli*, and their connection to processing hygiene and food handling practices will be included in this study as they are the most frequent causes of food poisoning in developing countries, including South Africa (Marriott & Gravani, 2006). These bacteria are also included in South African legislation (Republic of South Africa, 1972).

1.2 THE IMPORTANCE OF CLEANING AND SANITATION

The most important goals of cleaning are to reduce the initial number of microbes on any surface and slow the rate of their growth. The microorganisms that remain after the cleaning step are more susceptible to sanitisers because the organic matter which serves as a food source has been removed. The use of sanitisers, without proper cleaning, is usually a waste of money and time as they serve no purpose, as only the microorganisms in the top layer of soil will be killed. Cleaning compounds allow water to efficiently penetrate, dislodge and remove soil (Marriot & Gravani, 2006). A detergent solution that comes into contact with soil will remove it by means of good wetting and penetrating properties, namely: solid and dispersed soils and will be displaced from a given surface by saponifying the fat, peptizing the proteins and dissolving the minerals; the soil will be dispersed in the cleaning solution due to de-flocculation or emulsification; and the soil will be prevented from re-depositing on the surface due to the good rinsing quality of the cleaning compounds used. Given the huge variety of cleaning and sanitation programmes available and the manifold cleaning concepts that exist, it is important to identify which cleaning programme is best suited to a particular process. For instance, a complete food safety programme includes both cleaning and sanitation. Although cleaning removes soils, after the cleaning operation has been

completed, equipment surfaces and the environment in which food is handled can still be contaminated with microorganisms. If these microorganisms are not destroyed, the food being produced may become contaminated. The result may be food spoilage and possibly foodborne illnesses (Marriot & Gravani, 2006). An effective sanitation programme is important for many reasons and the most important principle in sanitization and/or disinfection is that a dirty surface cannot be sanitized. Before a cleaning chemical is selected, five key factors need to be understood (Rowberry, 2010). Firstly, it is important to know the nature of the soil that needs to be cleaned, as different soils require different cleaning chemicals and different cleaning methods. Secondly, the role of water is important (more than 90 % of the cleaning solution comprises water); therefore, it is necessary to know about the specific attributes and impurities in the water that will be used. Thirdly, is the consideration of the composition of the surface being cleaned. Knowing whether the surface is made of stainless steel, aluminium, brass, copper, iron, tile or plastic is important, as different materials interact with soil as well as with the cleaning chemicals in different ways. Even the nature of the surface itself affects the efficacy of cleaning and one must consider whether the surface is smooth, polished, rough, pitted or corroded (Cramer, 2006). Fourthly, the method of application should be taken into account very carefully, as there are a number of different ways to apply cleaning chemicals to the area being cleaned. Each application method presents a different level of exposure for the employee. During manual application, the employee has direct contact with the cleaning solution and when spraying or using high pressure cleaning, the chemical becomes airborne, which is of concern as it could affect the worker's health and safety. Cleaning chemicals can be applied to a surface as a foam or as a viscous material, thereby limiting, but not obliterating employee contact with the cleaning chemicals. For mechanical cleaning and cleaning in place (CIP), no direct employee contact is expected. Fifthly, consideration of the cleaning regime should be

supplemented by consideration of the impact of such a regime on the environment, as all cleaning solutions and soil eventually become part of the waste stream and need to be properly treated. The effluent may be treated at a public or privately owned treatment plant; in either case, there are certain restrictions on the quality or characteristics of a particular waste stream. When these factors and how they interact are understood, the 'right choice' can be made (Marriot & Gravani, 2006).

In food premises, stainless steel is the preferred material for food contact surfaces and 304 or 316 grade stainless steel is often specified. In addition to stainless steel, other 'soft' metals may be used, the most common being aluminium. Non-metallic surfaces, such as plastics that are used for cutting boards, are being used more widely, not only in equipment but also in packaging materials. The kind of surface that will be cleaned also determines the cleaning chemical that will be used as they need to be compatible.

There are three basic application methods commonly used in the food manufacturing industry: manual cleaning, high-pressure spray cleaning and foam cleaning. With manual cleaning, the employee has the greatest potential for physical contact and, as such, the pH of the solution needs to be kept between pH 4 and pH 10.5. Manual cleaning is mainly performed with a bucket, cloth, brush or broom and the work is, as implied, performed manually. When using high-pressure spray cleaning, the potential hazard exists that microbes will be distributed into the surrounding area due to the formation of aerosols. High pressure (> 80 Bar) is applied to the work surfaces, whereby the pressure supplies the cleaning action. Because of the risk of spreading microbes with high-pressure spray cleaning, this type of cleaning is generally not recommended for the food industry. With foam cleaning, on the other hand, there is potential for the detergent to make better contact with the surfaces. However, if the equipment is not adjusted properly, atomization can

occur, which break the chemicals into small particles would be inhaled by the cleaners this also applies to the organic matter which could then settle on already cleaned areas. Chemicals are applied in a foam format and as long as there is foam on the working surface, there is contact with the soil and the surface area will be cleaned as the foam bubbles burst and release energy (Stanga, 2010).

1.3 THE PRACTICES OF FOOD HANDLERS RELATED TO THE PROCESSING OF CONVENIENCE FOOD

Food handlers must have the skills and knowledge to handle food safely as they carry out the preparation work. Only food service workers who are healthy and practise good personal hygiene should be working in a ready-to-eat establishment. There are general food hygiene and food safety procedures that should be followed to help reduce the risk of contamination and mishandling at all levels of a food establishment. From the time the food is delivered to the minute it is served to the customer, food safety should be the top priority. Despite an increase in the number of food handlers receiving food hygiene training, a high proportion of food poisoning outbreaks still occur as a result of poor food handling practices (Jay, et al. 2005). Maintaining good levels of hygiene necessitates that certain basic requirements must be followed by food handlers, such as washing and sanitising their of before commencing work on the production line, after touching the hair or face, after picking up scraps from the floor and after adjusting equipment or handling non-product contact items. Employees must wear hairnets to ensure they do not shed hair in the product. In some instances, the use of disposable gloves, aprons and arm guards after washing one's hands and sanitising is also recommended to protect the end-product from contamination. After the food handlers have put gloves on, they should ideally dip their hands in a sanitising solution. Whenever food handlers work with rejected packages, they should wash, sanitize

and cover their hands with fresh disposable gloves and, once finished with the work, discard the protective wear before they commence work on the production line again. All utensils and equipment should be kept away from the production areas and unnecessary contact with these should be avoided (Arduser & Brown, 2005).

1.4 LEGISLATION APPLICABLE TO CONVENIENCE FOOD IN SOUTH AFRICA

Limited South African food legislation currently exists on specific food products. As such, the concern about foodborne illnesses is continuously growing. Aside from the Total Plate Count (TPC), no other guidelines or legislation exist in South Africa regarding acceptable indicatory levels of organisms on surfaces used in food handling. From a human health perspective, all foodstuffs manufactured, processed or sold in South Africa, as well as those imported into South Africa, are governed by the Department of Health under the Foodstuffs, Cosmetics and Disinfectants Act (Republic of South Africa, 1972). The Guidelines for Environmental Health Officers (Republic of South Africa, 1977) is provided to assist in the interpretation of microbiological analysis data for food. It sets out to explain to environmental health practitioners the significant species or groups of microorganisms used in microbiological standards and to guide their interpretation of microbiological analysis data, especially in instances where no microbiological legislative standards exist (Republic of South Africa, 1977). This legislation is based on the view that access to safe and affordable food is a basic human right. Consuming food that carries potential risks can be harmful to one's health and consumers are entitled to expect and deserve protection against preventable risks associated with consuming food. These aspects are all addressed in the Health Regulations (Regulation 918 of 1999) promulgated under the Health Act (Republic of South Africa, 1999). The Act aims to provide measures that can be used to promote the

health of the inhabitants of South Africa; to provide for the rendering of health services; to define the duties, power and responsibilities of certain authorities that render health services in South Africa; and to provide for the coordination of such health services. Regulation 918 deals with the hygiene requirements for food premises as well as the requirements for transporting food, both of which are deemed basic standards that a food manufacturing facility must comply with (Republic of South Africa, 1977). The South African Bureau of Standards (SABS, 2001) plays an integral part in the food chain, from primary production to the final consumer, by setting out the necessary good practices to ensure that food is handled in such a way that the safety of the consumer is assured (SABS, 2001). All handled food is expected to meet the minimum safety requirements expected by customers and regulatory authorities. It is therefore essential that levels of undesirable substances in food meant for human consumption be consistently below the levels stipulated as unsafe. Food handling refers to the handling of food in its raw or unprocessed state as well as during production, processing, packaging, transportation, delivery and display. The practices described in this standard aim to assist food handling organisations in managing their operations in such a way as to prevent or control the contamination of food, either through direct contamination or as a result of cross-contamination (SABS, 2001). It further aims to assist food handling organisations to initiate business operations that are based on a basic level of hygiene (SABS, 2001).

1.5 RATIONALE

1.5.1 Aims of the study

The study aimed to compare the efficacy of low-pressure foam cleaning and conventional cleaning in removing selected bacterial pathogens from surfaces associated with convenience food. In the convenience food plants, the microbiological contamination on the

hands of food handlers, which indicates the level of hand washing efficacy in the convenience food industry, were also be determined and a comparison of the food hygiene knowledge and practices of these food handlers in the convenience food industry was determined.

1.5.2 Research hypothesis

Cleaning methods have a significant influence on various convenience food quality and safety indicators.

1.5.3 Null hypothesis

Cleaning methods do not have a significant influence on various convenience food quality and safety indicators.

1.5.4 Data interpretation

The results were compared with the specifications advocated by the Department of Health under the Foodstuffs, Cosmetics and Disinfectants Act (Republic of South Africa, 1972) from a human health and safety control perspective (Republic of South Africa, 1972) as well as the proper interpretation of microbiological analysis data related to food and the specifications set out in the Guidelines for Environmental Health Officers in Regulation 918 (Republic of South Africa, 1977).

1.5.5 Relevance of study

The outcomes of this study should contribute to a better understanding of potential risks associated with the processing of convenience food. This study should provide invaluable information to the convenience food industry in order that it can optimise its processes and personal/general hygiene practices.

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CHAPTER 2: LOW-PRESSURE FOAM CLEANING COMPARED TO CONVENTIONAL CLEANING FOR REMOVAL OF BACTERIA FROM SURFACES ASSOCIATED WITH CONVENIENCE FOOD

2.1 ABSTRACT

The microbial load of eight convenience food manufacturing plants was determined by sampling stainless steel food contact surfaces after they had been cleaned and sanitised at the end of a day's shift. Samples were analysed for Total Plate Count (TPC), *Escherichia coli*, *Salmonella* species and *Staphylococcus aureus* and *Listeria* species. The results showed that 59 % of the total areas sampled for TPC failed to comply with the legal requirements for surfaces of the South African Health Act (< 100 cfu.cm^{-2}). *S. aureus* and *Salmonella* were not detected, but *Listeria* was detected in 23 % and *E. coli* in 1.3 % of the samples, respectively. Fifty percent of the plants applied conventional cleaning methods for cleaning and sanitation and 50 % used the low-pressure foam (LPF) method. The bacterial counts after each cleaning method were statistically compared and a statistically significant difference ($P \leq 0.05$) was found between the TPC means of the cleaning methods. No statistically significant difference ($P > 0.05$) was found in terms of the *Listeria* species present after both cleaning processes. The LPF method proved to be the superior cleaning option for lowering TPC counts. However, the results of this study emphasise that production workers need to understand the correct application of chemicals as well as receive intensive training in terms of proper chemical use.

2.2 INTRODUCTION

Public health concerned with food safety and food poisoning emerged in Britain in the 1880s, following the first indication that acute gastric illness was caused by a specific organism (Morabia & Hardy, 2005).

The word 'sanitation' is derived from the Latin word '*sanitas*', which refers to health. In the food industry, this means the application of a regime to provide safe, wholesome food processed in a clean environment by healthy workers who pose a limited health threat to the end-consumer. As a result of the continuously fluctuating South African economy and the ever-increasing cost of living, more people are now working than ever before in order to sustain the average household income. The South African food industry is changing rapidly and ready-to-eat products (convenience foods) internationally are becoming more popular (Guillermo, 2006). According to Brand (2008): "It was confirmed that there is a significant growth in the convenience food market."

The need to assess the safety of food is increasingly being recognised (Mattick et al. 2003). The attitude and/or knowledge required to practice effective hygiene control is lacking in some food businesses. The bacteria responsible for food poisoning can proliferate quickly in food, especially in warm and moist conditions. A single bacterial cell on an item of food left out of the fridge overnight could produce millions of bacteria by the morning – sufficient to cause foodborne illness (Prescott, Harley & Klein, 1996).

A recent study conducted in restaurants determined the incidence of a number of significant foodborne pathogens and the general hygiene status, as estimated by TPCs and total coliform counts (TCCs), on the interior surfaces of domestic refrigerators (Jackson et al. 2007). Some of the isolated species were found to survive and grow while refrigerated or under mild temperature abuse conditions. Such pathogens (pschycrophiles) may transfer to

food in domestic fridges and multiply until they reach clinically significant numbers (Hayes & Forsythe, 1989). These risks are of particular concerns in relation to 'ready-to-eat' foods, which will not receive any further processing before consumption (Jackson et al. 2007). A study by Chao et al. (2006) revealed that counts of *Listeria* were 13.4 % higher on delicatessen foods than on cooked foods tested during their study. Moreover, non-spore-forming bacteria might be able to withstand dry conditions on surfaces for an extensive period (Kusumaningrum, et al. 2003). Surveillance of bacteria has also become increasingly important due to the increase in international food trade (Mayes & Mortimore, 2001). In addition, microbiological hazards could stem from the introduction of new techniques for mass production as well as the rapidly growing, widespread distribution of foodstuffs (American Institute of Baking, 2002).

Organisms such as Total Aerobic Mesophiles, *E. coli*, *S. aureus*, *Listeria* species and *Salmonella* species normally isolated from meat, dairy and vegetable products have been universally utilised as indicators to determine the level of contamination on contact surfaces after they have been cleaned and sanitised (Beckwith, 2008). The South African legal limit for TPC on food contact surfaces is < 100 $cfu.cm^{-2}$ (Republic of South Africa, 1999). However, current legislation does not make provision for maximum counts related to *E. coli*, *S. aureus*, *Listeria* species or *Salmonella* species on food contact surfaces (Republic of South Africa, 1977).

2.3 A SYNOPSIS OF SURFACE-RELATED BACTERIA

E.coli is not considered a serious foodborne hazard in countries with high sanitary standards and practices. Water contaminated with human sewage may lead to contamination of foods, as can handling by infected food handlers. These organisms are infrequently isolated from products (Jay, Loessner & Golden, 2005).

S. aureus food poisoning usually occurs rapidly and is in many cases acute, depending on the individual's susceptibility to the toxin produced by this microbe, the amount of contaminated food eaten, the amount of toxin in the food ingested and the general health of the victim. *Staphylococci* exist in air, dust, sewage, water, milk and food or on food equipment, environmental surfaces, humans and animals. Humans and animals are the primary reservoirs of *Staphylococci* (Jay, Loessner & Golden, 2005), which are present in the nasal passages and throats and on the hair and skin of over 50 % of healthy individuals. Although food handlers are usually the main source of food contamination in food poisoning outbreaks, equipment and environmental surfaces can also be sources of contamination with *S. aureus* (Jay, Loessner & Golden, 2005).

Listeria species are of great concern to retailers in South Africa, especially *Listeria monocytogenes*. The presence of this organism immediately is a reason for concern and the retailer's procurement divisions will act strongly against any supplier who supplies products that indicate the presence of *Listeria* species (Augustin, 2003), (Loken, 1995). *L. monocytogenes* is a foodborne pathogen that causes listeriosis, which can be life threatening and causes septicaemia, meningitis and even stillbirth in babies in high-risk populations (Kornacki & Gurtler, 2007). Factory environments are not sterile and *L. monocytogenes* can be found anywhere in the natural environment (Food Safety and Inspection Service, 2004). This organism is easily introduced into food production facilities and also has the properties needed to survive refrigerated temperatures and resist freezing (Lou & Yousef, 1997), (Hemminger, 1999). Based on recent estimates from the Centres for Disease Control and Prevention of the United States, the annual incidence of death caused by listeriosis is about eight times greater than the mortality due to *E. coli* O157:H7 infections (Mead et al. 1999).

Salmonella food poisoning appears to be rising in the United States as well as in other industrialised nations (Arduser & Brown, 2005). *Salmonella enteritidis* isolations from humans have risen dramatically in the past decade, particularly in the Northeast USA (sixfold or more), and the increase in human infections is spreading south and west, with sporadic outbreaks occurring in other regions (Centres for Disease Control and Prevention, 1995). *Salmonella* live in the intestinal tracts of humans and other animals, including birds, and in any raw food of animal origin, such as meat, poultry, milk and dairy products, eggs, seafood and on some fruits and vegetables (Jay, Loessner & Golden, 2005).

The aim of this study was to identify whether selected organisms were present on sampled food contact surfaces from eight convenience food plants in Gauteng, to relate the bacterial count to the legal limit and to compare and evaluate the cleaning methods used with such food contact surfaces (Verran, Boyd, Hall & West, 2001).

2.4 MATERIALS AND METHODS

2.4.1 Sampling protocol

This study was conducted amongst a sample of convenience food manufacturers supplying convenience food products (ready-to-eat foods) during lunch hours to retail outlets in the Gauteng area. This sample amounts to 20 % of the medium to large manufacturing plants that supply the retail industry in the region. These eight outlets were chosen because they mainly focus on preparing ready-to-eat lunch meals. Examples of foods manufactured included ready-to-eat salads, sandwiches, fruit salads, filled pancakes or omelettes and cocktail burgers. The management staff at each of the manufacturing plants sampled granted permission to conduct the survey and subsequent interviews.

None of the premises were Hazard Analysis Critical Control Point (HACCP) certified. The various food manufacturers used different chemical suppliers and the chemical companies had different levels of cleaning technology; therefore, different levels of cleaning methods were applied. Fifty percent of the outlets used traditional methods such as manual cleaning (brush and bucket) and were supplied by local chemical manufacturers. International companies supplied the remainder of the plants and they used more modern technologies (for instance, low-pressure foam cleaning systems). Stainless steel food contact surfaces at the manufacturing plants were sampled by means of swabs after they had been cleaned and sanitised at the end of each day's shift (SANS, 2001). The samples were collected in accordance with local health legislation (Republic of South Africa, 1999). To ensure that the usual level of cleaning applied to contact surfaces occurred in all of the manufacturing plants, workers were not informed of the planned sample collection. The sampling was performed on days that required no overtime work, as overtime would potentially decrease the time allotted for cleaning the contact surfaces. Thus, adequate time was available for cleaning and sanitising of all contact surfaces. All samples were analysed on the same day.

A total of 477 microbiological samples were collected (205 samples were taken for the TPC tests, 79 samples to determine the presence of *E. coli*, 27 samples to test for *Salmonella* species and 27 samples to test for *S. aureus* and 139 samples to test for the presence of *Listeria* species). Table 2.1 illustrates the findings. The samples were collected according to the SABS swab technique method (South African Bureau of Standards: 1975) and all analyses were performed at least twice.

Table 2.1: Total samples collected from convenience food contact surfaces at eight food manufacturing plants.

Food Manufacturing Plants	**[1]TPC**	***[2]Salmonella species***	***[3]Listeria species***	***[4]Staphylococcus aureus***	***[5]Escherichia coli***	**Total/ plant**
1	25	3	17	3	10	58
2	41	5	27	5	13	91
3	21	3	14	3	8	49
4	30	4	20	4	12	70
5	14	3	10	3	7	37
6	23	3	16	3	9	54
7	32	4	21	4	11	72
8	19	2	14	2	9	46
Total	**205**	**27**	**139**	**27**	**79**	**477**

[1] ISO Method 4833 (International Organisation for Standardization, 2003)
[2] Method SWJM 42 (Swift Micro Laboratories)
[3] ISO method 11290-1 (International Organisation for Standardization, 1996)
[4] ISO method 6888-1 (International Organisation for Standardization, 1999)
[5] ISO method 16649-2 (International Organisation for Standardization, 2001)

2.5 MICROBIOLOGICAL ANALYSIS

The TPC samples were analysed using the conventional pour plate technique specified in ISO Method 4833 (International Organisation for Standardization, 2003), whereas *E. coli* analysis was performed by using solid growth media, as stipulated in ISO Method 16649-2 (International Organisation for Standardization, 2001). *S. aureus* was analysed using a spread plate technique on Baird-Parker agar medium i.e. a pre-determined volume of the test sample suspension spread onto the surface of a dried pre-poured BPA plate. No coagulase-positive *S. aureus* growth was detected in the samples analysed using ISO Method 6888-1 (International Organisation for Standardization, 1999). *Listeria* species were analysed using the conventional technique described in ISO 11290-1 (International Organisation for Standardization, 1996).

Salmonella species were analysed using Malthus's methodology. The samples were enriched using a non-selective enrichment broth and incubated at 35-37°C for 16-18 hours. Presumptive positive colonies were confirmed using a *Salmonella* latex kit (SWJM 42) (Swift Micro Laboratories).

2.6 DATA ANALYSIS

The results were analysed in collaboration with the Cape Peninsula University of Technology's Corrie Uys, Statistician, Centres for Postgraduate Studies, and they are presented in tables and graphs, using frequencies and percentages.

RESULTS AND DISCUSSION

2.6.1 Microbiological results for convenience food contact surfaces

2.6.1.1 Total Plate Count

The sample size (205 samples) proved to be 95 % accurate as a representative sample of the population when using the Confidence and Error method with a tolerance of 5 % (Krishnamurty, Kasovia-Schmitt & Ostroff, 1995). According to Figure 2.1, the highest TPC found was 2.07 x 10^5 cfu.cm^{-2} (Plant 1) and the lowest had no detectable growth (0 cfu.cm^{-2}). Although all plants sampled had areas where there was no bacterial growth, the legal limit of < 100 cfu.cm^{-2} with respect to the average TPC was exceeded without exception (see Figure 2.1). Figure 2.1 furthermore shows the normal data distribution or standard deviation and the average bacterial count, which considerably exceeded the legal limit. This may indicate insufficient cleaning and disinfection, as one would expect a significantly reduced or zero TPC after these cleaning processes have been conducted.

Table 2.2 presents a summary of the total samples taken and shows the compliance with the legal limit (< 100 cfu.cm^{-2} for TPC) (Republic of South Africa, 1999). Overall, 84 of the 205 TPC samples (41%) complied with the legal requirement, whereas 121 of the 205 samples (59%) did not comply. This is an indication of the shortcomings in the used cleaning methods of the eight manufacturing plants that were included in this study (Keller et al. 2002). All TPC samples were collected from convenience food contact surfaces after they had been cleaned and disinfected.

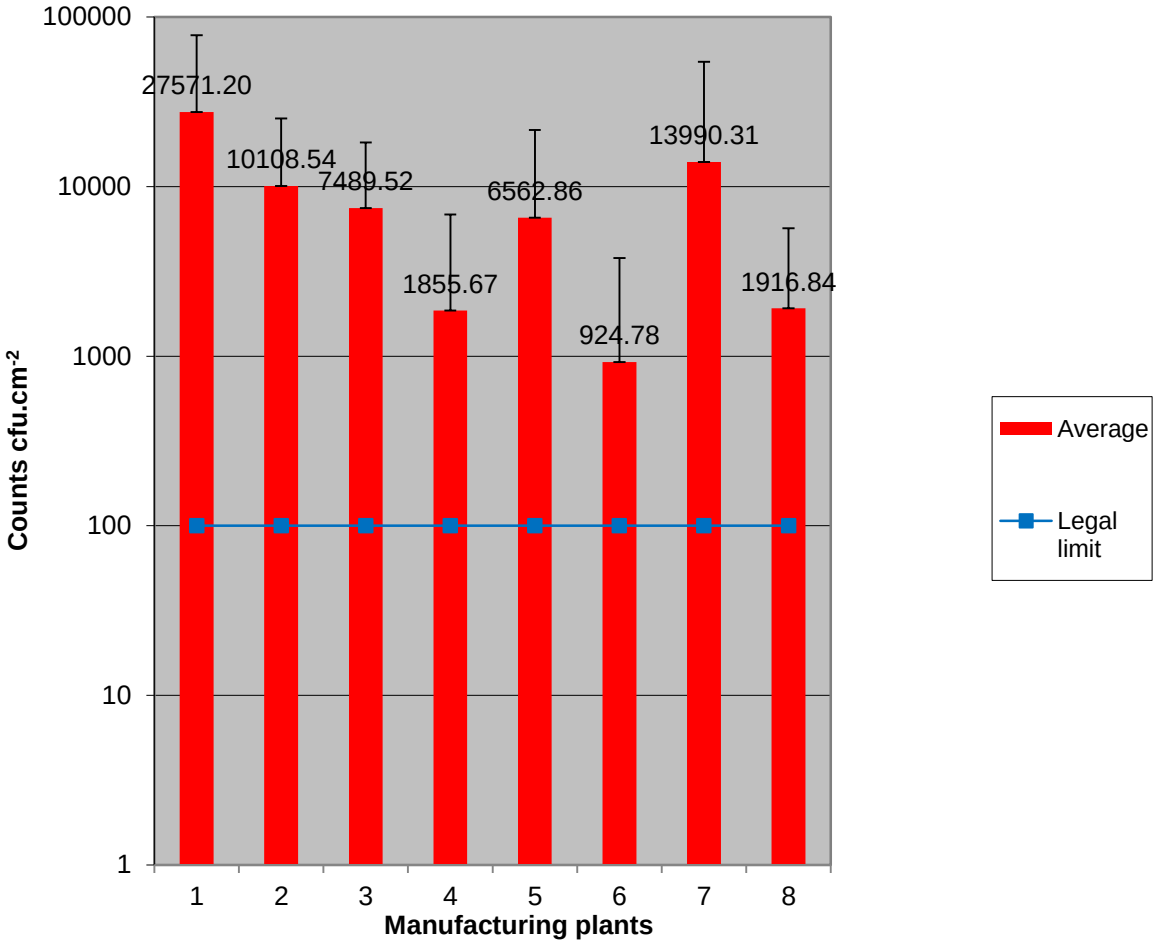

Figure 2.1: A comparison between the average Total Plate Count versus the legal limit of < 100 cfu.cm^{-2} across manufacturing plants.

Table 2.2: The distribution of organisms according to compliance/non-compliance and occurrence.

		Compliance		**Non-compliance**	
Test	**No. of samples (n)**	**Absent**	**< 100 cfu.cm^{-2}**	**> 100 cfu.cm^{-2}**	**Present**
TPC	205	-	84	121	N/O
Escherichia coli	80	79	N/O	N/O	1
Staphylococcus aureus	27	27	N/O	N/O	N/0
Salmonella species	27	27	N/O	N/O	N/0
Listeria species	139	107	N/O	N/O	32

N/O = NOT OBSERVED

2.6.1.2 *Escherichia coli, Staphylococcus aureus, Salmonella* species and *Listeria* species

Table 2.2 presents a summary of the total samples taken and indicate the presence or absence of pathogens detected on the samples. Only one positive *E. coli* sample was found and there was no detectable growth for *Salmonella* species and *S. aureus*. However, *Listeria* species appeared to be an serious problem, as 32 positive samples were found.

Listeria species can be introduced into food-processing environments through many routes and may establish colonies on food-processing equipment. Many commonly used disinfecting or sanitising agents, such as quaternary ammonium compounds, chlorine and iodophors have been shown to be effective against *Listeria* species in suspension, but organic material reduces the activity of disinfectants (Van de Weyer, Devleeschouwer & Dony, 1993). Subsequently, food products may become contaminated during processing. *L. monocytogenes* may grow in biofilms that protect them against environmental stress and can be isolated from surfaces after they have been cleaned and disinfected. In addition, *L. monocytogenes* can adhere to all of the materials commonly used in the food industry. In many food-processing environments, the conditions favour attachment and biofilm formation, i.e. flowing water, suitable attachment surfaces and ample nutrients supplied by the environment (Blackman & Frank, 1996). Therefore, several challenges exist in controlling the proliferation of *L. monocytogenes*, including their increased resistance to sanitisers and their ability to grow at the low temperatures found in ready-to-eat processing plants. Figure 2.2 shows the total samples analysed for the presence or absence of TPC, *E. coli*, *S. aureus*, *Salmonella* species and *Listeria* species. One point three percent (1.3 %) of the total *E. coli* samples analysed were similarly positive. Although *S. aureus* and *Salmonella* species were absent on these surfaces, 23 % of all *Listeria* species samples analysed tested positive for the presence of this organism (Figure 2.2). These pathogens

pose a considerable threat to the safety of convenience food consumers (Kornacki & Gurtler, 2007). The toxin produced by *S. aureus* bacteria, which is called enterotoxin causes the illness staphylococcal intoxication, which in turn leads to gastroenteritis or inflammation of the intestinal tract lining. Hospitalization may be necessary for dehydration, but recovery is usually within two days (Foodhandler, 2008). Although there are limited specifications available on bacteria in food in South Africa, the norm is that all pathogens should be absent (Republic of South Africa, 1997). *Listeria* species are very common and can be found almost anywhere in the environment. As such, with food processing and manufacturing, there is the potential to introduce the organism continuously (Donnelly, 2002). The challenge is to direct efforts to prevent the growth and establishment of *Listeria* within the plant through having appropriate controls such as sanitation, proper manufacturing practices and employee training (Gilbert et al. 2000). *E. coli* was found on one sample in Plant 1 only, whereas the most positive *Listeria* samples were found in Plant 1 and Plant 7. Plant 1 also showed the highest average bacterial count, followed by Plant 7. It appears that the overall hygiene standard of the plant influences the presence of *Listeria.*

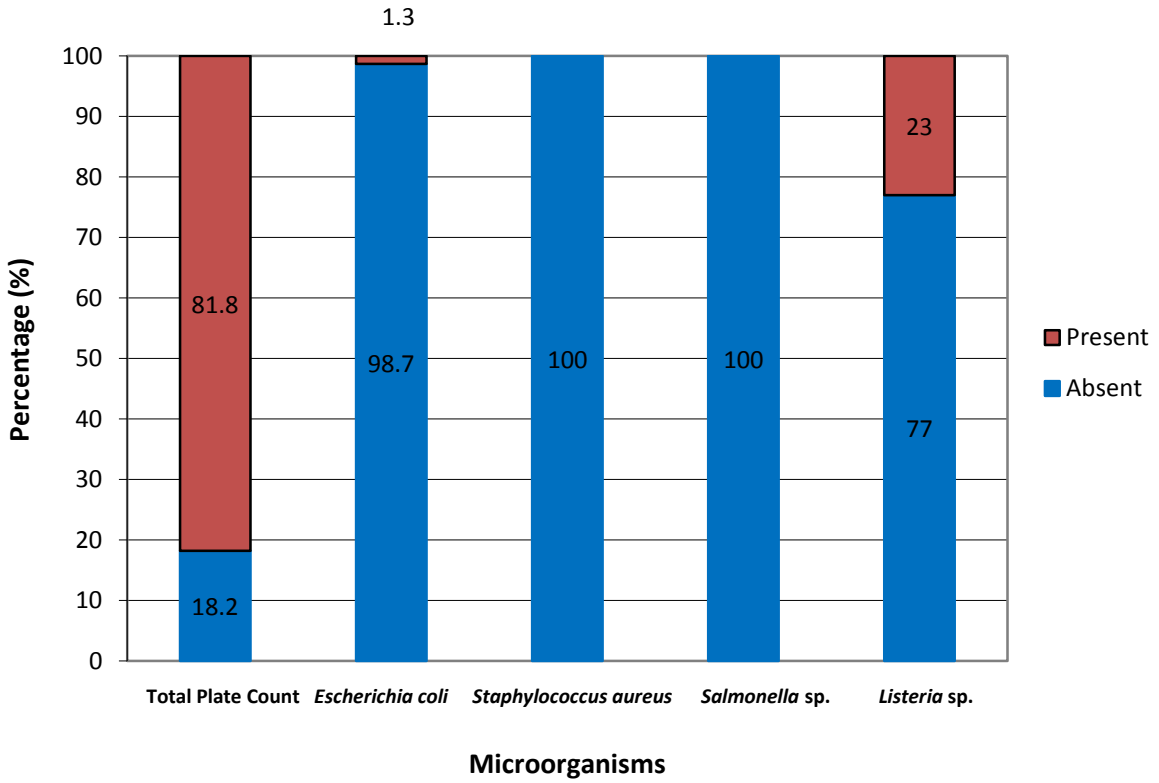

Figure 2.2: Total samples analysed for the presence or absence of Total Plate Counts, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* species *and Listeria* species that were collected from convenience food contact surfaces in eight food manufacturing plants.

2.6.1.3 Statistical comparisons of cleaning methods

Statistical analyses were used to determine which cleaning method (conventional cleaning methods or low-pressure foam cleaning) is the better method to apply in the convenience food industry. In order the conclusively demonstrate the efficacies of the cleaning methods, SABS 1853 approved sanitisers that kill 99.9% of micro-organisms were used in 7 out of the 8 plants. The expected outcome was that all samples should be close to zero or at least be compliant with the legal requirements of < 100 $cfu.cm^{-2}$. The samples were taken from identical surfaces to ensure uniform results. The results indicated that the LPF system is more effective, as proved by the lower mean of the TPC found on convenience food contact surfaces cleaned with this method (Table 2.3). A statistical significant difference was found in the TPC means of the cleaning methods ($P \leq 0.05$; Table 2.3). The LPF method consistently proved to be the better cleaning option for reducing TPCs. The presence of *Listeria* species on convenience food contact surfaces was statistically evaluated but no statistical significance was found between the cleaning methods used ($P = 0.812$) (Jankowicz, 2002).

Table 2.3: Statistical significance between conventional cleaning and low-pressure foam cleaning methods used on convenience food contact surfaces at eight food manufacturing plants in terms of Total Plate Count.

	Plants	**N = 205**	**Mean TPC**	**Median TPC**	**Standard deviation**	***P*-value cleaning methods**
Conventional method	1, 2, 3, 7	119	14358.82	1240.00	33560.897	
LPF method	4, 5, 6, 8	86	2386.51	35.00	7201.980	
						$P \leq 0.05$

**P*-values were calculated between the cleaning methods.

2.7 CONCLUSION

The results highlighted the presence of high counts of bacteria, including one pathogen in particular (*Listeria*) that was detected on the sanitised or disinfected convenience food contact surfaces. Fifty-nine percent (59 %) of the TPC samples analysed exceeded the legal specification (< 100 cfu.cm^{-2} for food contact surfaces) when measured against the requirements of the Health Act (Republic of South Africa, 1999). It is alarming that these plants use reputable chemical suppliers' approved products but they still exhibit a pathogen problem as well as generally high bacterial counts on contact surfaces. The majority of positive samples for *Listeria* and TPC were found in Plants 1 and 7, with Plant 1 also having one positive *E. coli* sample. Both of these plants made use of the conventional cleaning method.

The LPF method was found to be significantly better ($P \leq 0.05$) than the conventional cleaning method in the manufacturing plants utilising these methods, respectively. The results of this study may also raise questions as to whether workers or cleaners have sufficient knowledge and/or insufficient training on how to apply the chemicals correctly to achieve the desired results. It is therefore recommended that the management of the various plants investigate the possibility of providing intensive training to the production workers (including those acting as cleaners during their production shifts) and general cleaners. This study has further highlighted the fact that pathogens continue to flourish on various surfaces, including dry stainless steel, and present a contamination hazard for a considerable period, depending on the contamination level and type of pathogen (Kusumaningrum et al. 2003).

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CHAPTER 3: MICROBIOLOGICAL CONTAMINATION ON THE HANDS OF FOOD HANDLERS AS AN INDICATOR OF HAND WASHING EFFICACY IN THE CONVENIENCE FOOD INDUSTRY IN SOUTH AFRICA

3.1 ABSTRACT

The study aimed to evaluate the efficacy of hand washing practices and sanitation before commencing work. Samples were collected from the washed and sanitised dominant hands of food handlers in the convenience food industry in Gauteng and were analysed for the presence of Total Plate Count (TPC), *Staphylococcus aureus* and *Escherichia coli*. A total of 230 samples were collected, involving 100 % of the food handlers in selected convenience food outlets. The highest bacterial count from the hand samples was 7.4×10^3 $cfu.cm^{-2}$ and the lowest showed no detectable growth. Sixty percent of the TPC analysed exceeded the legal limit for food surfaces or hands of < 100 $cfu.cm^{-2}$ and only 18 % of the food handlers had no bacteria detectable on their hands. One sample tested positive for *E. coli*, which is generally viewed as an indication of faecal contamination. *S. aureus* could not be detected on the hands of any of the food handlers. The results of this study indicated that hand hygiene in convenience food plants is unsatisfactory and underlined the importance of further training to improve food handlers' knowledge of good hand washing practices.

3.2 INTRODUCTION

The hands of ready-to-eat food service employees have been shown to be vectors in the spread of foodborne disease, mainly because of poor personal hygiene. Howes, McEwen, Griffiths and Harris (1996) state that improper food handler practices contributed to approximately 97 % of foodborne illnesses in food service establishments and homes. It is of utmost importance that high standards of sanitation, cleanliness and good housekeeping be maintained at all times and any laxness in this regard may result in a serious epidemic or infection (Marriott, 1999). Employees should be trained on how to handle food as well as on sanitation and hand washing techniques, as bacteria from cuts, infections, boils or other communicable diseases may cause food poisoning (Richard, 2008). Statistical evidence indicates that food poisoning caused by the catering industry is 70 % higher than that caused by any other sector (Wilson et al. 1997). From this brief description, it should be evident that people involved with every stage of food production, from farm to fork must take responsibility to prevent infections and destroy pathogens (Nestle, 2003).

Hand washing is a fundamental precautionary measure to protect against the spread of disease and is one of the primary practices to reduce the transfer of bacteria, whether from person to person, or from person to food contact surfaces (Brodie, 1965). The main reason for limiting contact between ready-to-eat foods and people's hands is to prevent the transfer of viruses and bacteria that are already present in human bodies (Lues & Van Tonder, 2007).

Furthermore, it was established that a food worker's unwashed hands can transmit pathogens, especially faecal pathogens, to food products after he or she uses the toilets. Investigations of foodborne illness outbreaks have shown that poor personal hygiene, primarily ineffective hand washing, is an important contributor to foodborne illness, second only to inadequate temperature controls of food (Scarborough, 2002). When consumed in

food, these pathogens can cause illness and disease (Eley, 1997). In 1986, the Centres for Disease Control and Prevention (CDC) *Guidelines for Hand Washing and Hospital Environmental Control* recommended the following procedure to prevent transmission of infectious diseases in hospitals: "For routine hand washing, a vigorous rubbing together of all surfaces of lathered hands for at least 10 seconds, followed by thorough rinsing under a stream of water (FDA, 1997). If plain soap / bar soap is used, it should be kept on racks that allow drainage of water." If liquid soap is used, the soap container should be replaced when it is empty because of the possible introduction and growth of pathogens in the liquid soap during refilling (Snyder, 1999). These recommendations are designed to prevent the transfer of infectious organisms from one person to another in healthcare settings (Sehulster & Chinn, 2003) (Lee, Long & Phillip, 2004). The effects of hand washing in the prevention of disease transmission from person to food and food to person are undeniable; however, the goal of effective compliance remains unmet (Le Texier, 2001).

According to Government Regulation 918 of 1999, promulgated under the Health Act, No. 63 of 1977 (Republic of South Africa, 1999), it is a requirement for food handlers to wash their hands with soap and hot and/or cold water before handling any food product or container or working in a food facility. This regulation further stipulates that a maximum of 100 viable organisms are allowed per cm^2 after cleaning and sanitation of food contact surfaces has occurred. For the purpose of this study, the same standard will be applied to workers' hands, as they come into direct contact with the ready-to eat food produced. Annexure B of the *Guidelines for Environmental Health Officers on the Interpretation of Microbiological Analysis Data of Food* (2007) for South Africa does not make provision for maximum counts related to *E. coli* and *S. aureus* on food contact surfaces or hands, but the organisms must be absent in all food products.

This study was done to evaluate the efficacy of hand washing practices and sanitation amongst food handlers before they commence working in convenience food plants in the Gauteng Province of South Africa. The study should add to the existing body of knowledge on hand washing and sanitation in the ready-to-eat food industry.

3.3 MATERIALS AND METHODS

3.3.1 Sampling protocol

A 20 % sample was randomly selected from 40 convenience food outlets in Gauteng, which were selected because their predominant focus is on preparing ready-to-eat foods (Krishnamurty, Kasovia-Schmitt & Ostroff, 1995). Workers' cleaned and disinfected dominant hands, which are normally in direct contact with the food, were sampled after staff passed through the hand washing area and before they commenced work, according to SABS method 762 regarding the swab technique (1975). A total of 230 microbiological samples were collected and analysed for the presence of TPC, *S. aureus* and *E. coli* (Table 3.1). One manufacturing plant per day was sampled and samples were transported to the laboratory on ice and analysed on the same day as sampling occurred. A total of 88 samples were collected for TPC analysis, 77 samples for the presence of *E. coli* and 65 samples to test for *S. aureus*. In order to ensure the consistency of workers' normal practices in washing and disinfection, they had no prior knowledge of the planned sampling runs. In total, 100 % of the workers at the eight convenience food plants were sampled for the microorganisms mentioned. Furthermore, the samplings were collected on working days and adequate time was allowed for workers to clean and sanitize their hands. Results are the means of duplicate analyses.

Table 3.1: Distribution of samples collected from hands.

Convenience Food Manufacturing Plants	**[1]Total Plate Count**	***[2]Escherichia coli***	***[3]Staphylcoccus aureus***	**Total/ plant**
1	9	9	9	27
2	12	11	10	33
3	11	8	8	27
4	13	12	11	36
5	9	7	6	22
6	14	12	9	35
7	10	9	5	24
8	10	9	7	26
Total	**88**	**77**	**65**	**230**

[1] ISO method 4833 (International Organisation for Standardization, 2003)
[2] ISO method 16649-2 (International Organisation for Standardization, 2001)
[3] ISO method 6888-1 (International Organisation for Standardization, 1999)

3.3.2 Microbiological analysis

The TPC samples were analysed using the conventional pour plate technique in ISO Method 4833 (International Organisation for Standardization, 2003). *E. coli* analysis was performed with three test methods, using both broth and solid growth media, as stipulated in ISO Method 16649-2 (International Organisation for Standardization, 2001). *S. aureus* was analysed using a spread plate technique on Baird-Parker agar medium i.e. a pre-determined volume of test sample suspension spread onto the surface of a dried pre-poured BPA plate. No coagulase positive *S. aureus* growth was detected in the samples analyzed using ISO Method 6888-1.

Data analysis

The results were analysed in collaboration with the Cape Peninsula University of Technology's Corrie Uys, Statistician, Centres for Postgraduate Studies, and they are presented in tables and graphs, using frequencies and percentages.

RESULTS AND DISCUSSION

3.3.3 Microbiological results of convenience food worker's hands

3.3.3.1 Total Plate Count

The highest bacterial count found from the hand samples was 7,4 x 10^3 cfu.cm^{-2} (Plant 2) and the lowest had no detectable growth (Figure 3.1). Although hands with a count of 0 cfu.cm^{-2} were found in all of the plants, the results indicated that all of the premises sampled exceeded the legal limit of < 100 cfu.cm^{-2} when the average bacterial counts on hands were compared.

The normal data distribution, standard deviation and average bacterial count considerably exceeded the legal limit (Jankowicz, 2002). Except at plants 5 and 8, the average bacterial count was higher than 10^3 cfu.cm^{-2} and one premises (Plant 2) exceeded 10^4 cfu.cm^{-2}. The primary action of hand washing is the mechanical removal of viable transient microorganisms, whereas the primary action of antimicrobial soap includes both mechanical removal and killing or inhibition of both transient and resident flora (Larson, 1989), (SABS, 2001). This is an indication of insufficient hand washing and sanitation, as one would expect a significantly reduced bacterial count on the workers' hands after they have cleaned and sanitised them (South African Bureau of Standards, 2001). Paulson (1992) & Raspor (2008) reported the importance of management training of all employees in the use of effective hand washing procedures, and that the safety of food chain supply can easily be broken proper enforcement these procedures, is the only solution. Sixty percent of the TPC samples analysed exceeded the legal limit (< 100 cfu.cm^{-2}) stipulated by the Health Act for food contact surfaces (Republic of South Africa, 1999)(Figure 3.2).

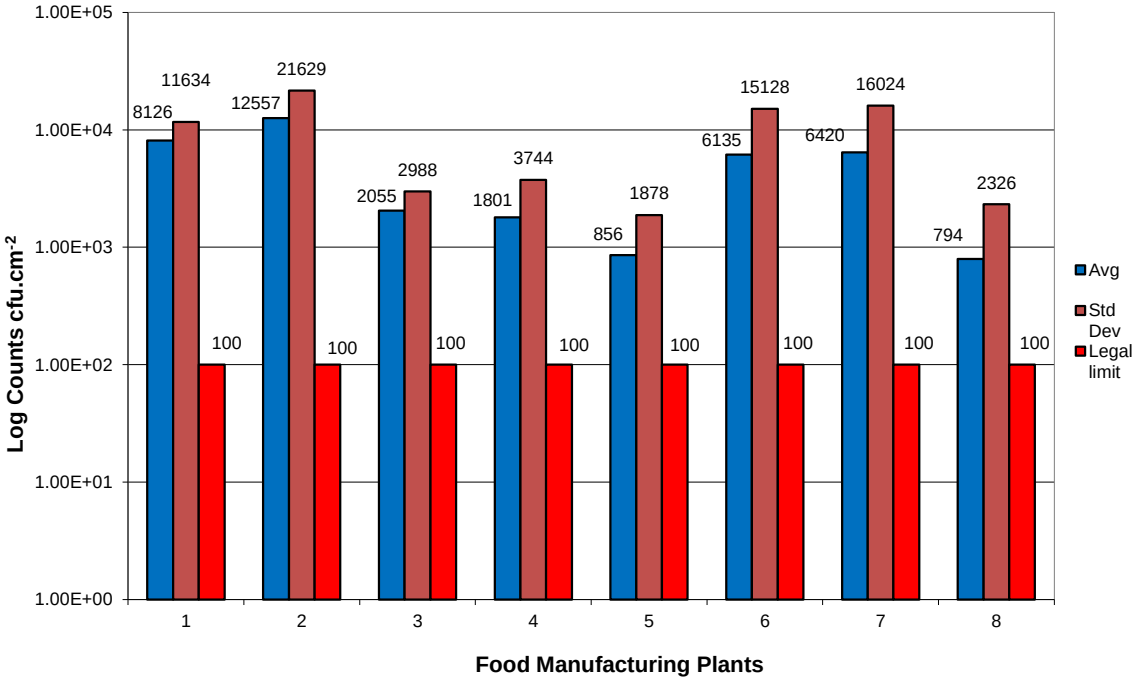

Figure 3.1: Comparison between the standard deviation and the average Total Plate Count versus the legal limit of < 100 cfu.cm^{-2}.

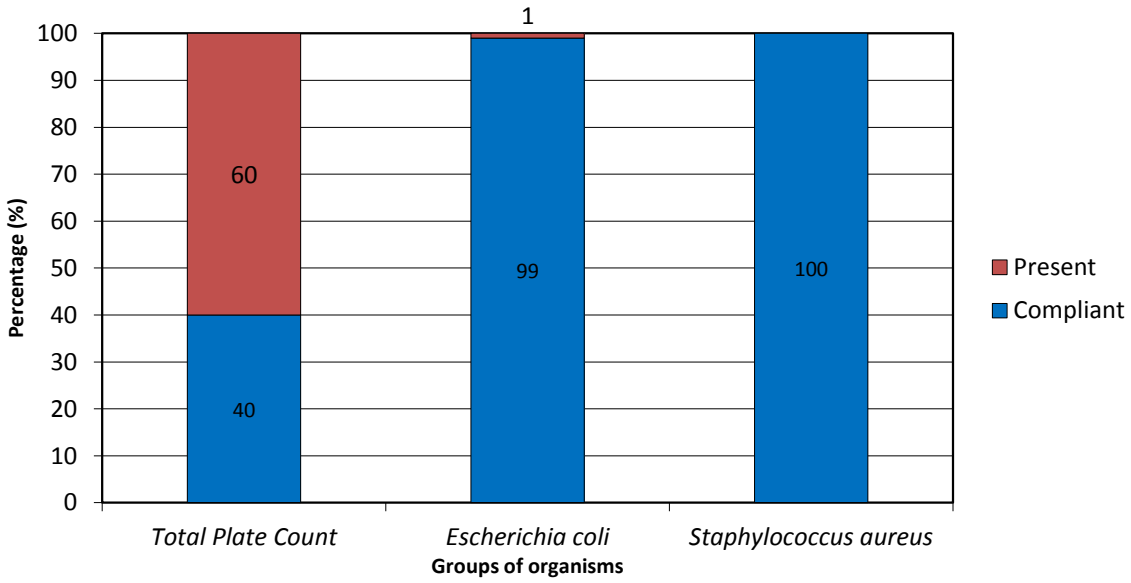

Figure 3.2: Total samples analysed for the presence or absence of Total Plate Count, *Escherichia coli* and *Staphylococcus aureus* that were collected from workers' cleaned and sanitised dominant hand surfaces in eight convenience food manufacturing plants.

3.3.3.2 *Escherichia coli*

Only one sample (Plant 6) tested positive for *E. coli* in the hand samples analysed (Figure 3.2). As *E. coli* is found in the intestinal tract of both humans and animals, finding this organism in ready-to-eat foods is generally viewed as an indication of faecal contamination. Faecal contamination, in turn, indicates that other harmful organisms, whether they be bacterial genera (*Salmonella, Shigella, Campylobacter*), viral (Hepatitis A, norovirus, rotavirus) or helminthic or protozoal parasites (*Taenia, Toxoplasma, Cryptosporidium, Giardia*), could be present (Jay, 1997). In addition, the test for generic *E. coli* may also point to highly pathogenic strains of *E. coli* that have the ability to cause diarrhoea as well as systemic disease, resulting in multi-organ failure and death (*E. coli* 0157:H7) (Sciencedaily, 2010). It is for these reasons that the confirmation of *E. coli* in ready-to-eat food is followed by an automatic recommendation for a thorough review of the constituent ingredients, as well as finished product re-testing and task-oriented training of those individuals involved in the preparation of those specific ready-to-eat food items.

3.3.3.3 *Staphylococcus aureus*

Throughout the eight food premises, *S. aureus* could not be detected on the hands of food handlers (Figure 3.2). *S. aureus* and coagulase-negative *Staphylococci* (CNS) inhabit the human skin and mucous membranes, where they exist mostly as commensal flora (Nobel, 1992). Humans are the natural carriers of *S. aureus* and the organism can be found in a healthy human population (Montville & Matthews, 2008). The onset of symptoms in staphylococcal food poisoning is usually rapid and in many cases acute, depending on the individual's susceptibility to the toxin, the amount of contaminated food eaten, the amount of toxin in the food ingested and the general health of the victim. *Staphylococci* exist in air, dust, sewage, water, milk and food or on food equipment, environmental surfaces, humans and animals. Humans and animals are the primary reservoirs of *Staphylococci* (Montville & Matthews, 2008). Table 3.2 represents a summary of the TPC samples collected and shows the distribution of organism growth as well as the legal limit (100 cfu.cm^{-2}).

Table 3.2: The distribution of compliance in terms of Total Plate Count compared to the legal limit.

Test	**No Growth**	**> 0 - ≤ 10 cfu.cm^{-2}**	**> 10 - ≤ 100 cfu.cm^{-2}**	**> 100 cfu.cm^{-2}**
TPC	16	7	12	53
Comply = 40 %				Not Comply = 60 %

3.4 CONCLUSION

It appears that the overall hand hygiene does not necessarily influence the presence of indicator organisms. Plant 6 showed the fourth highest average bacterial count in the hand samples and was the only plant with *E. coli* present. There are limited specifications available for bacteria in food but the norm is that all pathogens and/or indicator organisms should be absent (Guidelines for Environmental Health Officers on the Interpretation of Microbiological Analysis Data of Food, 2007).

The microbiological quality of food can be improved, especially with regard to contamination from bacteria on food handlers' hands. Nevertheless, the study revealed that hand hygiene is unsatisfactory and it underlines the need to improve food handlers' hygiene knowledge by focusing on hand washing practices. The hands examined using the TPC revealed unacceptable contamination in 60 % of the samples, whereas 18 % had no bacterial growth in terms of the species analysed. These findings indicate that sanitation protocols are not being applied in such a way that they will ensure complete food safety in ready-to-eat manufacturing plants. Furthermore, the microbiological levels on the hands sampled can be used as an indicator to determine controls in future Hazard Analysis Critical Control Point (HACCP) systems. Knowing about these problems is essential to improving the controls systems in ready-to-eat food production establishments and for adjusting the existing staff training programmes. Training the workers in basic hand washing principles is recommended considered, as the overall results indicated that the hands of food handlers in all eight ready-to-eat food manufacturing plants involved in this study exceeded the legal requirements for food contact surfaces.

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CHAPTER 4:
FOOD HYGIENE KNOWLEDGE AND PRACTICES OF FOOD HANDLERS IN THE CONVENIENCE FOOD INDUSTRY IN THE GAUTENG PROVINCE, SOUTH AFRICA

4.1 ABSTRACT

The purpose of this study was to present data on the food hygiene knowledge and practices of food handlers and managers based on a representative sample from convenience food outlets in the Gauteng area. Management as well as food handlers were interviewed by means of a structured questionnaire. Interviews were conducted without prior announcement and managers were interviewed prior to starting their shifts, followed by food handlers, after they had passed through the change room and hand wash facilities. Although the majority of food handlers adhered to basic hygiene principles, the results highlighted a need for proper and continuous training in hygiene practices, not only for food handlers, but also for management. Failure to wash hands after blowing noses and smoking were found to be issues of concern. Food handlers failed to select the correct answer in 36.4 % and 30.7 % of these cases, respectively. Some of the plants did not have an adequate supply of hot water to use for cleaning. Only 34 % of respondents had received training from the chemical suppliers on how to use their products. It is recommended from this study that all food handlers should adhere to a formal cleaning schedule. Specific courses should be planned for food workers as, currently, most training is done away from the workplace and the workers might find it difficult to translate theory into practice. Although food safety training programmes are essential, behavioural changes will not occur merely as a result of having received training, thus should be further developed. In-house training explaining the problems and solutions should be done and the food handlers should take ownership of the problem.

4.2 INTRODUCTION

Accessing good quality food has been humankind's main endeavour from the earliest days of existence and food safety remains a critical issue in the light of outbreaks of foodborne illnesses that result in substantial cost to individuals, the food industry and the economy (Kaferstein, Motarjemi & Bettcher, 1997). Some food is inherently contaminated with microorganisms and food handlers must therefore be taught the significance of hygiene knowledge and good practices and fully understand that they must ensure that microorganisms do not spread to other items. Food handlers are responsible for proper cooking, segregation and storage of food (Barrie, 1996). The safety of food is a basic requirement of food quality. "Food safety" implies an absence or acceptable and safe levels of contaminants, adulterants, naturally occurring toxins or any other substance that may make food injurious to health on an acute or chronic basis (McElhatton & Marshall, 2007). Food handlers' errors have been responsible for most outbreaks of food poisoning (Clayton et al. 2002). Despite an increase in the number of food handlers receiving food hygiene training in recent years, a high proportion of food poisoning outbreaks still occur as a result of poor food handling practices (Gomes-Neves et al. 2007). The kitchen staff and food handlers of a restaurant, deli, cafeteria, meat market and bar are a common source of bacteria and viral contamination in food, which can very readily cause consumers to become ill (Doom, 2008). Hand washing is easy to perform and it is one of the most effective ways to prevent the spread of many types of infections and illnesses in all settings – from the home and workplace to childcare facilities and hospitals (Baş, Ersun & Kivanç, 2006). When it comes to preventing and controlling the spread of microbes in food processing operations, it is hard to overstate the importance of implementing and enforcing proper employee hand washing regimes. Various studies indicate that poor hand washing habits by food handlers and the contamination of food by animal faeces were among the prime

reasons that Americans get sick due to foodborne microbes (Centres for Disease Control and Prevention, 2005). In cases where a foodborne agent was identified, norovirus was the most common cause of illness (39 %), followed by *Salmonella* (27 %). The most common cause of norovirus outbreaks can be attributed to infected food handlers who do not wash their hands well after using the toilet (Centres for Disease Control and Prevention, 2008). *Salmonella* outbreaks are most often caused when food is contaminated with animal faeces. *Salmonella* contamination usually involves animal-related foods such as beef, poultry, milk and eggs; however, vegetables and other foods can also be contaminated, according to the *Diagnosis and Management of Foodborne Illnesses* data (Centres for Disease Control and Prevention, 2004). Studies indicate that personnel in both the healthcare and food service industries have poor hand washing habits. For instance, 60 % of the food service personnel in one study did not wash their hands after using the toilet (Emery, 1990). This study examined food handler's beliefs about food safety and determined food handler's self-reported practices.

4.3 MATERIALS AND METHODS

Eight convenience food manufacturing plants were randomly selected for the purpose of conducting interviews with food handlers who prepare ready-to-eat foods. Confidentiality agreements were signed to ensure that the manufacturers remain anonymous.

4.3.1 Pilot study

The questionnaire was piloted in one outlet and involved eight food handlers and the manager of the respective department. This outlet was not included in the final sample. The purpose of the pilot study was to determine whether enough time would be available to complete the questionnaires before production started, whether the information gathered would provide enough evidence to draw conclusions, whether respondents generally understood the questions correctly as well as to adjust the study if any minor difficulties were experienced.

4.3.2 Sampling protocol

Interviews based on structured questions were completed by a target population (88) that represented 100 % of the population of food handlers in each manufacturing department of each plant, including the manager. All of the managers and food handlers were permanent employees and had been with each respective manufacturing plant for more than 12 months. The eight convenience food manufacturing plants were selected because they predominantly supply ready-to-eat products to the bigger retailers and produce the biggest volumes of food. These plants constitute about 20 % of the ready-to-eat food manufacturing plants in the Gauteng region. The interviews were conducted on a one-on-one basis with the food handlers before they commenced their shift, but after they had entered their working environment. The interviews were done on an unannounced basis. The same interviewer

conducted all of the interviews to ensure consistency and the correct explanation of the questions and interpretation of the answers.

4.3.3 Questionnaire design

A questionnaire was designed to determine three elements: a) the level of involvement of the management in protecting the product integrity; b) whether a safe product reaches the consumer; and c) whether food handlers pose a risk to the safety of the product (Appendix A). It was stated at the outset of the interview that confidentiality would be protected and no names would be recorded. The questionnaire was only available in English; however, all of the food handlers indicated that they were comfortable to answer questions in English and no translation was required. Out of a total of 46 questions, 21 questions targeted management practices and 25 questions were aimed at the food handlers. The questions aimed at the managers were related to food safety systems and prerequisite standards as well as risk assessment within the plant and compliance with standards and/or legislation. The remaining questions designed for the food handlers were strictly focused on their knowledge of personal hygiene and cleaning and sanitation practices in their working environment. The structured interview method allowed the interviewer to ask all of the respondents the same questions in the same manner (Rogers, 2001).

4.3.4 During the interview

The interviews were conducted without prior announcement and care was taken not to deviate from the questions listed in the questionnaire. Upon entering the various manufacturing plants, the managers were interviewed prior to starting their respective shifts, followed by the food handlers as they entered the respective facility after passing through the change room and hand wash area. The purpose of the study was explained to them and assurance was given about the confidentiality of their identities.

4.3.5 Data analysis

The data collected were analysed and statistically prepared for reporting. The results were expressed in percentages and frequencies as well as indicated the response rate (n) for each question.

4.4 RESULTS AND DISCUSSION

4.4.1 Level of management involvement

Management involvement is important, as it is necessary to manage plant hygiene practices in a top-down manner. The eight selected plants were not Hazard Analysis Critical Control Point (HACCP) certified but implemented control measures to improve their own hygiene quality. Only 62.5 % of the plants performed regular testing of process water to determine the quality of water used for processing, washing hands and work surfaces (Table 4.1). The respondents reported performing risk assessments: 62.5 % identified critical areas; 50 % reported that they verified the control measures for the critical areas, whereas 37.5 % conducted validations of the critical process steps. Thirty-seven point five percent of the respondents used an official food safety decision tree to determine the critical areas correctly (Table 4.1). Richardson and Stevens (2003) conclude that management may represent a contributing factor to poor microbiological quality and prioritizing improved training of managers is more important than training the food handlers to ensure the good hygiene of the premises. By setting an example, the senior management can further enhance the level of training of food handlers (Sprenger, 1991). Results were obtained from management regarding their awareness of the necessity of deep cleaning, validation of cleaning procedures and compliance with regulatory standards. Fifty percent were aware of the necessity of the validation of cleaning procedures and compliance with regulatory standards, with 37.5 % and 50 % responses in these categories, respectively (Table 4.2).

Table 4.1: Food safety assessment indicating compliance with food safety standards in SANS 10330-2009 (Appendix A).

Risks/CCP assessment (Management)	**Yes**	**% n = 8**	**No**	**% n = 8**
Have you identified areas/process steps in your facility that are critical to preventing foodborne diseases?	5	62.5 %	3	37.5 %
Have you done a verification of the control measures in place to control the critical areas/process steps?	4	50.0 %	4	50.0 %
Have you done a validation of the process steps that are critical?	3	37.5 %	5	62.5 %
Did you use a decision tree to identify critical areas?	3	37.5 %	5	62.5 %

Table 4.2: Food safety assessment indicating compliance with general cleaning and hygiene principles (Appendix A).

GMP/PRP assessment (Management)	**Yes**	**% n = 8**	**No**	**% n = 8**
Does your facility comply to GMP standards (SABS 049)?	4	50.0 %	4	50.0 %
Are your detergents SABS 1828 approved?	8	100.0 %	0	0.0 %
Is your sanitizer SABS 1853 approved?	7	87.5 %	1	12.5 %
Do you have a Master Cleaning Schedule (MCS)?	6	75.0 %	2	25.0 %
Do you have a deep cleaning procedure in place?	3	37.5 %	5	62.5 %
Do you verify your cleaning efficiency by taking surface samples?	4	50.0 %	4	50.0 %
Has your staff had formal/external hygiene awareness training?	8	100.0 %	0	0.0 %

4.4.2 Bacteriological safety of the food product

Only 75 % of the manufacturing plants made use of an official Master Cleaning Schedule (MCS) as well as complied with the requirements stated in their policy document on a monthly basis. However, correct responses about hand washing procedures ranged between 49 % and 51 % (Figure 4.1) and the results probably reflect a lack of commitment from the workers. All of the manufacturing plants frequently send product samples for microbiological analysis and 75 % did regular surface monitoring. Results from the questionnaire showed that 25 % of the food plants contained samples that tested positive for *S. aureus,* 50 % for *Listeria* and 37.5 % for *E. coli* (Table 4.3). According to Sagoo, Little and Mitchell (2003), microbiological analysis of ready-to-eat salad vegetables from retail outlets showed a direct relationship between management having received food hygiene training, managements' confidence and food safety procedures being followed.

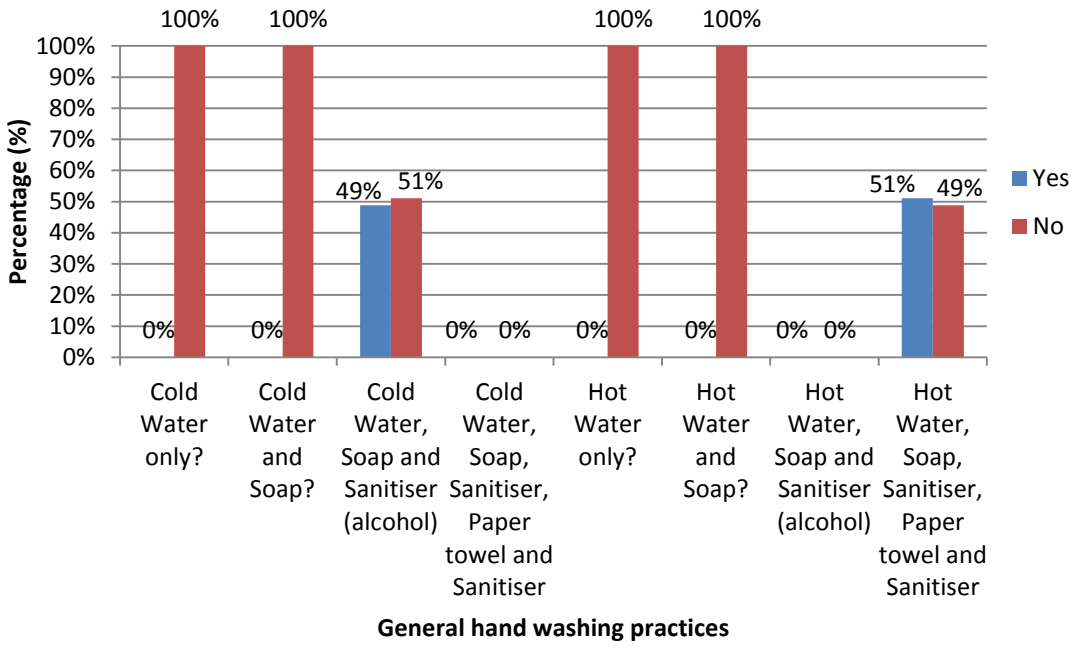

Figure 4.1: Hand washing procedures followed by food handlers (Appendix B).

Table 4.3: Bacteriological risk assessment (Appendix A).

Bacteriological risk assessment (Management)	**Yes**	**% n = 8**	**No**	**% n = 8**
Do you have a microbiological sampling programme?	8	100.0 %	0	0.0 %
Do you do regular surface monitoring?	6	75.0 %	2	25.0 %
Do you do surface monitoring during production?	4	50.0 %	4	50.0 %
Do you send samples for frequent microbiological analysis?	8	100.0 %	0	0.0 %
Have you detected one of the following pathogen organisms on your final product before?				
Salmonella	0	0.0 %	8	0.0 %
Staphylococcus aureus	2	25.0 %	6	75.0 %
Listeria	4	50.0 %	4	50.0 %
Escherichia coli.	3	37.5 %	5	62.50 %
Do you do frequent microbiological analysis of your process water?	5	62.5 %	3	37.5 %

4.4.3 Knowledge and practices of food handlers

Fifty-six of the respondents (36.4 %) and 61 respondents (30.7 %) failed to select the correct answer for the question about hand washing after blowing their noses and after smoking, respectively (Fig 4.2). As indicated in Figure 4.2, the risk of workers introducing microorganisms after rest periods or visiting the toilet signals a potential risk to the consumer i.e. 13.6 % were found not to wash their hands after a rest period and 9.1 % did not do so after visiting the toilet. Hands are a common carrier of bacteria that can cause foodborne disease outbreaks. Ordinarily, these outbreaks relate to ineffective hand washing. A study by Dag (1996) showed that the most common bad habits of workers at mass-production food facilities were touching their mouth with their hands, using the same towel to clean many places and to wipe their hands on their face or clothes while working. The majority of food handlers and managers expressed a positive attitude towards food safety, but this was not supported by self-reported practices and the observed discrepancy between self-reported behaviour and actual behaviour (Ansari-Lari, Soodbakhsh & Lakzadeh, 2010). The food workers had a good general knowledge of general sanitation measures in the workplace. Hundred percent were aware of the need to wash their hands at the beginning of every shift (Figure 4.2) and 100 % answered correctly on the need to properly clean surfaces every day (Figure 4.3). However, various studies have shown that the efficacy of training in terms of changing behaviour and attitudes to food safety is questionable (Mortlock, Peters & Griffith, 1999).

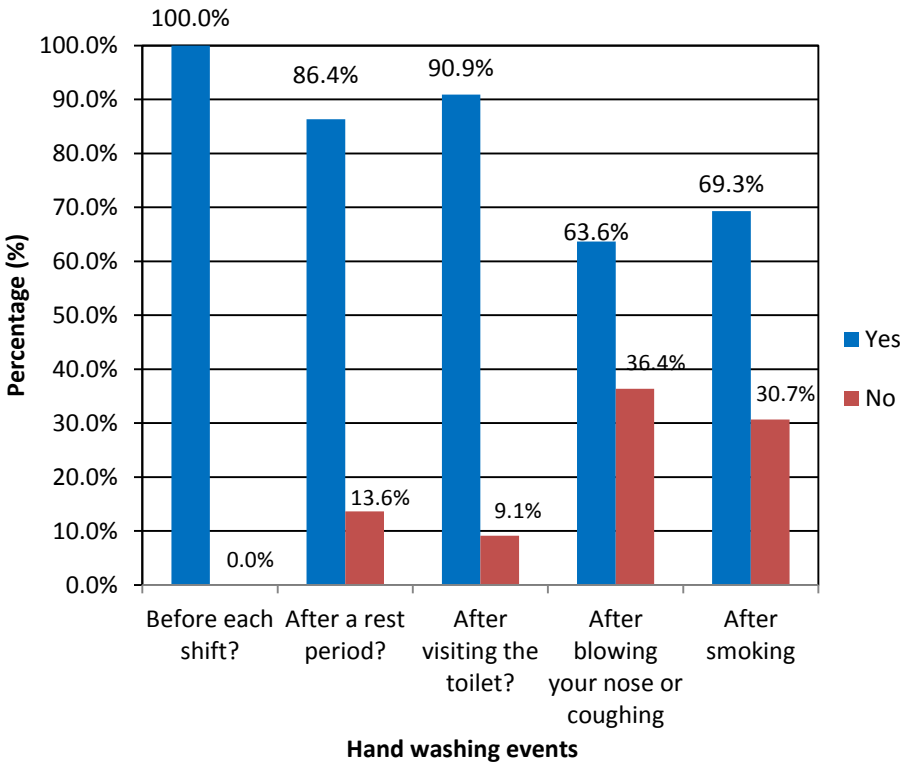

Figure 4.2: Frequency of hand washing indicating non-compliance of hand washing practices.

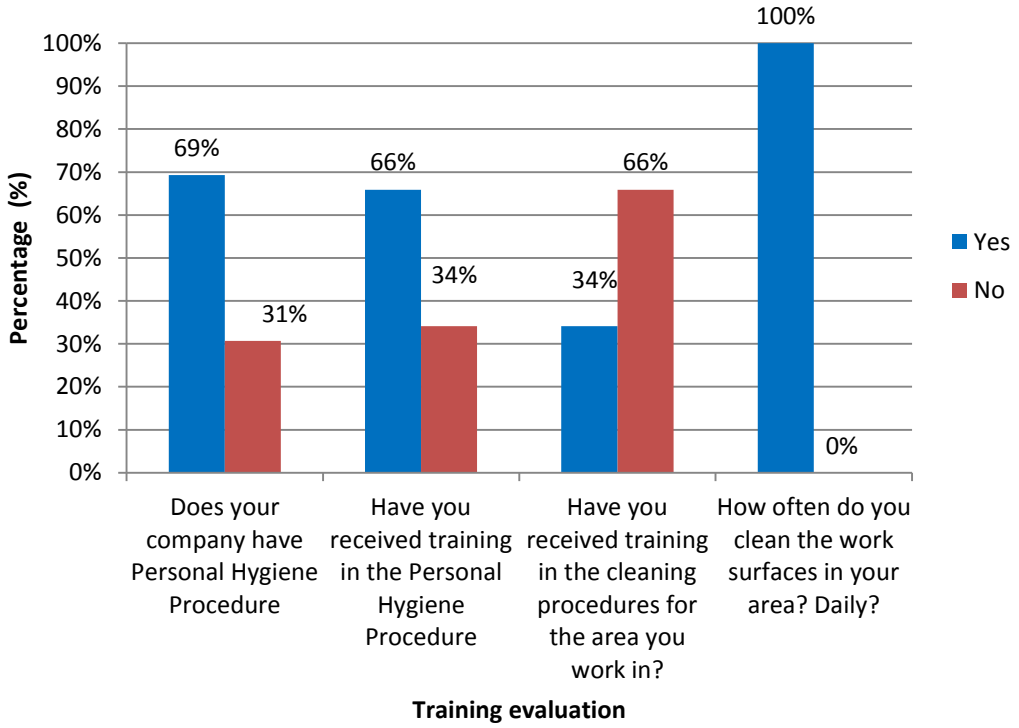

Figure 4.3: Food handlers' knowledge regarding specific personal and hygiene procedures.

It seems that more workplace-specific courses should be planned for food workers, as most training is currently done away from the workplace and the workers might find it difficult to translate the theory into practice. The training courses also need some form of evaluation to ensure their effectiveness (Miller & Osinski, 2002). In agreement with various previous studies, the overall attitudes of the respondents were very positive toward food safety measures, despite the fact that they had relatively poor hygiene practices (Walker, Pritchard & Forsythe, 2003). The results of the present study showed that with self-reported hygiene practices, only an average of 82 % of respondents always washed their hands as a standard hygiene practice; 100 % at the beginning of each shift; 86.4 % after a rest period; 90.9 % after visiting the toilet; 69.3 % after smoking; and 63.6 % after coughing and/or blowing their noses. Food workers in many settings have been responsible for foodborne disease outbreaks for decades and there is no indication that this is diminishing (Greig, Todd, Bartleson & Michaels, 2007). The general cleaning practices of the food handlers in their work environment were further evaluated and the food handlers answered several questions (Appendix A). Unfortunately, none of the manufacturing plants has an adequate supply of hot water to be used for cleaning. A combination of cold water, soap, water pressure and sanitizer are used in the practices generally applied. All of the plants use chemicals and/or detergents for washing, but only 47.7 % (Table 4.4) use cold water, soap, pressure and sanitizer, which comprise the best option.

Table 4.4: Food handlers' knowledge of good cleaning practices for work surfaces.

How do you clean your working area? (Production staff) n = 88	**Yes**	**%**	**No**	**%**
Cold water only	0	0	88	100.0 %
Cold water & soap & sanitizer	0	0	46	52.3 %
Cold water & soap & pressure	0	100.0 %	88	0
Cold water & soap & pressure & sanitizer	0	47.7 %	42	52.3%
Hot water only	0	0	88	100.0 %
Hot water & soap	0	0	88	100.0 %
Hot water & soap & pressure	0	0	88	100.0 %
Hot water & soap & pressure & sanitizer	0	0	88	100.0 %

General information regarding hygiene and sanitation

Of the respondents participating in this study, 66 % had received some form of food hygiene training (Figure 4.3). Only 34 % received training from the chemical supplier on how to use their products and training in the immediate areas they work in, but all of the workers were aware that they have to clean their working environment daily (Figure 4.3). The management of the eight manufacturing plants indicated that there are some obvious problems in complying with the basic requirements of food safety stipulated in the Good Manufacturing Practices Guide (South African Bureau of Standards, 2001). All eight plants use SABS 1828-approved detergents that are non-toxic and safe for use in a food plant, whereas 87.5 % (7 plants) use SABS 1853-approved sanitisers that carry the SABS mark on the container. The one plant that does not use SABS 1853-approved products does so because they cannot afford them and instead use an unformulated sodium hypochlorite solution.

4.5 CONCLUSION

This study examined the beliefs of food handlers towards food safety and determined food handlers' self-reported practices. This review particularly focused on studies that attempted to evaluate the effectiveness of food safety and hygiene training. The results of the present study showed that food workers in the eight manufacturing plants had an acceptable knowledge level of good food hygiene practices, but relatively poor implementation thereof. Despite the workers' good knowledge and attitudes toward food hygiene, their practices were inadequate. Although food safety training programmes are essential, behavioural changes will not occur merely as a result of training, thus should be further developed through continuous programs and skills development. Evaluation of the programme's impact is needed to show the merit of a programme and possible areas to change and/or

modify. The study further demonstrates that although food handlers may be aware of the need for personal hygiene, they do not comprehend crucial aspects of hygiene.

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CHAPTER 5:
GENERAL DISCUSSIONS

5.1 INTRODUCTION

The popularity of convenience food is bound to increase with the growing appeal for food that reduces/eliminates the preparation time. People's time is limited and convenience food is the food of the future for the working mother. It is clear that managing foodborne disease is a challenge and an economic problem subject to various constraints. This study endeavoured to add to the understanding and contribute to the improvement of hand and plant hygiene and the knowledge of food handlers in the Gauteng convenience food industry. Senator Tom Harkin stated: "That is both frightening and unacceptable to say that food safety in this country is a patchwork system is giving it too much credit. Food safety has too often become a hit-or-miss gamble, with parents obliged to roll the dice when it comes to the safety of their children's food." (Harkin, 2010). When Senator Harkin made this comment, he was addressing issues in the United States of America, but his comment is also applicable to other countries, including South Africa. Consumers in South Africa nowadays demand good quality and safe products at a reasonable cost (Brand, 2008). The industry therefore needs to improve processes to prevent the contamination of foods and use methods to ensure safe food for consumers. To achieve this, training, more testing and regular theoretical as well as practical testing (better methods of tracking food) must be utilised to verify that the processes are working. This study endeavoured to add to the understanding and improvement of hygiene processes as well as food handlers' practices in the convenience food industry in the Gauteng Provence of South Africa.

5.2 COMPARISONS BETWEEN LOW-PRESSURE FOAM CLEANING AND CONVENTIONAL CLEANING TO REMOVE SELECTED BACTERIAL PATHOGENS FROM SURFACES ASSOCIATED WITH CONVENIENCE FOOD

Chapter 2 of this study deals with the results of the comparison between low-pressure foam cleaning and conventional cleaning of food contact surfaces in the convenience food industry. The results obtained highlighted the presence of high counts of bacteria, including one pathogen (*Listeria*), that were detected on the sanitized/disinfected convenience food contact surfaces. The majority (59 %) of the Total Plate Count (TPC) samples exceeded the specified requirements for food contact surfaces (< 100 cfu.cm^{-2}) of the Health Act (Republic of South Africa, 1999). Even the plants that used SABS approved cleaning chemicals and disinfectants/santisers still had a pathogen problem. Plants 1 and 7 had the highest presence of *Listeria* and highest TPC results and both of these plants also made use of conventional cleaning method. Plant 1 also had the only positive *Escherichia coli* sample. Throughout the eight plants, the low-pressure foam cleaning method proved to be more effective in controlling microorganisms than the conventional cleaning method. After analysing and interpreting the results, it was clear that the food handlers who also act as cleaners of their specific working environment do not have sufficient knowledge or adequate equipment to apply the chemicals correctly or the chemicals are not as effective as stated to achieve the desired results. It is strongly recommended that the management of the various plants investigate the possibility of providing intensive training for the production workers as well as oversee cleaning until the bacterial counts improve and comply with the regulatory standards. This study has highlighted the fact that pathogens remain viable on dry stainless steel surfaces and present a contamination hazard for considerable periods, depending on the contamination levels and type of pathogen (Kusumaningrum et al. 2003).

There was a statistical relationship between the cleaning methods used and the TPC results ($P \leq 0.05$), but no statistical difference was found between the presence of *Listeria* and the cleaning methods used.

5.3 MICROBIOLOGICAL CONTAMINATION ON THE HANDS OF CONVENIENCE FOOD HANDLERS AS AN INDICATOR OF HAND WASHING EFFICACY IN THE CONVENIENCE FOOD INDUSTRY

The microbiological quality of food can improve, especially with regard to contamination from bacteria on hands, which may be transferred to the food during manual handling. The study revealed that worker's hand hygiene in the convenience food industry is unsatisfactory and underlines the need to improve the hygiene knowledge of food handlers, by focusing on hand washing practices. Bacteria were found on 60 % of the samples taken by swabbing workers hands and only 18 % of the hand samples taken showed no bacterial growth after washing and sanitation processes had been performed. The hand soap and sanitisers used were certified by the SABS and complied with the requirement of SABS 1853. These findings indicate that sanitation protocols are not being applied in a way that will minimise food safety in ready-to-eat manufacturing plants. Continuous training and follow up is absolutely vital to ensure that the food handlers follow hand washing procedures to prevent contamination of foodstuffs. Furthermore, the microbiological quality of employees' hands can be used as an indicator to determine controls of the critical points for future Hazard Analysis Critical Control Point (HACCP) systems. The results of the present study revealed that, firstly, workers' hands can severely affect the microbiological quality of food. As such, it is essential to identify weak points in general hand washing processes. Contamination of the food handlers' hands poses a bigger risk to the product than anticipated. Secondly, knowledge of these problems is essential to improving the control

systems of ready-to-eat food production establishments and to adjusting the staff training programmes. Thirdly, training the workers in basic hand washing principles and the validation of hand washing procedure and contact time should be considered, as the overall results indicated that all the worker's hands in all eight ready-to-eat food manufacturing plants involved in this study exceeded the legal requirements for food contact surfaces and thus they potentially pose a risk to the consumer.

5.4 FOOD HYGIENE KNOWLEDGE AND PRACTICES OF FOOD HANDLERS IN THE CONVENIENCE FOOD INDUSTRY IN THE GAUTENG PROVINCE

In Chapter 4 of this study, a structured questionnaire was used to interview 88 food handlers in the convenience food plants selected in Gauteng. The main foci were: the level of managements' involvement in food safety, the product safety and the hygiene practices of the food handlers. The results showed good/adequate knowledge on hygiene of the food handlers in the eight manufacturing plants, but shortcomings in their attitudes and practices (Clayton et al. 2002). Concerning results were obtained from management in convenience food plants (62 %) who admitted that their awareness of the necessity of deep cleaning, validation of cleaning processes and compliance with regulatory standards were lacking. It seems that more workplace-specific courses should be planned for food handlers, as most training is currently done away from the workplace and the workers might find it difficult to translate the theory into practice. The questionnaire indicated that selected pathogens and indicator organisms (*Staphylococcus aureus, Listeria* spp., *E.coli*) had been found on food samples tested in the past. Compliance with the basic regulatory standards is one of the obvious problems and this encompasses compliance with the standards for cleaning chemicals used in food manufacturing plants for cleaning and sanitation. It is often

misunderstood that the sole responsibility of the government and its agencies is to provide a legislative and regulatory framework to lay down certain mandates for those involved in the provision of safe food to the consumer. As in most of the developing countries around the world, South Africa has a very basic and undeveloped food legislatory system with multiple problem areas, such as the existence of fundamental differences in agency missions and approaches to inspection, non-uniformity of facilities, the unavailability of skilled personnel, money wastage on non-essential issues and poor efforts being made in the development of new technologies for controlling concerns. To an extent, it would be reasonable to say that South Africa does not have an integrated food safety framework, but has a set of laws dealing with selected aspects of food safety. Although laws have the potential to ensure food safety standards, an absence in understanding and implementing them at all levels leaves too many loopholes to be filled.

5.5 CONCLUDING REMARKS

Despite an increase in the number of food handlers receiving food hygiene training, a high number of food poisoning outbreaks still occur as a result of improper food handling practices in the general food industry. The implementation of the HACCP, ISO 22000 awareness, changes in the labelling legislation (Republic of South Africa, 2010) of foodstuffs and the promulgation of the Consumer Protection Act (Republic of South Africa, 2008) have brought new responsibilities for food manufacturing plants. Not only is the general population becoming more aware of the safety of food but also about the quality of food that is sold to them. The current world economic climate and recession is forcing food manufacturers to employ a cheaper labour force comprising people from lower income groups with low levels of education and these people are now entrusted with preparing ready-to-eat food, the most risky foodstuff available in the convenience market. These

employees' socioeconomic backgrounds may not necessarily support good hygiene practices, as many of them come from informal settlement areas where there is a lack of sanitation, proper housing and medical care.

5.6 RECOMMENDATIONS TO GOVERNANCE AND AUDIT BODIES

Microbiological guideline documents in South Africa are limited and as a result, very few microbial standards are available. In addition, the enforcement appears to require improvement. Future research can be conducted to compare international standards with those available in South Africa. The South African Health Department should expand on the available local list of microbiological standards as well as adopt globally accepted standards to give the food industry and controlling bodies more information to work with and measurable standards with which they can/must comply. The availability of more comprehensive microbiological standards could serve as measurable objectives where against the industry could compare itself to determine compliance and goals for improvement.

5.7 RECOMMENDATIONS TO INDUSTRY

- Management should be more aware of the hygiene standards in the industry and enforce them and increase the focus on importance of adequate cleaning. Food manufacturing plants deliver a basic necessity to people and it is essential that the appropriate attention be given to hygiene and cleaning principles to ensure safe food.

- Proper, relevant and measurable training should be provided and continues progress should be monitored.

- External verification audits are vital to improving the overall hygiene in food manufacturing plants and in creating awareness of problem areas.
- Cleaning chemical suppliers, with the assistance of testing laboratories, should be more involved in the validation of cleaning processes in food manufacturing plants and more frequent sampling and validation of cleaning methods must be done.

5.8 FUTURE RESEARCH

The following further research opportunities have been opened-up by the research:

- A study on the prevalence of *Listeria* species in ready-to-eat manufacturing plants and to determine why such levels exist.
- Determination of the training required to train food handlers in better practices and implementation.
- Determination of the acceptable level of microorganisms on all working surfaces as well as food handlers' hands.
- A study to compare local microbiological standards with international standards that will include all ready-to-eat products from all sectors of the food industry, to improve and expand on the existing microbiological standards that are available.

5.9 REFERENCES

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APPENDIX A

APPENDIX A

An assessment of food safety risks associated with ready-to-eat foods from suppliers in the Gauteng –area.

Questionnaire: Management

Thank you for taking part in this confidential survey. The aim of this survey is to determine your practices regarding food safety at work. Your answers are confidential and will not be used against you, as no names are recorded. The questions will be asked by the researcher

No.	Questions	Yes	No
	GMP/PRP (Management)		
1.	Does your facility comply to GMP standards (SABS 049)		
2.	Is your detergents SABS 1828 approved?		
3.	Is your sanitiser SABS 1853 approved?		
4.	Do you have a Master Cleaning Schedule (MCS)?		
5.	Do you have a Deep Cleaning Procedure in place?		
6.	Do you verify your cleaning efficiency by taking swabs?		
7.	Has your staff had formal/external hygiene awareness training?		

	Bacteriological risk assessment (Management)		
8.	Do you have a microbiological sampling programme?		
9.	Do you do regular surface swabs?		
10.	Do you send samples for frequent microbilogical analysis?		
11.	Do you do surface swabs during production?		
12.	Have you detected one of the following organisms on your final product before:		
13.	*Salmonella*		
14.	*Staphyloccous aureus*		
15.	*Listeria*		
16.	*Escherichia coli*		
17.	Do you do frequent microbiological analysis of your process water?		

	Risks/CCP assessment (Management)		
18.	Have you identified areas/process steps in your facility that is critical to prevent foodborne diseases?		
19.	Have you done a verification of the control measures in place to control the critical areas/process steps?		
20.	Have you done a validation of the process steps that are critical?		
21.	Did you use a decision tree to identify critical areas?		

APPENDIX B

APPENDIX B

An assessment of food safety risks associated with ready-to-eat foods from suppliers in the Gauteng –area.

Questionnaire: Production

Thank you for taking part in this confidential survey. The aim of this survey is to determine your practices regarding hygiene at work. Your answers are confidential and will not be used against you, as no names are recorded. The questions will be asked by the researcher.

	How do you clean your working area (Production staff)	**Yes**	**No**
1	Cold Water only?		
2	Cold Water & Soap & Sanitiser		
3	Cold Water & Soap & Pressure		
4	Cold Water , Soap & Pressure & Sanitiser		
5	Hot Water only?		
6	Hot Water and Soap?		
7	Hot Water, Soap & Pressure		
8	Hot Water , Soap & Pressure & Sanitiser		

	When do you wash your hands? (Production staff)		
9	Before each shift?		
10	After a rest period?		
11	After visiting the toilet?		
12	After blowing your nose or coughing		
13	After smoking		

	How do you wash your hands? (Production staff)		
14	Cold Water only?		
15	Cold Water and Soap?		
16	Cold Water, Soap and Sanitiser (alcohol)		
17	Cold Water, Soap, Sanitiser, Paper towel and Sanitiser		
18	Hot Water only?		
19	Hot Water and Soap?		
20	Hot Water, Soap and Sanitiser (alcohol)		
21	Hot Water, Soap, Sanitiser, Paper towel and Sanitiser		

	Training (Production staff)		
1.	Does your company have Personal Hygiene Procedure		
2.	Have you received training in the Personal Hygiene Procedure		
3.	Have you received training in the cleaning procedures For the area you work in?		
4.	How often do you clean the work surfaces in your area?		