Central University of Technology, Free State

A SURVEY OF PROCESS HYGIENE AND ASSOCIATED FOOD HANDLER PRACTICES IN A RETAIL GROUP IN THE WESTERN CAPE, SOUTH AFRICA

By

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DECLARATION OF INDEPENDENT WORK

I, IZANNE SUSAN VAN TONDER, do hereby declare that this research project submitted to the Central University of Technology, Free State for the degree DOCTOR TECHNOLOGIAE: ENVIRONMENTAL HEALTH, is my own work and has not been submitted before to any institution by myself or any other person in fulfillment of the requirements for the attainment of any qualification.

.....Gonder..... ...12/03/2005...

SIGNATURE OF STUDENT DATE

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for knowledge of all around us, and the more we gain, the more the more we are capable of seeing" – Maria Mitchell.

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SUMMARY

A SURVEY OF PROCESS HYGIENE AND ASSOCIATED FOOD HANDLER PRACTICES IN A RETAIL GROUP IN THE WESTERN CAPE, SOUTH AFRICA

The continuing high incidence of food-borne diseases has made food safety a global concern and the potential of food handlers and the environment to act as vectors in the transmission of food-borne disease remains significant. In recent years, increased consumer awareness, fastidious specifications of export clients and vigorous advertising campaigns have put pressure on the retail industry, leading to a considerable degree of rivalry. New regulations governing the application of safety managements systems such as the issuing of certificates of acceptability, hygiene systems auditing and the Hazard Analysis Critical Control Point (HACCP) system have replaced the traditional concepts of quality control with its emphasis on end-product monitoring. With the exception of Total Viable Counts, legislation in South Africa governing acceptable levels of indicator organisms on the hands of food handlers, on the surfaces and in the air of food handling premises is limited.

This study was conducted amongst a randomly selected sample of retail outlets in the Western Cape Province of South Africa, specifically targeting the delicatessen sections where high-risk ready-to-eat foods are sold. In the study the personal and general hygiene practices of food handlers and their levels of food hygiene training were evaluated concomitant with the occurrence of indicator microbiota (including Total

Viable Counts, Total Coliforms, *Escherichia coli*, members of the family Enterobacteriaceae and *Staphylococcus aureus*) on hands and aprons. The delicatessen sections were further investigated in terms of airborne concentrations of these organisms and their relationship to ventilation and lastly, the interactions between microbiota and food handler practices were assessed.

The majority of food handlers were found to conform to the requirements as stipulated in the Health Regulations promulgated under the Health Act (Act 63 of 1977) as well as related directive documents such as the SABS 049 (2001) and the Codex Alimentarius (1997). The results, however, reiterated the need for proper and continuous staff training in personal and general hygiene. Reporting of illness, long fingernails and the wearing of jewellery and dressings that are not moisture-proof were issues of particular concern. Total Viable Counts on hands and aprons conformed to the South African national standard of 1×10^2 cfu.cm^{-2} without exception. When Total Coliforms on hands and on aprons were compared to the general microbial target value of <2.5 cfu.cm^{-2} after disinfection (as suggested in the literature), 32% of food handlers were found to have exceeded the limit with regard to hands and 8% with regard to aprons. No significant statistical correlation could be found between the occurrence of organisms on hands and their occurrence on aprons and in general, correct food handling practices were adhered to by the majority of the respondents. Since no microbiological guidelines exist in South Africa with regard to airborne microbial load, counts obtained in this study were compared to available literature and appeared relatively low. Apart from Enterobacteriaceae counts that differed significantly between the three groups of visitors (Group 1: below normal; Group 2: normal and Group 3: above normal) and Total Viable Counts that differed between the two ventilation groups (Group 1: extractor fan and air conditioner and Group 2:

extractor fan or air conditioner or fan), no statistically significant differences existed between the bioaerosol counts and the selected physical parameters of the delicatessen sections. Therefore the occurrence of organisms was likely to have been related to environmental influences rather than aspects such as the type of ventilation, temperature and number of clients. The only tangible interactions between microbiota and food handler practices were, therefore, in terms of Enterobacteriaceae counts on aprons, and differences between respondents who had received training in personal hygiene and those who never received training, as well as between respondents who had received training in general hygiene and those who never received training. Negligible counts of *Escherichia coli* were found throughout the study.

In conclusion, improper training could present a greater risk to food safety than no training at all and, as prescribed by the Codex Alimentarius (1997). Only properly trained staff should be allowed to work in the delicatessen. Service providers of training courses, whether in-house or external, should be credible and of high quality. In order to ensure that hygiene practices are not compromised, the number of food handlers working a specific shift should be varied according to the number of clients visiting an outlet. Furthermore, it is advisable that extractor fans as well as air conditioners be used in all the outlets and that a positive airflow be maintained from the delicatessen sections outward. Environmental regulating mechanisms should be adapted to minimise bioaerosol counts and air-intake vents should be located so as to avoid the intake of contaminated air. Bioaerosol monitoring should, in addition to other routine microbiological analyses, be conducted on at least a six-monthly basis to ensure that ventilation systems are effective. Finally, it is advised that the retail group studied establish and maintain clear policy and procedures regarding bioaerosol control in high-risk areas.

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OPSOMMING

'N ONDERSOEK NA DIE PROSESHIGIËNE EN GEASSOSIEERDE PRAKTYKE VAN VOEDSELHANTEERDERS IN 'N KLEINHANDELAFSETGROEP IN DIE WES-KAAP, SUID-AFRIKA

Die aanhoudende hoë insidensie van voedselgedrae siektes het voedselveiligheid 'n dilemma van wêreldomvang gemaak en die potensiaal vir voedeselhanteerders en die omgewing om as draers in die oordrag van voedselgedrae siektes op te tree bly 'n betekenisvolle kwessie. Toenemende verbruiker bewustheid, streng spesifikasies deur uitvoer kliënte en omvattende advertensieveldtogte het druk op die kleinhandelindustrie geplaas wat gelei het tot aansienlike kompetisie. Nuwe regulasies wat veiligheidsbestuur sisteme soos uitreiking van sertifikate van voldoening, higiëne-sisteem ouditering en die "Hazard Analysis Critical Control Point" (HACCP) stelsel het die tradisionele konsepte van gehaltekontrole met sy klem op eindprodukmonitering vervang. Behalwe vir Totale Lewensvatbare Tellings, is die wetgewing in Suid-Afrika met betrekking tot aanvaarbare vlakke van indikatororganismes aan die hande van voedselhanteerders, op die oppervlaktes en in die lug van voedselhanteringspersele, beperk.

Hierdie studie is gedoen by ewekansige geselekteerde kleinhandelafsetgroepe in die Wes-Kaap streek van Suid Afrika met die spesifieke fokus op delikatesse-afdelings waar hoë risiko kitsmaaltye verkoop word. In die huidige studie is die persoonlike en algemene higiëne-praktyke van voedselhanteerders en hul vlak van voedselhigiëne-

opleiding geëvalueer en die voorkoms van indikatororganismes (insluitende Totale Lewensvatbare Tellings, Totale Kolivorme, *Escherichia coli*, lede van die Enterobacteriaceae-familie en *Staphylococcus aureus*) aan hande en voorskote is vermeld. Die delikatesse-afdelings is verder ondersoek vir luggedraagde konsentrasies van hierdie organismes en hul verhouding tot ventilasie en laastens is die interaksies tussen mikrobiota en die praktyke van voedselhanteerders geassesseer.

Daar is gevind dat die meerderheid van voedselhanteerders aan die vereistes, soos uiteengesit in die Gesondheidsregulasies gepromulgeer onder die Gesondheidswet (Wet 63 van 1977), asook rigtinggewende dokumente soos die SABS 049 (2001) en die Codex Alimentarius (1997) voldoen het. Die resultate van hierdie studie het 'n behoefte vir behoorlike en volgehoue opleiding in persoonlike en algemene higiëne uitgelig. Die verslaglewering van siekte, lang vingernaels en die dra van juweliersware en wonddekkings wat nie vogdig is nie, was ook kommerwekkende kwessies. Totale Lewensvatbare Tellings aan hande en voorskote het sonder uitsondering aan die Suid-Afrikaanse nasionale standaard van 1×10^2 cfu.cm^{-2} voldoen. Wanneer Kolivorme aan hande en voorskote vergelyk is met die algemene mikrobiese doelwitwaarde van <2.5 cfu.cm^{-2} na ontsmetting, soos voorgestel in die literatuur, het 32% van voedselhanteerders die limiet met betrekking tot hande oorskry en 8% met betrekking tot voorskote. Geen betekenisvolle statistiese korrelasie kon tussen die voorkoms van organismes aan hande en hul voorkoms aan voorskote gevind word nie en oor die algemeen het dit geblyk dat daar aan die korrekte voedselhanteringspraktyke deur die meerderheid van die voedselhanteerders voldoen is. Aangesien geen mikrobiologiese riglyne in Suid-Afrika bestaan met betrekking tot luggedrae mikrobiese populasies nie, lyk hierdie tellings relatief laag wanneer dit vergelyk word met die resultate wat in soortgelyke studies gevind is. Behalwe vir die Enterobacteriaceae-tellings wat

betekenisvol tussen die drie groepe van besoekers verskil het (Groep 1: onder normal; Groep 2: normaal en Groep 3: bo normaal) en die Totale Lewensvatbare Tellings wat tussen die twee ventilasiegroepe (Groep 1: suigwaaier en lugversorger en Groep 2: suigwaaier of lugversorger of waaier) verskil het, kon geen statisties betekenisvolle verskille tussen die bioaërosol-tellings en die geselekteerde fisiese parameters van die delikatesse-afdelings gevind word nie. Die voorkoms van organismes kon daarom eerder met omgewingsinvloede verband gehou het as aspekte soos die tipe lugversorging, temperatuur en die aantal besoekers. Die enigste interaksies tussen mikrobiota en die praktyke van voedselhanteerders was met betrekking tot Enterobacteriaceae-tellings aan voorskote tussen respondente wat opleiding in persoonlike higiëne ontvang het en diegene wat nooit opleiding ontvang het nie en tussen respondente wat opleiding in algemene higiëne ontvang het en die wat nooit opleiding ontvang het nie. Onbeduidende tellings van *Escherichia coli* is regdeur die studie gevind.

Om saam te vat: onvoldoende opleiding mag 'n groter risiko inhou ten opsigte van voedselveiligheid as geen opleiding nie en die Codex Alimentarius, (1997) skryf voor dat slegs opgeleide personeel toegelaat mag word om in die delikatesse te werk. Diensverskaffers moet geloofwaardig wees met betrekking tot interne of eksterne opleidingskursusse en 'n diens van hoë kwaliteit lewer. Die aantal voedselhanteerders wat 'n spesifieke skof werk moet afgewissel word ooreenkomstig die aantal kliënte wat die afsetgroep besoek sodat higiëne praktyke nie benadeel word nie. Dit word verder aanbeveel dat uitsuigwaarers en lugversorgers in afsetgroepe gebruik word en dat 'n positiewe lugvloei gehandhaaf word vanaf die delikatesse-afdelings uitwaarts. Omgewingsreguleringsmeganismes moet aangepas word om die bioaërosol-tellings te minimaliseer en lug-inlate moet so geplaas word dat die inlaat van gekontamineerde

lug vermy word. Lugmonitering, tesame met ander roetine mikrobiologiese analises, moet op ten minste 'n ses-maandelikese basis uitgevoer word om te verseker dat ventilasie sisteme effektief is. Laastens word aanbeveel dat die afsetgroepe beleide en prosedures met betrekking tot lug kontrole in hoë risiko areas daarstel en onderhou.

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CHAPTER 1

INTRODUCTION

1.1 BACKDROP TO THE SOUTH AFRICAN RETAIL INDUSTRY WITH REFERENCE TO FOOD

The food industry in South Africa is partly a reflection of the country's major agricultural activities and partly a reflection of the existence of a sophisticated though smallish First World economy contained within a larger Third World one. The South African food industry boasts a market capitalisation of 24 food manufacturing companies quoted on the Johannesburg Stock Exchange, worth *circa* R30 billion (Mbendi, 2003). Expansion into international markets dictates current trends and serves as a strategy to expand outside of low growth markets, to gain access to rand-hedged earnings and to leverage local expertise and competencies in foreign markets. Popular export destinations include the Middle East and regions in Africa, mainly due to similarities to the African market, proximity and the possibility of higher earnings (Ernst and Young, 2003).

According to trade sources the South African retail market is dominated by five major retail groups, accounting for over half of the retail sector: OK Bazaars, Pick 'n Pay, Shoprite Checkers, Spar Group and Woolworths. These retail groups obtain most of their supplies from manufacturers inside South Africa, although they usually import at least some of their stock, depending on the products concerned (Kortbech-Olesen, 1997). Constant competition exists amongst retail outlets in order to provide food that is not only high in quality, but also safe and wholesome. Recent extortionist and terrorist threats highlight the realities of food tampering, but although the technology to prevent or identify such tampering of foodstuffs exists, related additional costs would have to be borne by the consumer, which is not feasible in the majority of developing countries (Wilson, 2003).

In the food industry, the increase in sales densities (sales/m^2) has been predominantly inflation driven, with little actual growth in trading volumes per m^2, and in order to maintain profitable growth, food retailers have begun to expand outside of their traditional income groups. For example, Pick 'n Pay is expanding its offering to attract both high (higher margin, ready-to-eat meals) and low (through rural acquisitions) end consumers; Spar has expanded its supermarket brand (Super Spar) to compete more directly with Pick 'n Pay; Shoprite is rebranding its Checkers chain to compete head-on for Pick 'n Pay's core mid-market consumer and Woolworths Food is looking to refocus its efforts to capture consumers from a wider income spectrum (Ernst and Young, 2003).

Retailing in South Africa is increasingly evolving into a dynamic industry, driven by changes in technology, saturating markets and globalisation. The future challenge therefore to the South African retail sector will be to promote profitable growth amidst an increasingly competitive market (Ernst and Young, 2003). According to Wilson (2003), investment in innovation is a critical success factor and producers need to follow and meet the changing demands of the market. In South Africa examples of this include a shift to convenience foods, and a rise in the purchase of particularly ready-to-eat foods is currently experienced. The majority of retail outlets have a separate section called the "delicatessen" which is a prominent area in the outlet where ready-to-eat foods are prepared, displayed and handled by food handlers. Figure 1.1 shows the layout of a typical delicatessen section with food preparation and food display areas where ready-to-eat foods are offered. Depending on the size of the retail outlet, a variety of hot foods are available, for example beef with gravy, chicken, fish and chips, rice, vegetables and salads (refer to Appendixes).

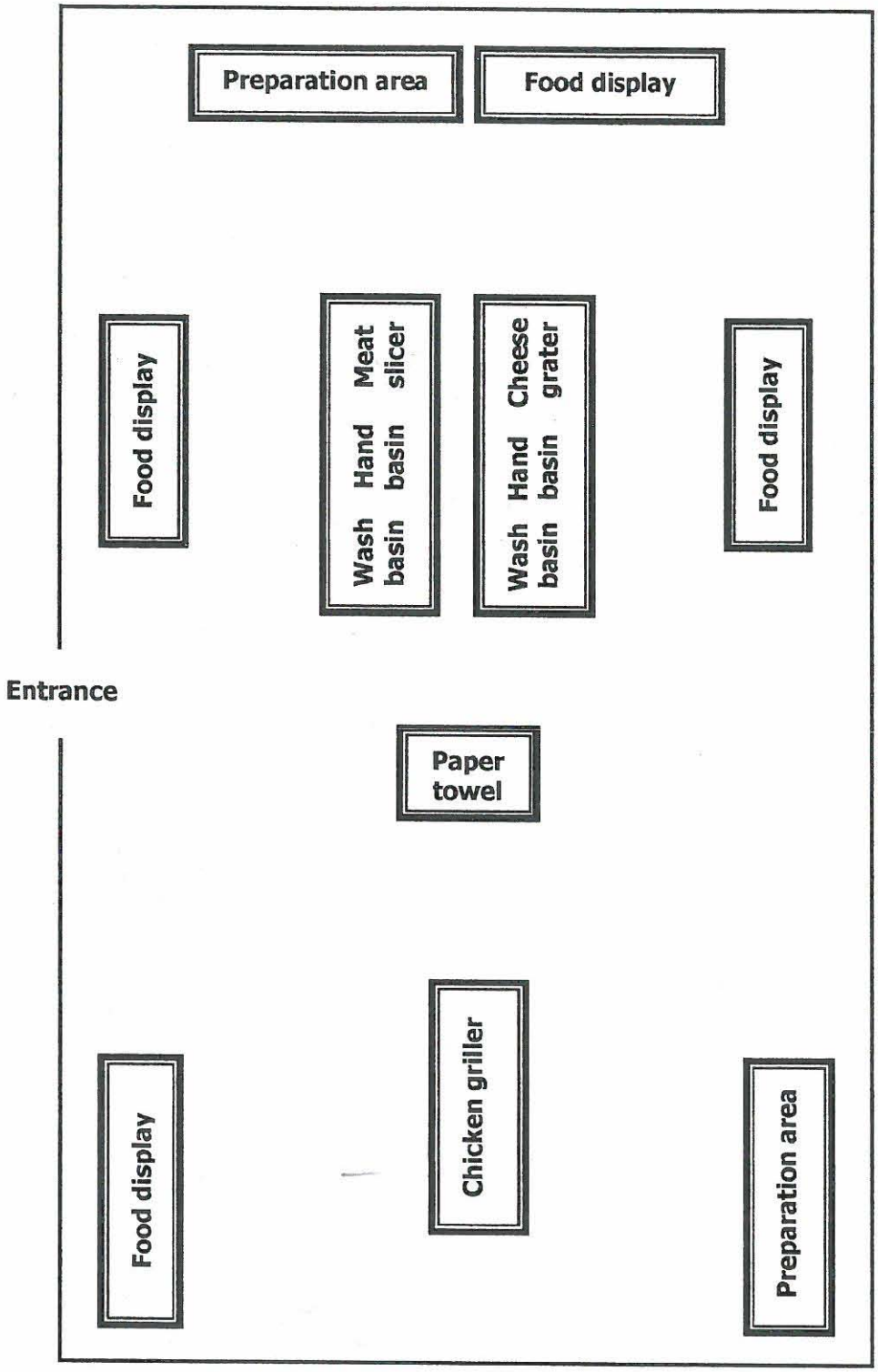

Figure 1.1 Schematic representation of the layout of a typical delicatessen section

1.2 RELEVANT ORGANISMS RELATED TO PROCESS HYGIENE AND FOOD HANDLER PRACTICES

According to Moore and Griffith (2002), in the majority of food processing environments the conditions necessary for microbial proliferation are nearly always present and the main purposes of ensuring high standards of cleanliness are to maintain shelf-life, limit contamination and to protect consumer health. The assessment of indicator organisms is a handy tool in obtaining a measure of the levels of contamination of particular foodstuffs as well as the presence of pathogens. Furthermore, indicator organisms shed light on particular sites of contamination and food handling malpractices, as these organisms are associated with specific conditions and environments. Indicator microbiota often used in the food industry include Total Viable Counts (TVC), Total Coliforms, *Escherichia coli*, members of the family Enterobacteriaceae and *Staphylococcus aureus* (Department of Health, 2000 b).

1.2.1 Total Viable Counts

Counts of viable bacteria are commonly based on the number of colonies that develop under aerobic conditions on basal media such as nutrient agar. Basal media do not contain any inhibitors or indicators and are mainly used to determine the total microbial content in products or on other materials and surfaces (Martley *et al.*, 1970). According to the Health Regulations (Republic of South Africa, 1999) and the Code of Practice: Food Hygiene Management (SABS 049, 2001), a surface shall be cleaned and washed before food comes into direct contact with it and as and when necessary, during and/or immediately after the handling of food so that

contamination of the food that comes into contact with such a surface is prevented. Such a surface shall, before food comes into direct contact with it, contain no more than 100 viable micro-organisms per cm^2 upon analysis, conducted in accordance with acknowledged micro-biological methods (Republic of South Africa, 1999).

1.2.2 Total Coliforms, *Escherichia coli* and members of the family Enterobacteriaceae

The presence of enteric bacteria, for example Coliforms and *Escherichia coli*, has been widely accepted as an indicator of faecal contamination. Coliforms are commonly used as a means of assessing the adequacy of sanitation and substantial numbers of *E. coli* in foods suggest a general lack of cleanliness in food handling (Department of Health, 2000 b). Coliforms are Gram-negative asporogenous rods and since *E. coli* is more indicative of faecal pollution (and enteric pathogens), it is often desirable to determine its incidence in a coliform population (Jay, 1996). An important reservoir of *E. coli* is the intestinal tract of humans and animals and *E. coli* strains can cause various forms of intestinal infection such as dysentery-like diarrhea (Krieg and Holt, 1984; Department of Health, 2000 b; Gorman *et al*, 2002).

The family Enterobacteriaceae include the genera *Escherichia*, *Shigella*, *Edwardsiella*, *Salmonella*, *Citrobacter*, *Klebsiella*, *Enterobacter*, *Serratia*, *Proteus*, *Morganella*, *Providencia* and *Yersinia* (Krieg and Holt, 1984; Holt *et* al, 1994; Nel *et al.*, 2004). *Salmonella* occurs worldwide, its primary habitat is the intestinal tract of humans and animals and it can also cause food-borne disease (Department of Health, 2000 b). Enterobacteriaceae are distributed worldwide where they are found in soil, water, fruits, vegetables, grains, flowering plants and trees, as well as in animals from

insects to man. They have been reported to be responsible for about 50% of nosocomial infections (Krieg and Holt, 1984). These micro-organisms can generally be described as Gram-negative straight rods, are motile by peritrichous flagella and grow in the presence or absence of oxygen (Krieg and Holt, 1984).

1.2.3 *Staphylococcus aureus*

Micro-organisms on human skin can be divided into two groups, namely permanent and transitory, and the only pathogenic micro-organism amongst the permanent group is *Staphylococcus aureus* (Ayçiçek *et al.*, 2004). *Staphylococcus aureus*, one of three pathogenic species of the Gram-positive cocci, are ubiquitously distributed throughout man's environment and are often found as part of the normal microflora of the human skin, the upper respiratory and intestinal tracts (Krieg and Holt, 1984; Genigeorgis, 1989; Bachert *et al.*, 2002). Transmission of the organism is frequently achieved by direct contact with an infected individual, although it may also be airborne (Bachert *et al.*, 2002). Strains present in the nose can contaminate the back of hands and fingers and therefore nasal carriers can easily become skin carriers (Genigeorgis, 1989). The presence of *S. aureus* in large numbers is in general a good indication of poor hygiene (Department of Health, 2000 b). *Staphylococcus aureus* is a bacteria predominantly involved in food-borne diseases and a leading cause of gastroenteritis resulting from the consumption of contaminated food (Le Loir *et al.*, 2003). They are Gram-positive, facultative anaerobes and are spherical single or paired cocci, sometimes forming grape-like clusters (Holt *et al.*, 1994; Le Loir *et al.*, 2003).

1.3 LEGISLATION AND GOVERNANCE CONCERNED WITH THE RETAIL FOOD INDUSTRY IN SOUTH AFRICA

1.3.1 Food safety control and legislation

Because of concerns about food-borne illnesses, both the food industry and the regulators have been compelled to develop new methods of ensuring food safety and compliance with health codes (Raval-Nelson and Smith, 1999). However, with the exception of Total Viable Counts, no guidelines or legislation yet exist in South Africa regarding acceptable levels of indicator organisms on surfaces used in food handling.

a) The Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972)

All foodstuffs manufactured, processed or sold in South Africa, as well as those imported into South Africa, are governed by the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972) from a human health perspective and safety control point of view (Republic of South Africa, 1972; Department of Health, 2000 b). This act in addition empowers the Director General of the Department of Health to order that imported foodstuffs that are contaminated be confiscated and destroyed, returned to port of shipment or place of origin, be imported on certain conditions or be dealt with in a specific manner (Department of Health, 2000 c).

This act furthermore deals with aspects such as the declaration of perishable foodstuffs; preservatives and antioxidants; emulsifiers, stabilisers and thickeners and the amounts thereof that foodstuffs may contain; labelling and advertising of

foodstuffs; duties of inspectors and analysts; food colourants; milk and dairy products; microbial standards for foodstuffs, etcetera.

b) The Health Act, 1977 (Act 63 of 1977)

The Health Regulations (Regulation 918 of 1999) promulgated under the Health Act (Act 63 of 1977) govern the general hygiene requirements for food premises and the transportation of food (Republic of South Africa, 1977; Republic of South Africa, 1999). This act prescribes the standards and requirements for food premises, including the requirement of effective ventilation to facilitate the addition of adequate fresh air to and the effective removal of polluted or stale air from the food handling area, to the extent that air contaminants that could contaminate food, as well as vapours, steam and warm air that may arise during the handling of food, are effectively removed. It furthermore deals with the standards and requirements for facilities on food premises as well as protective clothing and duties of food handlers and persons in charge of a food premises regarding personal and general hygiene and training.

c) Regulations relating to the application of the Hazard Analysis Critical Control Point system (Regulation 908 of 2003) promulgated under the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972)

The Hazard Analysis and Critical Control Point (HACCP) concept evolved to compensate for the shortcomings of the traditional approaches to food protection and places an emphasis on prevention rather than cure (Bryan, 1999). According to the South African Regulations relating to the application of the HACCP system, such

a system should be fully implemented in any food handling premises to the satisfaction of the relevant authorities (Republic of South Africa, 2003). Critical control points (CCP's) in food-processing operations are the key points in the process that shall be controlled to safeguard the health of the consumer (SABS 049, 2001). The use of food safety management systems such as HACCP has resulted in an increased awareness and understanding within the food industry of the risks associated with microbial contamination. However, microbial contaminants are likely to continue to be a major hazard associated with food production because the effective implementation of quality assurance and safety programs such as HACCP is dependant on time, competency and standardisation (Moore and Griffith, 2002).

d) The South African Bureau of Standards

Food hygiene management in South Africa benefits considerably from codes of practice (standards) developed by the South African Bureau of Standards. Such a standard (SABS 049) covers aspects relating to the hygienic handling of food and beverages for human consumption, in order to ensure a safe, sound and wholesome product (SABS 049, 2001). The standard includes, amongst others, a comprehensive guideline addressing aspects such as plant design, cleaning and disinfecting of facilities, sanitation, food safety, hygiene of personnel, training, the involvement of management, pest control, ventilation and air quality.

e) Codex Alimentarius

The Codex Alimentarius, also used in South Africa, is a collection of internationally adopted food standards presented in a uniform manner and implementing the Joint

FAO/WHO Food Standards Programme, with the purpose of protecting the health of consumers and to ensure fair practices in the food trade (Codex Alimentarius, 1997). The document, amongst others, contains requirements for food premises such as the design and layout, personnel hygiene facilities and toilets, and air quality and ventilation. It also emphasises the use of cleaning programmes and pest control systems and furthermore deals with matters such as illness and injuries, personal hygiene and training.

1.3.2 The role of local authorities in food safety control

The statutory mandate of local authorities related to food control is derived firstly from the authorisation of individual local authorities by the Minister of Health to enforce the provisions of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972) and secondly the Health Act, 1977 (Act 63 of 1977). The activities of local authorities related to food safety control generally pivot around the following:

- Law enforcement based on inspections of food premises and sampling of foodstuffs.
- Health education of food processors, handlers and consumers.
- Advising existing and prospective entrepreneurs on requirements related to food premises and the safe handling of food.
- Controlling of illegally imported foodstuffs offered for sale within allocated areas of jurisdiction.
- Investigating and introducing appropriate control measures with regard to all incidences of food-borne diseases which come to their attention.
- Investigating and taking remedial action concerning all food safety related complaints received.

- Certification of foodstuffs destined for export according to the national guidelines provided by the Directorate: Food Control for this purpose.

1.3.3 The role of the National Department of Health

The National Department of Health in South Africa (Directorate: Food Control) is directly responsible for all matters related to food safety control at a national level and addresses this through the following broad objectives within the Health Sector Strategic Framework's Ten Point Plan (2000-2005) (Department of Health, 2000 c):

- To protect consumers and facilitate trade by preparing and administering food legislation, regulations, policy documents and guidelines that are in line with international standards.
- To ensure safe food intake as well as compliance with legal requirements by exposure studies and monitoring/auditing programmes.
- To promote the health of people by informing and educating consumers, industry and law enforcers.
- To ensure that the Department of Health fulfils its obligation as National Contact Point of the Codex Alimentarius Commission.
- To participate in the development of new food control systems for the country.

1.4 CONSUMER KNOWLEDGE AND AWARENESS REGARDING FOOD SAFETY

The majority of consumers don't give much thought to food safety until a food-related illness prompts concern (Hingley, 1997). Previous investigations indicate that consumers do not always take the necessary precautions to reduce risks of food-

borne diseases and that they do not fully understand the hazards relating to food-borne contamination (Altekruse *et al.*, 1998). There is considerable debate about factors responsible for the increase in food-borne diseases and the role of producers, manufacturers and consumers in food safety (Worsfold and Griffith, 1995).

A food handler may be defined as any person who directly handles packaged or unpackaged food, food equipment and utensils, or food contact surfaces (Codex Alimentarius, 1997) whilst food handling is described as any operation in the growing, harvesting, preparation, processing, packaging, storage, transportation, distribution and sale of food (SABS 049, 2001). Food handlers have a key responsibility in the prevention of food poisoning during food production and distribution (Walker *et al.*, 2003). One of the major risks of food contamination originates from the working practices of food handlers and disease-causing micro-organisms present in or on the food handler's body that are subsequently transported from the food handler to the food during the handling process (Gordon-Davis, 1998).

According to Le Loir *et al.* (2003) food-borne diseases are defined as "diseases of infectious or toxic nature caused by, or thought to be caused by the consumption of food or water". Food-borne diseases are of major concern worldwide and represent a very large group of pathologies with a detrimental impact on the health of the population (Le Loir *et al.*, 2003; Legnani *et al.*, 2004). The fact that little consideration is sometimes given to food-borne diseases due to the fact that their symptoms are often moderate and self-limiting, has led to a general underestimation of their importance, and consequently to incorrect practices during preparation,

resulting in the frequent occurrence of outbreaks involving groups of varying numbers of consumers (Legnani *et al.*, 2004).

Diseases caused by contaminated food remain one of the leading causes of morbidity in several countries and despite continuing progress made in food quality and safety, several food-borne disease outbreaks have been reported in literature (Angelillo *et al.*, 2000). In South Africa there is currently a lack of information on the occurrence of food-borne diseases and the numbers reported do not reflect actual occurrences, since notification is required only when five or more cases are reported by one physician. Furthermore, in South Africa, a need exists to quantify the situation regarding food-borne diseases as well as to verify the necessity for the implementation of methods to prevent and control outbreaks (Nortjé *et al.*, 1999).

A study done in the United States of America suggested that improper food handling practices contributed to approximately 97% of food-borne illnesses in food-service establishments (Howes *et al.*, 1996). In the United Kingdom, cross-contamination has been identified as an important contributing factor in 39% of general food-borne disease outbreaks (Moore *et al.*, 2001). In 1997, of a global total of 52.2 million deaths, 17.3 million were attributable to infectious and parasitic diseases, of which diarrhoea was responsible for 2.5 million deaths (WHO, 1998). To date, *circa* 250 different food-borne diseases have been described, and bacteria are the causative agents of two thirds of food-borne disease outbreaks (Le Loir *et al.*, 2003). In the United States of America, current estimates of the number of cases of food-borne illness range upward from 80 million cases annually, including more than 9 000 deaths (Hingley, 1997; Daniels, 1998).

Air quality should also be emphasised as a contributor to food contamination because of the possibility of microbiological distribution (Cundith *et al.*, 2002). High bioaerosol concentrations consisting of spoilage microbiota in the food processing environment have been reported to reduce the quality and shelf-life of foodstuffs (Shale *et al.*, 2004). Several routes of contamination exist: surface contact, personnel and recontamination of food products via the air have all been shown to cause food-borne illness and/or spoilage of foods (Den Aantrekker *et al.*, 2003; Ammor *et al.*, 2004). Adequate means of natural or mechanical ventilation should be provided in order to minimise air-borne contamination of food and to control ambient temperatures (Codex Alimentarius, 1997).

The deaths, time lost due to illness and even the gastrointestinal discomfort for those who experience mild food poisoning, make it overwhelmingly important that everything possible be done to minimize food-borne illness (Daniels, 1998).

1.5 HIV/AIDS AND FOOD SAFETY

In South Africa, statistics based on the 1999 Antenatal HIV Survey suggested that about 10% of the population are HIV positive (Department of Health, 2000 a). In assessing the potential impact of food-borne disease, it is important to recognise that individuals who are immuno-compromised, such as those suffering from AIDS, infants, young children, pregnant women, and the elderly, are prone to infections and might be at greater risk of serious illness than the general population (Department of Health, 2000 a; Martínez-Tomé *et al.*, 2000). In people whose immune systems are comprised, food-borne disease might result in severe illness and could even cause death (Department of Health, 2000 a). Therefore, the food

handler's knowledge of good manufacturing practice is one of the most important factors in obtaining good hygiene and quality in food preparation. It is furthermore crucial that food handlers be equipped with knowledge of personal hygiene practices as hands have been identified as the main agents for cross-contamination within a food handling establishment (Gordon-Davis, 1998; Mortlock *et al.*, 1999).

In the retail industry, HIV/AIDS is also a serious issue as it impacts on a number of fronts: on the size of the market; employees (their health, performance and cost to the company); and suppliers (cost and efficiencies). This multi-faceted impact makes it a complex issue for all retailers and legislation is expected to take it a step further with guidelines towards quantifying and reporting on the impact of the disease in companies (Ernst and Young, 2003).

1.6 RATIONALE

In order to ensure that staff members conform to personal hygiene requirements, two issues should, according to Johns (1991), be considered: (1) the environment within which the staff operates; and (2) the "quality" of the staff members. From a food hygiene point of view, the working environment depends on the facilities provided, which include aspects such as toilets and protective clothing. The quality of staff, in turn, depends upon their health, hygiene and habits. Evidence exists from the food industry that transient micro-organisms are transferred to the hands during the process of handling food such as meat and poultry, and also through poor personal hygiene after, for example, visiting the toilet. Such practices could, for example, result in the hands being heavily contaminated with enteric pathogens (Taylor *et al.*, 2000). Compliance could be achieved by engaging only staff qualified

in food hygiene or by ensuring that new and inexperienced staff are given food hygiene training prior to taking up their duties (Worsfold and Griffith, 2003). However, uncertainty still exists regarding the efficacy of current food hygiene training because, according to Tebbutt (1992) and Clayton *et al.* (2002) poor training has been shown to be linked to increased health risk.

In addition to surface and food analysis, bioaerosol monitoring should be a routinely measured parameter in food processing industries aimed at assessing the potential exposure of the public and workers to airborne micro-organisms (Griffiths and DeCosemo, 1994).

The aims of this study are therefore:

- to evaluate the personal and general hygiene practices of food handlers in the delicatessen sections of a prominent retail group in South Africa and to assess their level of training and knowledge regarding safe food handling;

- to enumerate the occurrence of indicator organisms including Total Viable Counts, Total Coliforms, *Escherichia coli*, members of the family Enterobacteriaceae and *Staphylococcus aureus* on the hands and the aprons of food handlers and to evaluate the results against legislation in South Africa or microbial target values such as infective doses reported in literature;

- to quantify the airborne microbial populations in delicatessen sections in order to shed light on their occurrence and distribution in the air as well as their relationship to ventilation; and

- to assess the nature and extent of relationships that may exist between microbiota and food handler practices in the delicatessen sections.

It is envisaged that this cross-sectional study may cast light on the possible sources of contamination of food and the managerial aspects related to it, the level of hygiene of food handlers as well as personal and general hygiene training and the possible linkages between training and food handler practices in order to ensure improvement in quality, safety and wholesomeness of food products. Data generated through this study should provide invaluable information to be used by the management of the retail group as well as auditing bodies and environmental health practitioners in attempts to optimise process and personal hygiene. Finally, being able to market the fact that the group is involved in research and development in attempts to improve quality and safety, should contribute to a competitive advantage for the group studied amongst its main rivals in the retail industry.

1.7 REFERENCES

Altekruse, S.F., Timbo, B.B., Mowbray, J.C., Bean, N.H., and Potter, E. (1998) Cheese-associated outbreaks of human illness in the United States, 1973 to 1992: sanitary manufacturing practices protect consumers. *Journal of Food Protection, 61*, 1405-1407.

Ammor, S., Chevallier, I., Laguet, A., Labadie, J., Talon, R. and Dufour, E. (2004). Investigation of the selective bacterial effect of several decontaminating solutions on bacterial biofilms including useful, spoilage and/or pathogenic bacteria. *Food Microbiology, 21(1)*, 11-17.

Angelillo, I.F., Viggiani, N.M.A., Rizzo, L. and Bianco, A. (2000). Food handlers and food-borne diseases: knowledge, attitudes, and reported behaviour in Italy. *Journal of Food Protection, 63(3),* 381-385.

Ayçiçek, H., Aydoğan, H., Küçükkaraaslan, A., Baysallar, M. and Başustaoğlu, A.C. (2004). Assessment of the bacterial contamination on hands of hospital food handlers. *Food Control, 15,* 253-259.

Bachert, C., Gevaent, P. and Van Cauwenberge, P. (2002). *Staphylococcus aureus* enterotoxins: a key in airway disease? *Allergy, 57*, 480-487.

Bryan, F.L. (1999). Hazard Analysis Critical Control Point approach to food safety. *Environmental Health, 61,* 9-14.

Clayton, D.A., Griffith, D.J., Price, P. and Peters, A.C. (2002). Food handlers' beliefs and self-reported practices. *International Journal of Environmental Health Research, 12*, 25-39.

Codex Alimentarius. (1997). *Food hygiene: Basic Texts.* Rome.

Cundith, C.J., Kerth, C.R., Jones, W.R., McCaskey, T.A. and Kuhlers, D.L. (2002). Air-cleaning system effectiveness for control of airborne microbes in a meat-processing plant. *Journal of Food Science, 67(3),* 1170-1174.

Daniels, R.W. (1998). Home food safety. *Food Technology, 52(2)*, 54-56.

Den Aantrekker, E.D., Boom, R.M., Zwietering, M.H. and Van Schothorst, M. (2003). Quantifying recontamination through factory environments – a review. *International Journal of Food Microbiology, 80(2),* 117-130.

Department of Health, South Africa. (2000 a). Food for thought. Directorate: Food Control. Government Printer, Pretoria.

Department of Health, South Africa. (2000 b). Guidelines for environmental health officers on the interpretation of microbiological analysis data of food. Directorate: Food Control. Government Printer, Pretoria.

Department of Health, South Africa. (2000 c). Information Document: Role and responsibility of the public health sector in South Africa regarding food safety control. Directorate: Food Control. Government Printer, Pretoria.

Ernst and Young. (2003). Retail and consumer products. Available: www.ey.com/global/downlads.nsf/South_Africa/Jun03_SA_Retail_Industry/$file/S.A.%20Retail%20Industry%20June%202003.pdf Accessed 2004-10-22.

Genigeorgis, C.A. (1989). Present state of knowledge on staphylococcal intoxication. *International Journal of Food Microbiology, 9,* 327-360.

Gordon-Davis, L. (1998). *The hospitality industry handbook on hygiene and safety: for South African students and practitioners.* Kenwyn: Juta.

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

Griffiths, W.D. and DeCosemo, G.A.L. (1994). The assessment of bioaerosols: a critical review. *Journal of Aerosol Science, 25(8),* 1425-1458.

Hingley, A. (1997). Focus on food safety. *FDA Consumer, 31(6),* 8-11.

Holt, G.H., Krieg, N.R., Sneath, P.H.A., Staley, J.T. and Williams, S.T. (1994). *Bergey's manual of determinative bacteriology.* Williams and Wilkens, Baltimore.

Howes, M., McEwen, S., Griffiths, M. and Harris, L. (1996). Food handler certification by home study: measuring changes in knowledge and behaviour. *Dairy, Food and Environmental Sanitation, 16,* 737-744.

Jay, J.M. (1996). *Modern food microbiology.* (5th ed.) New York: Van Nostrand Reinhold.

Johns, N. (1991). *Managing food hygiene.* Houndmills and London: The Macmillan Press Ltd.

Kortbech-Olesen, R. (1997). Report from the African buyers/sellers meeting: The South African Market for Food and Beverages. Available: www.intracen.org/sstp/doc/report/byslr.htm Accessed 2004-10-22

Krieg, N.R. and Holt, J.G. (1984). *Bergey's manual of systematic bacteriology.* Volumes 1 and 2. Williams and Wilkens, Baltimore.

Legnani, P., Leoni, E., Berveglieri, M., Mirolo, G. and Alvaro, N. (2004). Hygienic control of mass catering establishments, microbial monitoring of food and equipment. *Food Control, 15(3),* 205-211.

Le Loir, Y., Baron, F. and Gautier, M. (2003). *Staphylococcus aureus and* food poisoning. *Genetics and Molecular Research, 2(1),* 63-76.

Martínez-Tomé, M., Vera, A.M. and Murcia, M.A. (2000). Improving the control of food production in catering establishments with particular reference to the safety of salads. *Food Control, 11,* 437-445.

Martley, F.G., Jayashankar, S.R. and Lawrence, R.C. (1970). An improved agar medium for the detection of proteolytic organisms in total bacterial counts. *Journal of Applied Bacteriology, 33*, 363-370.

Mbendi – Information for Africa. (2003). Overview of South African food industry. Available: www.mbendi.co.za/indy/tdbt/at/sa/p0005.htm Accessed 2003-05-15.

Moore, G. and Griffith, C. (2002). A comparison of surface sampling methods for detecting Coliforms on food contact surfaces. *Food Microbiology, 19*, 65-73.

Moore, G., Griffith, C. and Fielding, L. (2001). A comparison of traditional and recently developed methods for monitoring surface hygiene within the food industry. A laboratory study. *Dairy, Food and Environmental Sanitation, 21(6)*, 478-488.

Mortlock, M.P., Peters, A.C. and Griffith, C.J. (1999). Food hygiene and hazard analysis critical control point in the United Kingdom food industry: practices, perceptions and attitudes. *Journal of Food Protection, 62(7)*, 786-796.

Nel, S., Lues, J.F.R., Buys, E.M. and Venter, P. (2004). Bacterial population associated with meat from the deboning room of a high throughput red meat abattoir. *Meat Science, 66,* 667-674.

Nortjé, G.L., Vorster, S.M., Greebe, R.P. and Steyn, P.L. (1999). Occurrence of *Bacillus cereus* and *Yersinia enterocolitica* in South African retail meats. *Food Microbiology, 16,* 213-217.

Raval-Nelson, P. and Smith, P.M. (1999). Food safety certification and its impacts. *Environmental Health, 61,* 9-12.

Republic of South Africa. (1972). Foodstuffs, Cosmetics and Disinfectants Act, No. 54 of 1972. Government Printer, Pretoria.

Republic of South Africa. (1977). Health Act, No. 63 of 1977. Government Printer, Pretoria.

Republic of South Africa. (1999). Regulation 918 of 1999: Health Regulations governing general hygiene requirements for food premises and the transport of food, promulgated under the Health Act No. 63 of 1977. Government Printer, Pretoria.

Republic of South Africa. (2003). Regulation No. R.908 of 2003: Regulations relating to the application of the Hazard Analysis and Critical Control Point system (HACCP system), promulgated under the Foodstuffs, Cosmetics and Disinfectants Act, No. 54 of 1972. Government Printer, Pretoria.

SABS 049. (2001). South African Bureau of Standards, Code of Practice: Food Hygiene Management (3rd ed.). Pretoria.

Shale, K., Lues, J.F.R., Buys, E. and Venter, P. (2004). The distribution of staphylococci bioaerosols from red meat abattoirs. *Food Microbiology, 22,* 433-438.

Taylor, J.H., Brown, K.L., Toivenen, J. and Holah, J.T. (2000). A microbiological evaluation of warm air hand driers with respect to hand hygiene and the washroom environment. *Journal of Applied Microbiology, 89,* 910-919.

Tebbutt, G.M. (1992). An assessment of food hygiene training and knowledge among staff in premises producing or selling high-risk foods. *International Journal of Environmental Health Research, 2,* 131-137.

Walker, E., Pritchard, C. and Forsythe, S. (2003). Food handlers' hygiene knowledge in small food businesses. *Food Control, 14,* 339-343.

WHO (1998). The World Health Report: life in the 21st century: a vision for all. World Health Organisation, Geneva.

Wilson, M. (2003). South African food and drink industry. Available: www.ey.com/global/download.nsf/South_Africa/retail_industry_food_drink/$file/retail_industry_food_drink.pdf Accessed 2004-10-22.

Worsfold, D. and Griffith, C. (1995). A generic model for evaluating consumer food safety behavior. *Food Control, 6,* 357-363.

Worsfold, D. and Griffith, C.J. (2003). A survey of food hygiene and safety training in the retail catering industry. *Nutrition and Food Science, 33(2),* 68-79.

CHAPTER 2

THE PERSONAL AND GENERAL HYGIENE PRACTICES OF FOOD HANDLERS IN THE DELICATESSEN SECTIONS OF A PROMINENT RETAIL GROUP

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2.1 ABSTRACT

The purpose of this study was to present data on the personal and general hygiene knowledge and practices of food handlers in a retail group as well as their level of training in personal and general hygiene. In this survey, food handlers in the delicatessen sections of retail outlets were interviewed by means of a structured questionnaire. The study was performed amongst a representative sample of outlets belonging to a prominent retail group in the Western Cape. Although the majority of food handlers adhered to basic hygiene principles, the results highlighted a need for proper and continuous training in personal and general hygiene, not only for food handlers, but also for management. Reporting of illnesses and injuries to management and management's response to such incidents as well as the wearing of jewellery and dressings that are not moisture-proof and having long fingernails, emanated as issues of concern. Furthermore, all food handlers should adhere to a formal cleaning schedule. This study is of importance particularly in the view of new local regulations governing the application of the Hazard Analysis and Critical Control Point (HACCP) system. Management is responsible for the implementation of this system and where supervision is not adequate, the manager of the outlet should intervene to ensure that staff conform to the requirements.

Keywords: Hygiene practices, food handler, retail.

2.2 INTRODUCTION

The continuing high incidence of food-borne illnesses has made food safety a global concern and the potential for food handlers to act as vectors in the transmission of food-borne disease remains significant (Paulson *et al.*, 1999). Indicator organisms such as Total Viable Counts (TVC), Total Coliforms, *Escherichia coli*, Enterobacteriaceae, and *Staphylococcus aureus* have been used universally to determine the conditions to which foodstuffs are exposed during handling (Department of Health, 2000 a). *Salmonella* and *S. aureus* have been associated with food-borne illnesses for decades and typical symptoms of staphylococcal food poisoning had already been described in 1936 (Borch and Arinder, 2002). Several food-borne disease outbreaks associated with poor personal hygiene of persons handling foodstuffs and also as a result of cross-contamination have been reported in the literature (Bryan, 1988; Altekruse, 1998; Parish, 1998; Vought and Tatini, 1998; Shapiro *et al.*, 1999). *Escherichia coli* 0157:H7 outbreaks in the United States led to the tragic deaths of four children in 1993 (Knabel, 1995). Food handlers have a major role to play in the prevention of food poisoning during the production and distribution of food: if their level of personal hygiene is lacking, they furthermore may cross-contaminate raw and processed foodstuffs and could be asymptomatic carriers of food poisoning organisms (Walker *et al.*, 2003).

Although significant advances in food safety have been made in some countries, inadequate practices and surveillance systems persist in many developing countries (Escartin, 1997) and as a result, food can become microbiologically hazardous to the consumer when the principles of hygiene and sanitation are not adhered to or when it becomes contaminated by pathogens from humans or from the environment

during processing or preparation (Department of Health, 2000 a). The socio-economic impact of food-borne illness includes loss of productivity, loss of income, loss of trade, loss of food as a result of condemnations and ultimately loss of tourism (Department of Health, 2000 b).

As a result of the internationalisation of the South African industry following the removal of sanctions, a growing awareness exists concerning the need to improve quality in order to be more competitive. This is taking place through formalised disciplines such as HACCP, which are replacing the traditional concepts of quality control with its emphasis on end-product monitoring (Mbendi, 2003). According to the South African Regulations relating to the application of the HACCP system (not compulsory to date), no owner of a food handling premises will be allowed to handle food without a HACCP system fully implemented to the satisfaction of the relevant authority (Republic of South Africa, 2003). The provision of food hygiene training to all food handlers should reduce the incidence of food-borne disease significantly (Ehiri and Morris, 1996) and management should ensure that all staff are medically fit, adequately trained in good hygiene practices, behave in such a manner as not to contaminate the food and wear clean, protective clothing when entering or working in the food premises (SABS 049, 2001). Tebbutt (1992) identified correlations amongst management attitude towards training, levels of hygiene knowledge and standards of food handling practice. Food hygiene training is therefore crucial in food safety and is an essential part of the hazard analysis critical control point concept (Walker *et al.*, 2003). Adequate personnel facilities should furthermore be provided and there should be adequate supervision of food handlers (Republic of South Africa, 1999; SABS 049, 2001).

The aim of this study was to cast light on the personal and general hygiene practices of food handlers in the delicatessen sections of a major retail group as well as to investigate their level of training in personal and general hygiene. Because of the constant competition between outlets based on quality, safety and wholesomeness, the results of this study will be available to the management of the outlets in order to assess the need for further training.

2.3 MATERIALS AND METHODS

The management of the retail group granted their permission to conduct interviews with food handlers in the delicatessen sections after a confidentiality agreement was signed between themselves and the interviewer.

2.3.1 Pilot study

The questionnaire was piloted in one outlet and involved six food handlers. This pilot survey was to assess the clarity of the questions and to determine the time requirements, as it was important that the time required for completing the questionnaire was not perceived by the retail outlet managers as disruptive to the normal activities (Walker *et al.*, 2003).

2.3.2 Sampling protocol

An interview, based on a structured questionnaire, was conducted amongst a random selection of food handlers in the delicatessen sections of a major retail group in the Western Cape, South Africa, totalling 35 outlets visited. The target population

represents 50% of food handlers in delicatessen sections of retail outlets which, in turn, constitutes 75% of the total outlets in the Western Cape region. Fifty respondents were interviewed one by one on a once-off basis during working hours (weekdays between 10:00 and 14:00) without previous notification of either the date or the contents of the interview. All the interviews were conducted by the same interviewer to limit variation.

2.3.3 Questionnaire design

A comprehensive questionnaire was compiled with questions designed to obtain information about each food handler's knowledge of personal hygiene, general process hygiene and training (refer to Appendixes). The aim of the survey was clearly stated on the front of the questionnaire and the fact that confidentiality would be preserved was highlighted. Questionnaires were compiled in both Afrikaans and English (these were the predominant languages used by the food handlers) and consisted of a total of 37 questions which included both closed as well as open-ended questions (Coggon, 1995). The structured interview method, as described by Czaja and Blair (1996) and Katzenellenbogen *et al.* (1997), was followed in this survey because of the following advantages: (1) the interviewer was able to follow a well-defined structure which prevented the respondent from own interpretation, (2) respondents with low or no literacy levels could be interviewed and (3) the interviewer could explain questions that were not clear to the respondent.

2.3.4 During the interview

Upon entering the premises, the manager was approached to answer selected questions prior to commencing with the interviews amongst the food handlers. After introducing and explaining the purpose of the study to the food handlers in the delicatessen, assurance was given that the survey was confidential. Care was taken to ensure consistency of approach in conducting the survey in each food premises in order to minimise any influences or subsequent biases in results (Walker & Jones, 2002).

2.3.5 Data analysis

The questionnaires were coded and analysed in collaboration with the Department of Biostatistics, University of the Free State (SAS/STAT, 1989). The results were presented in tables using frequencies and percentages (Nel *et al.*, 2003).

2.4 RESULTS AND DISCUSSION

2.4.1 Status of the food handlers

During the interview, respondents were asked general questions regarding their age (data not shown) and they indicated ranges from 18 to 21 years (18%); 22 to 30 years (32%); older than 30 to 40 years (28%) and older than 40 years (22%). 74% of the respondents had a qualification lower than senior certificate, while 24% had a senior certificate and 2% had a post-school qualification. All the respondents were full-time employees in the delicatessen section of each outlet. With regard to their

experience, 2% of the respondents had less than 3 months' experience, while 14% had more than 6 to 12 months and 84% more than a year's work experience in the delicatessen section.

2.4.2 Hand-washing and hand-drying facilities available in rest rooms

A common cause of food-borne disease outbreaks related to food handlers is the use of bare hands without effective washing. Effective hand-washing by food handlers is therefore an important control measure for preventing transmission of food-borne diseases in food-service establishments (Paulson *et al.*, 1999). Personnel facilities should be adequate to ensure an appropriate degree of personal hygiene as well as to avoid contamination of food (Codex Alimentarius, 1997). According to SABS 049 (2001) hand-washing basins in toilet areas should be supplied with warm/hot and cold water, hand-cleaning preparations should be provided in dispensers and paper towels or air hand-dryers should be provided.

As shown in Table 2.1, 72% of the respondents reported that a hand-washing facility and cold and/or hot water, soap, an air dryer or disposable hand-drying material were available in rest rooms. During the survey, it became evident that at least a hand-washing facility and cold and/or hot water and soap were always available in the rest rooms of all the outlets (Table 2.1).

Table 2.1 Equipment available in rest rooms

	Frequency	Percentage (%) (n=50)
A hand-washing facility and cold and/or hot water and soap	2	4
A hand-washing facility and cold and/or hot water, soap, an air dryer/disposable hand-drying material	36	72
A hand-washing facility and cold and/or hot water, soap, plastic nail brushes and an air dryer/disposable hand-drying material	5	10
A hand-washing facility and cold and/or hot water, soap, plastic nail brushes, disposable hand-drying material and an air dryer	7	14

2.4.3 Practices of food handlers regarding the frequency and means of hand-washing

Epidemiological studies show that one of the factors that often contribute to staphylococcal food poisoning outbreaks is the human carrier who handles foods in food service establishments (García *et al.*, 1986). Humans are a potential source of disease-producing micro-organisms occurring as normal commensuals in certain parts of the body, mainly the hair, nose, mouth, throat, bowels and in sores. These micro-organisms can easily be transferred to the hands that are in contact with such parts of the body during the course of the day. Even blowing one's nose into a handkerchief can contaminate one's hands (SABS 049, 2001). The hands of food handlers should be kept clean and food handlers should avoid direct contact with food where possible (Martínez-Tomé *et al.*, 2000).

Without exception, the respondents indicated that they wash their hands prior to the commencement of each work shift, at the beginning of the day's work or after a rest period, after visiting a latrine or urinal, after handling a handkerchief, money, a refuse container or refuse and after they have smoked or on return to the food premises, while 98% of the respondents washed their hands every time they blew their nose or touched their hair, nose or mouth (Table 2.2). Furthermore, 96% of the respondents washed their hands after handling raw vegetables, fruit, eggs, meat or fish and before handling ready-to-eat food. Food handlers can act as vectors of disease in several ways. For example, food handlers who handle contaminated raw foods or cleaning aids, touch surfaces without washing hands and handle foods that are not further heat-processed, are a probable source of cross-contamination (Paulson *et al.*, 1999).

Table 2.2 Practices of food handlers regarding hand washing

	Frequency	Percentage (%) (*n*=50)
Frequency		
Immediately prior to the commencement of each work shift	50	100
At the beginning of the day's work or after a rest period	50	100
After every visit to a latrine or urinal	50	100
Every time the nose is blown or hair, nose or mouth is touched	49	98
After handling a handkerchief, money, a refuse container or refuse	50	100
After handling raw vegetables, fruit, eggs, meat or fish and before handling ready-to-use food	48	96
After smoking or on return to the food premises	50	100
Under all the circumstances mentioned	47	94
Means of hand-washing		
Cold water, soap and a nailbrush	8	16
Hot water, soap and a nailbrush	22	44
Hot and cold water and soap	20	40
Means of hand-drying		
Disposable hand-drying material	49	98
Apron / clothes	1	2

94% of the respondents washed their hands in all the circumstances mentioned (Table 2.2). According to Lorenzini (1995) and the Health Regulations under the Health Act (Republic of South Africa, 1999) it is the responsibility of food handlers to wash their hands thoroughly with soap and water under all the circumstances.

Regarding the means of hand-washing, 16% of the respondents indicated that they used cold water, soap and a nailbrush, 44% used hot water, soap and a nailbrush, while 40% used hot and cold water and soap (Table 2.2). According to the Health Regulations (Republic of South Africa, 1999) and the Code of Practice: Food Hygiene Management (SABS 049, 2001) a hand-washing facility and hot and/or cold water should be available for the washing of hands on the food premises together with a supply of soap and clean disposable hand-drying material. Disposable hand-drying material was used by 98% of the respondents while 2% used their aprons or clothes for hand-drying. The possibility of cross-contamination is further eliminated when using disposable paper towels (Hobbs and Roberts, 1993).

2.4.4 Practices of food handlers during the preparation of food

Data on risk factors for food-borne diseases indicate that the majority of outbreaks result from faulty food handling practices and a recent study done in the United States of America suggested that improper food handling practices contributed to approximately 97% of food-borne illnesses in food-service establishments and homes (Clayton *et al.*, 2002). Table 2.3 shows that 6% of the respondents kept their fingernails long, while 12% of the respondents wore jewellery. In cases where unprotected food or raw food materials are handled, personnel should remove

Table 2.3 Practices while preparing food

	Frequency	Percentage (%) (n=50)
Keeps fingernails long	3	6
Wears dressings that are not moisture-proof	4	8
Wears jewellery	6	12
Wears jewellery and dressings that are not moisture-proof	2	4
Chews gum and wear dressings that are not moisture-proof	1	2
Does none of the above	34	68

jewellery from their hands and fingernails should be kept short and clean (Republic of South Africa, 1999; SABS 049, 2001).

Upon enquiring from the respondents whether they wore moisture-proof dressings after accidentally cutting themselves, 8% of the respondents indicated that they wore dressings that were not moisture-proof. According to the Health Regulations (Republic of South Africa, 1999) food shall not be handled by any individual who has on his or her body a suppurating sore, cut or abrasion, unless covered by a moisture-proof dressing which is firmly secured to prevent contamination of the food. Only one respondent (2%) chewed gum and wore dressings that were not moisture-proof. Any behaviour that could result in the contamination of food, such as eating and chewing (of gum, sticks and sweets) should be prevented in food-handling establishments (Republic of South Africa, 1999; SABS 049, 2001). Furthermore, two respondents (4%) indicated that they wore jewellery and dressings that were not moisture-proof and thirty-four respondents (68%) reported that they did none of these (Table 2.3).

2.4.5 Practices of food handlers regarding the reporting of illness

Employees suffering from fever, diarrhoea, upset stomach, nausea, vomiting, sore throat, coughing or sneezing should not touch food or clean or sanitise equipment but could be reassigned to non-food-handling duties or should stay at home (Lorenzini, 1995). With regard to diarrhoea, vomiting, fever and coughing, (data not shown), respondents indicated that they never suffered from diarrhoea (92%) and once per year (8%); never vomited (94%) and once per year (4%); never had fever (90%) and once per year (8%) and never coughed (74%) and once per year (14%). Upon being asked whether they ever had a cold or flu, 52% indicated once per year and 6%

indicated that they never suffered from a cold or flu. Furthermore, cut or bruised hands were experienced once per year by 18%; 2 to 5 times per year by 17%; and more than 10 times per year by 6% of the respondents, while 9% never experienced cut or bruised hands (data not shown). According to Cruickshank (1990) during the acute stages of gastroenteritis, large numbers of organisms are excreted and can be widely dispersed. Clearly, food handlers who are symptomatically ill may present a definite hazard and should, ideally, be excluded from work. Such individuals should furthermore be made aware of the need to immediately report illnesses and should be assured that if exclusion is necessary it will not result in loss of employment or wages.

Table 2.4 shows that 90% of the respondents indicated that they report illness to management. Individuals known or suspected to be suffering from or being a carrier of a disease or illness likely to be transmitted through food, should not be allowed to enter any food handling area if there is a likelihood of them contaminating food. Such a person should immediately report illness or related symptoms to management (Codex Alimentarius, 1997; Republic of South Africa, 1999; SABS 049, 2001). Medical examination of a food handler should be carried out if clinically or epidemiologically indicated (Codex Alimentarius, 1997) and a certificate by a medical practitioner stating that such person is fit to handle food should be submitted (Republic of South Africa, 1999). Thirty-seven (82%) of the forty-five respondents who indicated that they report illness to management, reported that management sees to it that they undergo a medical examination and receive sick leave. Furthermore, 7% of the respondents reported that they take sick leave and 4% indicated that they go for a medical examination. Three respondents (7%) reported that no action is taken by management after reporting of illness (Table 2.4).

Table 2.4 Reporting of illness

	Frequency	Percentage (%)
Reporting of illness to management (n=50)		
Yes	45	90
No	5	10
Action taken by management (n=45)		
Medical examination and sick leave	37	82
Only sick leave	3	7
Only medical examination	2	4
No action by management	3	7
Action taken when cut (n=50)		
Report to management and cover with moisture-proof dressing	47	94
Other	3	6

During the survey, it became evident that cuts and/or burns are a common phenomenon amongst food handlers. Forty-seven (94%) of the respondents indicated that they report such an injury to management and cover it with a moisture-proof dressing, while the remaining 6% of the respondents indicated that they do not report to management nor do they cover such injuries with a moisture-proof dressing. Cuts and abrasions should be cleaned using a disinfectant or soap and warm water prior to covering it with a moisture-proof dressing (Lorenzini, 1995).

2.4.6 Practices of food handlers regarding the cleaning and washing of surfaces

The role of contaminated surfaces in transmission of pathogens to food is well-known in food processing and catering (Kusumaningrum *et al.*, 2002). Although inadequate cooking and storage of food is considered to be the main cause of food-borne infection, poor surface hygiene has been shown to be a significant contributory factor (Cogan *et al.*, 2002). An inadequately cleaned surface can, if in contact with food, lead to cross-contamination (Moore *et al.*, 2001). Therefore, for many foods, especially those that are ready-to-eat, the cleanliness of food contact surfaces is likely to be identified as being critical to food safety (Moore and Griffith, 2002).

During this survey, the respondents were enquired as to whether they ever encountered rats, mice, flies or cockroaches in the food-handling areas (data not shown). Results showed that they encountered rats and mice never (64%), daily (4%), weekly (6%), monthly (10%), seasonal (2%) and annually (14%); whilst they encountered flies never (24%), daily (4%) and seasonal (72%); and cockroaches never (66%), daily (10%), weekly (2%), monthly (16%), seasonal by (2%) and

annually (4%). According to the Health Regulations (Republic of South Africa, 1999) a person in charge of a food premises should ensure that effective measures are taken to eliminate flies, other insects, rodents or vermin in food premises. A surface should be cleaned and washed before food comes into direct contact with it for the first time during each work shift, and as and when necessary, during and/or immediately after the handling of food, in order to prevent food contamination due to food contact with any such surface or facility (Republic of South Africa, 1999).

A formal cleaning schedule was used by 90% of the respondents while 10% indicated that they "clean-as-they-go". As indicated in Table 2.5, one respondent (2%) reported that surfaces are only cleaned and washed daily after work is finished whereas another respondent commented that surfaces are cleaned and washed daily before commencing with work, daily after work is finished and during and/or immediately after the handling of food. Two respondents (4%) reported that surfaces are cleaned and washed daily after work is finished, between shifts and during and/or after the handling of food. 92% of the respondents reported that surfaces are cleaned under all the circumstances mentioned. Cold water and detergent were used as a means of cleaning/washing by 22% of the respondents and 78% used hot water and detergent (Table 2.5). According to the South African Health Regulations (1999) a food premises must have a washing-up facility with hot or warm and cold water for the cleaning of facilities. The main purpose of ensuring high standards of cleanliness in food premises entails the maintenance of shelf-life and the protection of consumer health by preventing food contamination (Moore & Griffith, 2002).

Table 2.5 Surfaces cleaned and washed

	Frequency	Percentage (%) (*n*=50)
Frequency		
Daily after work is finished	1	2
Daily after work is finished, between shifts and during and/or after the handling of food	2	4
Daily before commencing with work, daily after work is finished and during and/or immediately after the handling of food	1	2
Clean surfaces under all circumstances	46	92
Means of cleaning / washing		
Cold water and detergent	11	22
Hot water and detergent	39	78

2.4.7 Information regarding the formal training of food handlers in personal and general hygiene

The two main approaches to reduce food-borne disease outbreaks include legislation and education (Worsfold and Griffith, 1995). In this survey, forty-two out of fifty (84%) respondents indicated that they had received formal training in aspects of personal hygiene and forty-two out of forty-nine (86%) had received formal training in general hygiene. Food hygiene training is fundamentally important and personnel should be aware of their role and responsibility in protecting food from contamination. Food handlers should boast the necessary knowledge and skills to enable them to handle food hygienically (Codex Alimentarius, 1997). All food handlers should be considered potential carriers of pathogenic micro-organisms and should be adequately trained in good manufacturing practices (GMP). Management should arrange for all food handlers to receive adequate and continued training in the hygienic handling of food and in personal hygiene in order to know which precautions to take to preclude contamination of food (SABS 049, 2001).

Studies in the United Kingdom have shown that training increases the level of hygiene and that businesses with a higher percentage of trained staff had a lower risk (Powell *et al.*, 1997). Respondents indicated that they had received training at Head Office with regard to personal hygiene (38%) and general hygiene (36%) (Table 2.6). On the other hand, according to Mortlock *et al.* (2000), whilst formal training might ensure greater consistency and quality, improper training could present a higher risk to food safety than no training at all. A study done by Tebbutt (1992) has confirmed that management's attitude is an important determinant in training standards. It was furthermore found that working practices and personal hygiene improved significantly

Table 2.6 Formal training in personal and general hygiene

	Frequency	Percentage (%)
Personal hygiene (n=42)		
Only video	15	36
Only courses	1	2
Only training at Head Office	16	38
Videos and training at Head Office	7	17
Videos and courses	1	2
Videos and talks	1	2
Videos and meetings	1	2
General Hygiene (n=42)		
Only videos	14	33
Only courses	1	2
Only training at Head Office	15	36
Videos and training at Head Office	7	17
Videos and courses	2	5
Videos and meetings	2	5
Videos and books	1	2

in premises where training programmes had been implemented for staff working with high-risk foods, while the risk of contamination decreased. For the food professional, the emphasis should be on continuous training and when it comes to food safety, it is incumbent on all food professionals to lead by example (Daniels, 1998). Adequate protection of the consumer from food-borne illness can be achieved by personnel training based on good manufacturing practices and hygienic food preparation through the application of a systematic approach to the identification and evaluation of food safety hazards (HACCP) (Soriano *et al.*, 2002). Proper training of food handlers is one of the cornerstones of the HACCP program and should be part and parcel of an operation's basic employee training (Norton, 2002). The benefits of hygiene training should be more widely promoted to encourage managerial commitment to staff training and by incorporating hygiene training with HACCP - the business would be encouraged to treat training as an ongoing rather than a once-off activity (Mortlock *et al.*, 2000).

2.4.8 Practices of food handlers regarding the wearing of protective clothing

Employees working in food production environments should wear hair restraints, clean uniforms, shoes and gloves (Codex Alimentarius, 1997; Martínez-Tomé *et al.*, 2000). During this survey, all the respondents wore plastic/material aprons, gloves and hairnets. According to the Health Regulations (Republic of South Africa, 1999) no person shall be allowed to handle food without wearing suitable protective clothing which must be: (1) clean and neat when a person begins to handle food; (2) at all times during the handling of food be in a clean condition and of such design and material that it cannot contaminate the food; and (3) be so designed that the

food cannot come into direct contact with any part of the body, excluding the hands. Management is responsible for the cleaning and issuing of protective clothing and should ensure that it is not removed from the premises for cleaning or repair without authorisation, and that such clothing, when not in use, is kept in a change-room (SABS 049, 2001).

As shown in Table 2.7, 24% of respondents indicated that they replaced their aprons two to five times a day and two respondents (4%) indicated that they replaced their aprons more than five times a day. According to the SABS 049 (2001) the use of gloves in the handling of food shall be limited to cases where the workers' hands need to be protected against physical, chemical or temperature harm, or where foodstuffs are to be protected from possible contamination by the worker. According to the Health Regulations (Republic of South Africa, 1999) a person in charge of a food premises shall ensure that no food handler touches ready-to-eat non-prepacked food with his or her bare hands, unless it is unavoidable for preparation purposes. With regard to the frequency of replacing gloves with clean ones, 8% indicated that they replaced their gloves two to five times a day, while 92% replaced their gloves more than five times a day. All fifty respondents indicated that they discarded their gloves when they took them off.

In conclusion, the results of the survey indicate that room for improvement exists, especially with regard to training, as not all the respondents have received formal training in personal and general hygiene. Although the majority of the food handlers in this survey indicated that they adhere to good personal and general hygiene practices, the wearing of jewellery, long fingernails, dressings that are not moisture-proof, the lack of reporting of illness and/or injuries to management and the action

Table 2.7 Practices regarding protective clothing

	Frequency	Percentage (%) (*n*=50)
Frequency of replacing aprons with clean ones		
Never	2	4
Once a day	16	32
Twice a day	18	36
2-5 times a day	12	24
More than 5 times a day	2	4
Frequency of replacing gloves with clean ones		
2-5 times a day	4	8
More than 5 times a day	46	92

taken by management when illnesses are reported are the main issues of concern. In some cases where illnesses were reported to management, no action was taken. As a result, the need for mandatory training for managers could be appropriate. Managers should recognise the need for training within their own establishments and should implement training for all levels of staff. In some outlets, a need also exists for more adequate supervision to ensure that personnel practices personal and general hygiene. Selected individuals who are appointed food handlers in the delicatessen section should preferably be appointed as first-level supervisors. Where supervision is not adequate, it should be the task of the manager of the outlet to intervene and to ensure that staff conform to the requirements. It should furthermore be the manager's task to foster employee commitment regarding personal and general hygiene. The need for a formal cleaning schedule should also be emphasised and staff should be informed about their responsibilities and the importance of adhering to such a schedule. With the new regulations relating to the application of HACCP (Republic of South Africa, 2003), managers will increasingly be faced with new challenges in order to comply with the above regulations. In this day and age of the increasing incidence of food-borne illnesses, it is required of all food handlers and their managers to be acutely aware of their responsibilities to produce food that is not only high in quality, but also safe for consumption.

2.5 REFERENCES

Altekruse, S.F., Timbo, B.B., Mowbray, J.C., Bean, N.H., and Potter, E. (1998) Cheese-associated outbreaks of human illness in the United States, 1973 to 1992: sanitary manufacturing practices protect consumers. *Journal of Food Protection, 61*, 1405-1407.

Borch, E. and Arinder, P. (2002). Bacteriological safety issues in red meat and ready-to-eat meat products, as well as control measures. *Meat Science, 62*, 381-390.

Bryan, F.L. (1998). Risks of practices, procedures and processes that lead to outbreaks of food-borne diseases. *Journal of Food Protection, 51*, 663-673.

Clayton, D.A., Griffith, D.J., Price, P. and Peters, A.C. (2002). Food handlers' beliefs and self-reported practices. *International Journal of Environmental Health Research, 12*, 25-39.

Codex Alimentarius. (1997). *Food hygiene: Basic Texts.* Rome.

Cogan, T.A., Slader, J., Bloomfield, S.F. and Humphrey, T.J. (2002). Achieving hygiene in the domestic kitchen: the effectiveness of commonly used cleaning procedures. *Journal of Applied Microbiology, 92*, 885-892.

Coggon, D. (1995). Questionnaire based exposure assessment methods. *The Science of the Total Environment, 168*, 175-178.

Cruickshank, J.G. (1990). Food handlers and food poisoning: training programmes are best. *British Medical Journal, 300*, 207-208.

Czaja, R. and Blair, J. (1996). *Designing surveys: A guide to decisions and procedures.* Thousand Oaks, CA: Pine Forge Press.

Daniels, R.W. (1998). Home food safety. *Food Technology, 52(2)*, 54-56.

Department of Health, South Africa. (2000 a). Guidelines for environmental health officers on the interpretation of microbiological analysis data of food. Directorate: Food Control. Government Printer, Pretoria.

Department of Health, South Africa. (2000 b). Information Document: Role and responsibility of the public health sector in South Africa regarding food safety control. Directorate: Food Control. Government Printer, Pretoria.

Ehiri, J.E. and Morris, G.P. (1996). Hygiene training and education of food handlers: Does it work? *Ecology of Food and Nutrition, 35*, 243-251.

Escartin, E.F. (1997). Identification and prevention of microbial risks in foods: the HACCP approach and priorities in Mexico. *Journal of Environmental Health, 60(4)*, 40-42.

García, M.L., Francisco, J.J. and Moreno, B. (1986). Nasal carriage of *Staphylococcus* species by food handlers. *International Journal of Food Microbiology, 3*, 99-108.

Hobbs, B.C. and Roberts, D. (1993). *Food poisoning and food hygiene* (6th ed.). Cornwall: Edward Arnold.

Katzenellenbogen, J.M., Joubert, G. and Abdool Karim, S.S. (1997). *Epidemiology: A manual for South Africa.* Cape Town: Oxford University Press.

Knabel, S.J. (1995). Scientific Status Summary. *Food Technology, 49(4)*, 119-131.

Kusumaningrum, H.D., Riboldi, G., Hazeleger, W.C. and Beumer, R.R. (2002). Survival of food-borne pathogens on stainless steel surfaces and cross-contamination to foods. *International Journal of Food Microbiology, 2667*, 1-10.

Lorenzini, B. (1995). Identify food-safety hazards with HACCP. *Restaurants & Institutions, 105(6)*, 158-159.

Martínez-Tomé, M., Vera, A.M. and Murcia, M.A. (2000). Improving the control of food production in catering establishments with particular reference to the safety of salads. *Food Control, 11*, 437-445.

Mbendi – Information for Africa. (2003). Overview of South African food industry. Available: www.mbendi.co.za/indy/tdbt/at/sa/p0005.htm Accessed 2003-05-15.

Moore, G. and Griffith, C. (2002). A comparison of surface sampling methods for detecting Coliforms on food contact surfaces. *Food Microbiology, 19*, 65-73.

Moore, G., Griffith, C. and Fielding, L. (2001). A comparison of traditional and recently developed methods for monitoring surface hygiene within the food industry. A laboratory study. *Dairy, Food and Environmental Sanitation, 21(6)*, 478-488.

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

Nel, S., Lues, J.F.R., Buys, E.M., and Venter, P. (2004). The personal and general hygiene practices in the deboning room of a high throughput red meat abattoir. *Food Control, 15,* 571-578.

Norton, C. (2002). Proper food handling is a cornerstone skill: a strong HACCP program can also help you reach your other business objectives. *Food Management, 37(3)*, 52.

Parish, M.E. (1998). Coliforms, *Escherichia coli* and *Salmonella* serovars associated with a citrus-processing facility implicated in a salmonellosis outbreak. *Journal of Food Protection, 61*, 280-284.

Paulson, D.S., Riccardi, C., Beausoleil, C.M., Fendler, E.J., Dolan, M.J. Dunkerton, L.V. and Williams, R.A. (1999). Efficacy evaluation of four hand cleansing regimens for food handlers. *Dairy, Food and Environmental Sanitation, 19(10)*, 680-684.

Powell, S.D., Attwell, R.W. and Massey, S.J. (1997). The impact of training on knowledge and standards of food hygiene – a pilot study. *International Journal of Environmental Health Research, 7*, 329-334.

Republic of South Africa. (2003). Regulation No. R.908 of 2003: Regulations relating to the application of the Hazard Analysis and Critical Control Point system (HACCP system), promulgated under the Foodstuffs, Cosmetics and Disinfectants Act, 54 of 1972. Government Printer, Pretoria.

Republic of South Africa. (1999). Regulation 918 of 1999: Health Regulations governing general hygiene requirements for food premises and the transport of food, promulgated under the Health Act No. 63 of 1977. Government Printer, Pretoria.

SABS 049. (2001). South African Bureau of Standards, Code of Practice: Food Hygiene Management (3rd ed.). Pretoria.

SAS/STAT. (1989). User's Guide (4th ed.), Volumes 1 and 2, Version 6. Cary, NC: SAS Institute Inc.

Shapiro, R., Ackers, M., Lance, S., Rabbani, M., Schaefer, L., Daugherty, J., Thelen, C. and Swerdlow, D. (1999). *Salmonella* Thompson associated with improper handling of roast beef at a restaurant in Sioux Falls, South Dakota. *Journal of Food Protection, 62*, 118-122.

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

Tebbutt, G.M. (1992). An assessment of food-hygiene training and knowledge among staff in premises producing or selling high-risk foods. *International Journal of Environmental Health Research, 2*, 131-137.

Vought, K.J. and Tatini, S.R. (1998). *Salmonella enteritidis* contamination of ice cream associated with a 1994 multistate outbreak. *Journal of Food Protection, 61*, 5-10.

Walker, E. and Jones, N. (2002). An assessment of the value of documenting food safety in small and less developed catering businesses. *Food Control 13*, 307-314.

Walker, E., Pritchard, C., and Forsythe, S. (2003). Food handlers' hygiene knowledge in small food businesses. *Food Control, 14,* 339-343.

Worsfold, D. and Griffith, C. (1995). A generic model for evaluating consumer food safety behavior. *Food Control, 6,* 357-363.

CHAPTER 3

MICROBIAL CONTAMINATION ON HANDS AND APRONS OF FOOD HANDLERS IN A RETAIL GROUP

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3.1 ABSTRACT

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 retail industry. In this study, samples were collected from the hands and aprons of food handlers in the delicatessen sections of a prominent South African retail group and analysed for the presence of Total Viable Counts (TVC), Total Coliforms, *Escherichia coli*, members of the family Enterobacteriaceae and *Staphylococcus aureus* in order to assess the levels of contamination and to establish possible relationships. TVC were present on 98% of hands and 84% of aprons sampled and conformed to the national standard of 1×10^2 cfu.cm^{-2} without exception. Coliforms were present on 40% of food handler's hands and on 26% of aprons and when compared to the literature which suggests a target value of <2.5 cfu.cm^{-2}, 32% of food handlers exceeded the target with regard to hands and 8% with regard to aprons. *Escherichia coli* was found to only exceed the limit in the case of one food handler. Enterobacteriaceae were present on the hands of food handlers (44%) and on aprons (16%), ranging between 5 cfu.cm^{-2} and 1.8×10^1 cfu.cm^{-2} on hands and between 5 cfu.cm^{-2} and 2.9×10^1 cfu.cm^{-2} on aprons. *Staphylococcus aureus* counts were present on 88% of hands and 48% of aprons and ranged between negligible and 9.8×10^1 cfu.cm^{-2} for hands and up to 6.2×10^1 cfu.cm^{-2} for aprons. No significant statistical correlation occurred between the organisms on hands and aprons, indicating that the latter were not likely to be cross-contaminated by hands.

Keywords: Food hygiene, food handler, retail industry.

3.2 INTRODUCTION

Data on risk factors for food-borne diseases indicate that the majority of outbreaks result from faulty food handling practices (Clayton *et al*., 2002). In an era of frequent travel, safe food handling practices are imperative given the potential for widespread outbreaks of food-borne illness (Lynch *et al.*, 2003). Lacking personal hygiene amongst food handlers is one of the most commonly reported practices contributing to food-borne illness and poor hand and surface hygiene is also a significant contributory factor (Collins, 2001; Cogan *et al.*, 2002). Contamination of surfaces in food premises has been shown to be associated with poor hygiene standards (Powell and Attwell, 1997). In most countries, food-borne diseases remain a public health predicament in spite of the improvement in hygiene standards, improved food processing practices, education of food handlers and consumer awareness (Domínguez *et al.*, 2002).

The hands of food handlers can be pivotal as vectors in the spread of food-borne disease due to poor personal hygiene or cross-contamination (Setiabudhi *et al.*, 1997). According to Taylor *et al.* (2000) there is evidence from the food industry to show that micro-organisms are transferred to the hands in the process of handling food and through poor personal hygiene after visiting the lavatory, resulting in the hands being heavily contaminated with enteric pathogens. The transmission of enteric-related pathogenic micro-organisms via the hands of food handlers thus continues to be a problem in the food industry (Barza, 2004). Hand-washing, a simple and effective way to cut down on cross contamination, is all too often forgotten (Rippel, 2002). It was reported that 42% of food-borne outbreaks which

took place from 1975-1998 in the United States of America had been caused by the hands of food handlers (Ayçiçek *et al.*, 2004).

The risk of food-borne illness due to contact with hands or surfaces depends on both the level of contamination as well as the probability of transfer and the importance of contaminated surfaces in relation to potential transmission of pathogens to food is apparent in food processing (Den Aantrekker *et al.*, 2003; Kusumaningrum *et al.*, 2003). Several studies have indicated that various bacteria, amongst others *Staphylococcus aureus, Escherichia coli* and *Salmonella* sp., survive on hands and surfaces for hours or even days after initial contact with the micro-organisms (Scott and Bloomfield, 1990; Jiang and Doyle, 1999; Kusumaningrum *et al.*, 2002). These microbiota have been associated with food-borne illness for decades and there is no doubt that they, together with members of the genera *Listeria*, *Campylobacter*, *Bacillus*, *Clostridium*, etcetera are the cause of illness and even death to many people each year, at immeasurable economic cost and human suffering (Borch and Arinder, 2002).

A microbial indicator is a micro-organism or group of micro-organisms that is indicative of the possible presence of pathogens and the detection and enumeration of indicator organisms are widely used to assess the efficacy of sanitation programmes (Brown *et al.*, 2000; Ingham *et al.*, 2000; Moore and Griffith, 2002). Indicator organisms associated with hygiene practices include, amongst others, Total Viable Counts, Total Coliforms, *Escherichia coli*, members of the family Enterobacteriaceae and *Staphylococcus aureus* (Department of Health, 2000). Very little data is available, however, in terms of the limits associated with the occurrence of pathogenic bacteria on hands and aprons, particularly in South Africa currently. The only national standard

addresses Total Viable Counts on working surfaces as prescribed by the Health Regulations (Republic of South Africa, 1999). This study was therefore aimed at investigating the occurrence of indicator bacteria on hands and aprons of food handlers in a retail group and to determine the relationship between the occurrence of organisms on hands and on aprons. Such relationships were used to streamline training modules in terms of transfer of contaminants from hands to aprons and *vice versa*. Typically, the results were communicated to management in order to indicate the status of food handling practices of food handlers and to highlight the importance of contaminated surfaces in relation to potential transmission of pathogens to food.

3.3 MATERIALS AND METHODS

3.3.1 Pilot Study

A pilot study was conducted in an outlet which was not included in the actual test sample and involved six food handlers. The purpose of the pilot study was to determine the time requirements and streamline the methodology, as it was important that the time required for collecting the samples was not perceived by the retail outlet managers to be disruptive to the normal work pattern (Walker *et al.*, 2003).

3.3.2 Sampling protocol

Samples from food handlers' hands (indexfingers, thumbs and palms of both the left and the right hands) as well as from their aprons were collected from a random selection of 50% of workers in the delicatessen sections of 35 randomly selected outlets of a prominent retail group in the Western Cape Province, South Africa.

Samples were collected by the same surveyor on a once-off basis during working hours (week days between 10:00 and 14:00) without previous notification of nor the date or time of the survey. A total of 300 samples were collected from the hands of food handlers during the serving of ready-to-eat food and a further 300 samples were collected from the aprons of food handlers. The collected samples were stored and transported at 0°C prior to analysis.

3.3.3 Sampling procedures and enumeration of bacteria

Upon entering each outlet, the manager was informed about the study and the purpose of collecting samples from food handlers' hands and aprons. After random selection of 50% of workers in the delicatessen section, Rodac plates (MERCK) containing selected agar media were used to sample the forefinger (*Staphylococcus aureus*), thumb (Total Coliform Count, *Escherichia coli* and Enterobacteriaceae) and palm (Total Viable Count) of the left and right hand of each worker. Rodac Plates containing the various media were furthermore used to sample the aprons, focussing on these areas that are predominantly exposed (six samples were collected per apron). Colonies were differentiated on appearance and colour (Martley *et al.*, 1970; Stadhouders *et al.*, 1978; Manafi and Kneifel, 1989). Since no evidence could be found in the literature that the Swab technique is superior to the Rodac technique, the Rodac technique was selected because various agar media could be used for sampling of various indicator organisms.

Total Viable Counts

For the enumeration of Total Viable Counts, Plate Count Agar plates were incubated at 35ºC for 24 hours (MERCK, Martley *et al.*, 1970).

Total Coliforms, Escherichia coli and members of the family Entrobacteriaceae

Chromocult Coliform Agar plates were incubated at 35-37ºC for 24 hours and typical Coliforms were salmon to red in colour, whilst typical *Escherichia coli* colonies were dark-blue to violet in colour and members of the family Enterobacteriaceae colonies were colourless (MERCK, Kilian and Bülow, 1976; Frampton *et al.*, 1988; Manafi and Kneifel, 1989). *Escherichia coli* (ATCC 25922) and *Enterobacter aerogenes* (ATCC 15038) were used as positive controls whereas a blank plate was used as negative control.

Staphylococcus aureus

Baird Parker Agar plates were incubated at 35ºC for 24-48 hours and typical *Staphylococcus aureus* colonies (black colonies with white margins surrounded by clear zones) were enumerated. The colonies were confirmed using the coagulase test (Staphytect test kit, Oxoid) (MERCK, Niskanen and Aalto, 1978; Stadhouders *et al.*, 1978). *Staphylococcus aureus* (ATCC 25923) was used as positive control and a blank plate as negative control.

3.3.4 Statistical Analysis

Data were analysed in collaboration with the Department of Biostatistics, University of the Free State using Statistical Analysis Systems (SAS/STAT, 1989). Spearman correlations were calculated between organism counts on the hands and on the aprons, for each organism separately. Because food handling involves both hands equally, reported data are the means of indexfingers, thumbs and palms per food handler.

3.4 RESULTS AND DISCUSSION

3.4.1 Total Viable Counts

Total Viable Counts were detected on the hand palms of the hands (98%) and on the aprons of food handlers (84%). According to the Health Regulations (Republic of South Africa, 1999) a working surface, or any surface which comes into direct contact with food, shall contain no more than 100 viable micro-organisms per cm^2 upon analysis. Figure 3.1(A) and 3.2(A) show that the TVC for palms as well as for aprons remained below the national standard of 100 viable micro-organisms per cm^2 for all thirty-five outlets, thus based on this guideline, the samples conformed without exception.

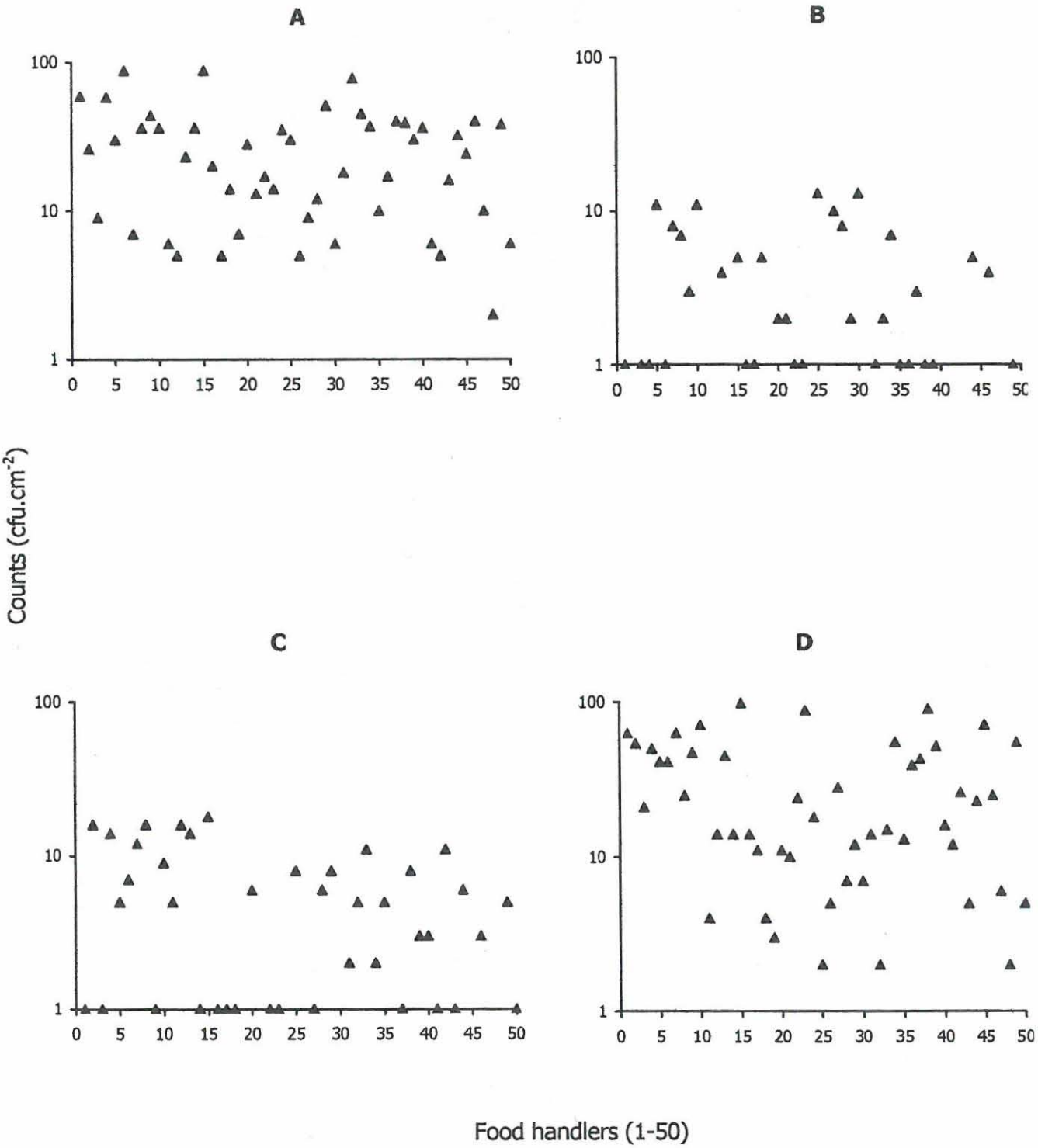

Fig. 3.1 The patterns of Total Viable Counts (A), Total Coliforms (B), Enterobacteriacea (C) and *Staphylococcus aureus* (D) on the hands of food handlers in th delicatessen sections of a retail group

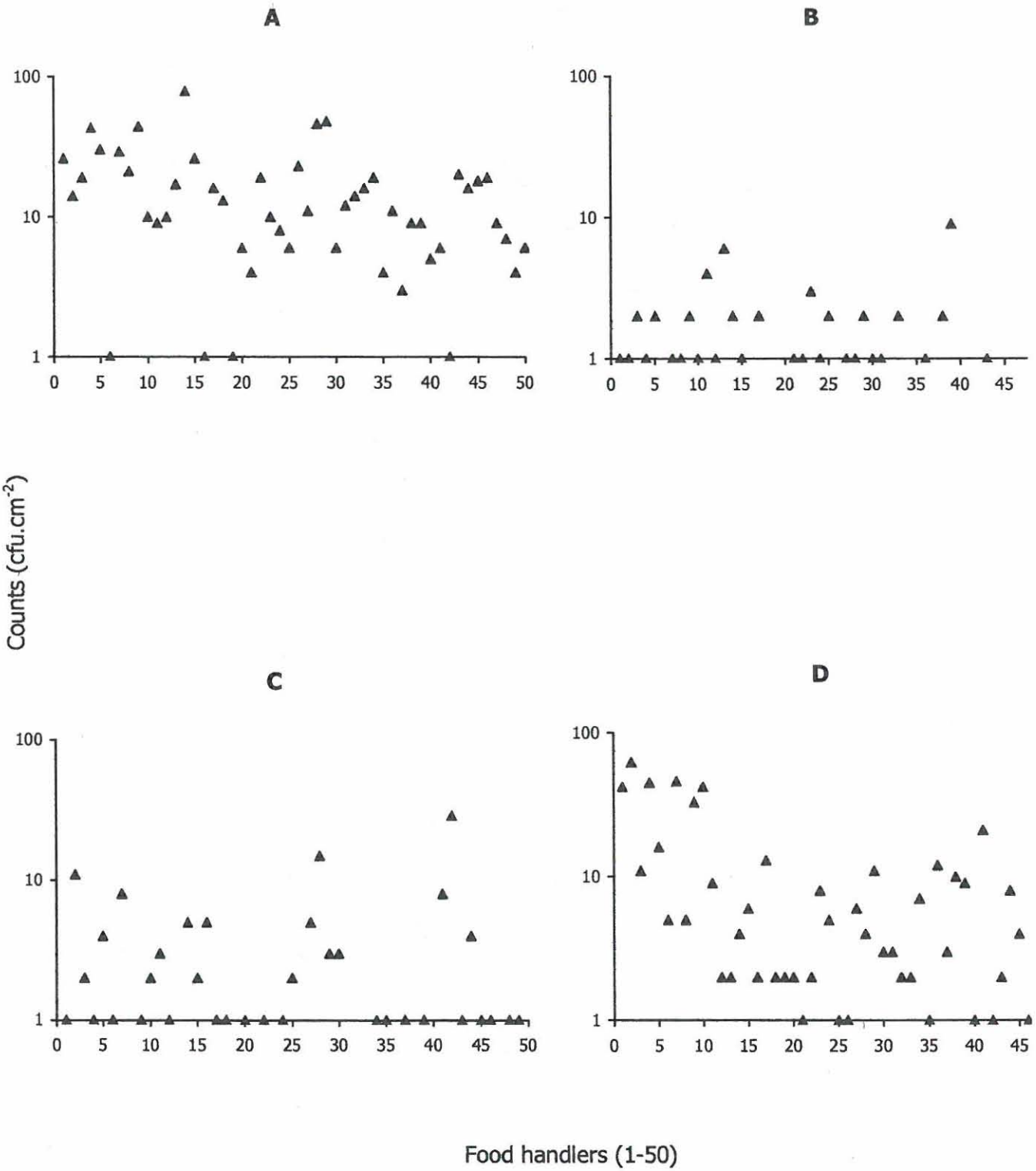

Fig. 3.2 The patterns of Total Viable Counts (A), Total Coliforms (B), Enterobacteriaceae and *Staphylococcus aureus* (D) on aprons of food handlers in the delicatessen sect of a retail group

Total Viable Counts on the palms of the hands could be regarded as negligible (one food handler) and the remainder ranged from 5 cfu.cm^{-2} (8% of food handlers) to 8.8 x 10^{1} cfu.cm^{-2} (food handlers 6 and 15). The highest incidences were 8.8 x 10^{1} cfu.cm^{-2} (food handlers 6 and 15); 7.8 x 10^{1} cfu.cm^{-2} (food handler 32); 5.9 x 10^{1} cfu.cm^{-2} (food handler 1); 5.8 x 10^{1} cfu.cm^{-2} (food handler 4) and 5.1 x 10^{1} cfu.cm^{-2} (food handler 29). The remainder of the food handlers' hands were shown to have TVC of below 5.0 x 10^{1} cfu.cm^{-2}, thus only 12% of the food handler's hands exceeded counts of 5.0 x 10^{1} cfu.cm^{-2} (Fig. 3.1A).

Counts on aprons were negligible (8 food handlers) and the remainder ranged from 5 cfu.cm^{-2} (food handler 40) to 7.9 x 10^{1} cfu.cm^{-2} (food handler 14). Aprons proved to have lower Total Viable Counts, not exceeding 5.0 x 10^{1} cfu.cm^{-2} except for food handler 14 whose apron had a count of 7.9 x 10^{1} cfu.cm^{-2} (Fig. 3.2A). The highest counts were 7.9 x 10^{1} cfu.cm^{-2} (food handler 14); 4.8 x 10^{1} cfu.cm^{-2} (food handler 29) and 4.6 x 10^{1} cfu.cm^{-2} (food handler 28).

According to Martínez-Tomé *et al.* (2000) the hands of food handlers as well as their protective clothing should be kept clean and food handlers should avoid contact with food whenever possible. For many foods, especially those that are ready-to-eat, the cleanliness of food contact surfaces is likely to be identified as being critical to food safety (Moore and Griffith, 2002). It should be kept in mind, however, that it is virtually impossible to exclude all microbiota from food-related surfaces except if such surfaces are sterilised – this would be unnecessary as well as unpractical.

3.4.2 Total Coliforms, *Escherichia coli* and members of the family Enterobacteriaceae

The detection of Coliforms is widely used as a means of measuring the effectiveness of sanitation programmes, their presence indicating a substantially increased risk of the presence of pathogens (Moore and Griffith, 2002). According to Moore and Griffith (2002) no surface specifications for Coliforms, after disinfection, are commonly available and general microbial target values of <2.5 cfu.cm^{-2} have been suggested and have been found to be attainable for a range of surfaces.

In this study, Total Coliforms were negligible on the hands (thumbs) of 60% of food handlers and counts ranged between 2 cfu.cm^{-2} (8% of food handlers) and 1.3 x 10^{1} cfu.cm^{-2} (food handlers 25 and 30) (Fig. 3.1B). The highest occurrences were 1.3 x 10^{1} cfu.cm^{-2}; 1.1 x 10^{1} cfu.cm^{-2} (food handlers 5 and 10 respectively) and 1.0 x 10^{1} cfu.cm^{-2} (food handler 27). With regard to aprons, Total Coliform Counts were undetectable on 74% of aprons of food handlers sampled and counts ranged between 2 cfu.cm^{-2} (18% of food handlers) and 9 cfu.cm^{-2} (food handler 39) (Fig. 3.2B). When comparing the Coliform Counts found in this study to the suggested general microbial target value of <2.5 cfu.cm^{-2} after cleaning (Moore and Griffith, 2002), 32% of food handlers exceeded the target with regard to Coliforms found on hands and 8% exceeded the target with regard to Coliforms isolated from aprons of food handlers.

According to De Wit and Rombouts (1992), *Escherichia coli* is normally absent from hands and the presence of *E. coli* is thought to give a better indication of faecal contamination (enteric pathogens in particular) than the entire group of Enterobacteriaceae. *Escherichia coli* was detected on the hands (thumbs) of only one

food handler (data not shown). This particular individual, who had amongst the highest occurrences of Total Coliforms on his/her hands (1.1×10^1 cfu.cm^{-2}), also showed the presence of *Escherichia coli* (8 cfu.cm^{-2}). No *E. coli* were detected on the aprons of food handlers in any of the 35 outlets. According to Legnani *et al.* (2004), the limit for *E. coli* on surfaces is 1 cfu.cm^{-2} and although *E. coli* is an acknowledged indicator for faecal contamination as well as for the possible presence of enteric pathogens (Gill *et al.*, 1996), the distribution of *Escherichia coli* in this study can be considered negligible.

For the purposes of this study, Enterobacteriaceae were defined as, amongst others, members of the genera *Salmonella*, *Shigella*, *Yersinia*, *Proteus* and *Klebsiella* (excluding Total Coliforms and *Escherichia coli*) and therefore present a holistic view of the presence of these organisms on hands and aprons of food handlers (Nel *et al.*, 2004). Enterobacteriaceae counts were not detected on hands (thumbs) of 56% of food handlers while counts ranged between 5 cfu.cm^{-2} (10% of food handlers) and 1.8×10^1 cfu.cm^{-2} (food handler 15) (Fig. 3.1C). One particular food handler, who had the highest occurrence of Enterobacteriaceae on hands, also showed the highest occurrence of Total Viable Counts. A study done by De Wit and Rombouts (1992) indicated that the presence of Enterobacteriaceae on hands is not a good indicator of personal and toilet hygiene, as it appeared that hands might be contaminated with Enterobacteriaceae regardless of toilet use and that the numbers of Enterobacteriaceae on hands were reduced after stools by hand washing; therefore the number of contaminated hands would be very low and furthermore the number of faecal micro-organisms would be very small. Members of the Enterobacteriaceae were not detected on 84% of food handler's aprons. With regard to the remainder of the

food handlers, counts ranged between 5 cfu.cm^{-2} (6% of food handlers) and 2.9 x 10^{1} cfu.cm^{-2} (Fig. 3.2C).

3.4.3 *Staphylococcus aureus*

Staphylococcus aureus is the predominant species involved in staphylococcal food poisoning outbreaks, which follow the handling of cooked foods by persons who carry enterotoxigenic staphylococci in their nares or on their skin (Angellillo, 2000; Portocarrero *et al.*, 2002). Staphylococci are ubiquitously distributed in man's environment and strains present in the nose often contaminate the back of hands, fingers and face and nasal carriers could therefore easily become skin carriers (García *et al.*, 1986; Genigeorgis, 1989; Desmarchelier, 1999; Gorman *et al.*, 2002). Micro-organisms on the human skin can be divided into two groups: permanent and transitory; and the only pathogenic micro-organism in the permanent group of bacteria associated with the human skin is *Staphylococcus aureus*. Further, because of the resident character of this micro-organism, it is not possible to fix an acceptable contamination level for *S. aureus* after proper hand washing (Ayçiçek *et al.*, 2004).

Figure 3.1(D) indicates that *Staphylococcus aureus* were isolated from the hands (indexfingers) of 88% of the population sampled. Levels ranged from undetectable to 9.8 x 10^{1} cfu.cm^{-2}. The highest occurrences was 9.8 x 10^{1} cfu.cm^{-2} (food handler 15); 9.0 x 10^{1} cfu.cm^{-2} (food handler 38) and 8.8 x 10^{1} cfu.cm^{-2} (food handler 23). Food handler 15 had the highest count of *Staphylococcus aureus*, the highest Total Viable Count (8.8 x 10^{1} cfu.cm^{-2}) as well as the highest Enterobacteriaceae count (1.8 x 10^{1} cfu.cm^{-2}).

Staphylococcus aureus was undetectable on 52% of food handlers' aprons (Fig. 3.2D). Counts ranged between 5 cfu.cm^{-2} (8% of food handlers) and 6.2 x 10^{1} cfu.cm^{-2} (food handler 2). The highest counts were 6.2 x 10^{1} cfu.cm^{-2} (food handler 2); 4.6 x 10^{1} cfu.cm^{-2} (food handler 7); and 4.5 x 10^{1} cfu.cm^{-2} (food handler 4). According to Moore *et al.*, (2001) an inadequately cleaned surface can, if in contact with food, lead to cross-contamination and contribute to a product's microbial load, which might result in a decreased shelf-life. Furthermore, cross-contamination was identified as an important contributory factor in 39% of general food-borne disease outbreaks recorded in the UK (Moore *et al.*, 2001).

Figures 3.3 and 3.4 represent the distribution of Total Viable Counts, Total Coliforms, Enterobacteriaceae and *Staphylococcus aureus*, using box plots. With regard to microbial contamination on hands, Total Viable Counts and *Staphylococcus aureus* appeared relatively similar in terms of their prevalence, 25th and 75th percentile distribution (Fig. 3.3). The mean Total Coliform Counts were between 3 cfu.cm^{-2} and 5 cfu.cm^{-2} and the 75th as well as the 95th percentiles on hands exceeded the suggested microbial target value of <2.5 cfu.cm^{-2}. In general, the microbial contamination on hands of food handlers appeared higher than the microbial contamination on aprons (Fig. 3.4). In the latter case Total Viable Counts and Total Coliforms remained within acceptable target values and the 95th percentiles of Total Viable Counts and *Staphylococcus aureus* were in the same range, whereas Total Coliforms and Enterobacteriaceae counts had similar 25th percentiles and medians. In general, organism counts remained relatively low throughout this study and their distribution as illustrated by the box plots were well below 100 cfu.cm^{-2}.

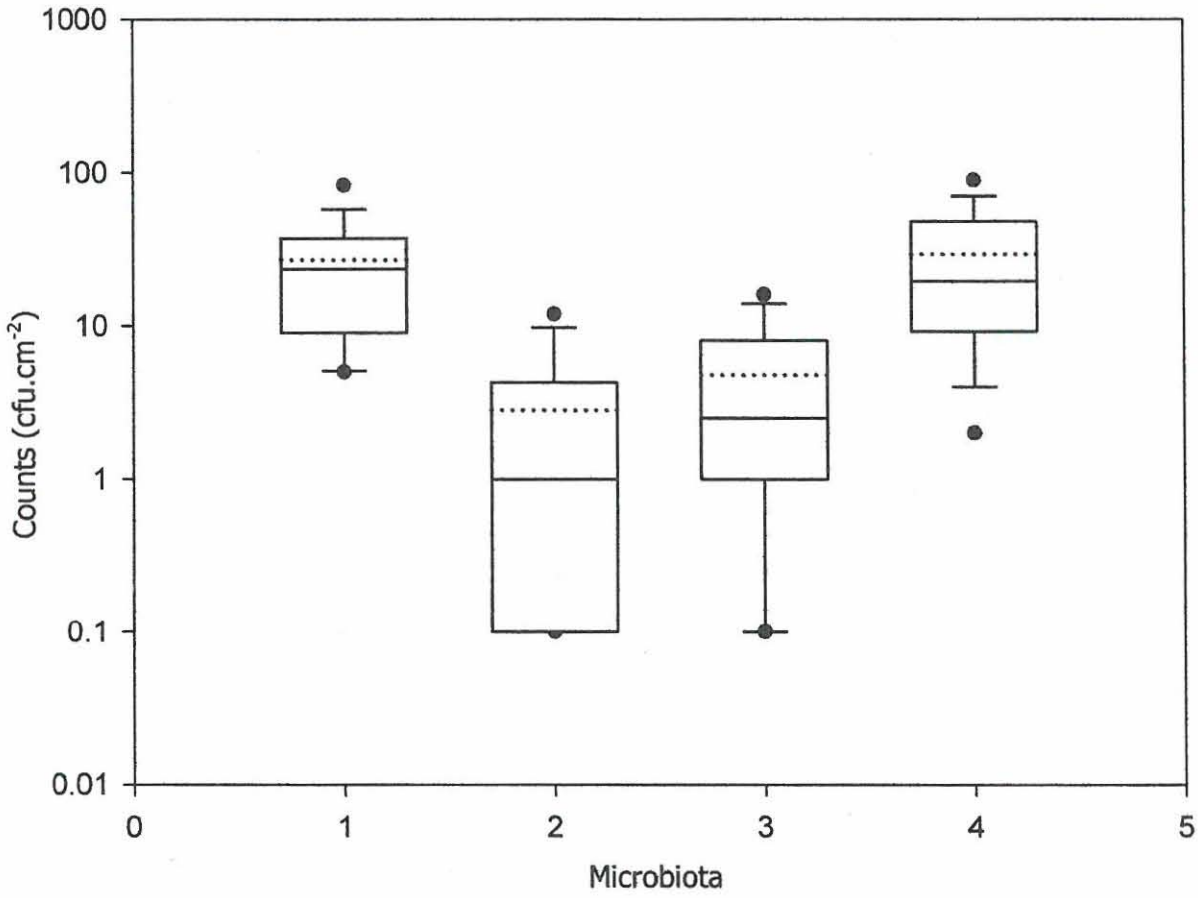

Fig. 3.3 Microbial contamination on hands of food handlers: each box plot represents the 5th and 95th percentiles (dots below and above box), the 25th and 75th percentiles (bottom and top of box), the median (solid line inside box), the mean (dotted line) and the standard deviation (short solid lines outside box) of Total Viable Counts (1), Total Coliforms (2), Enterobacteriaceae (3) and *Staphylococcus aureus* (4)

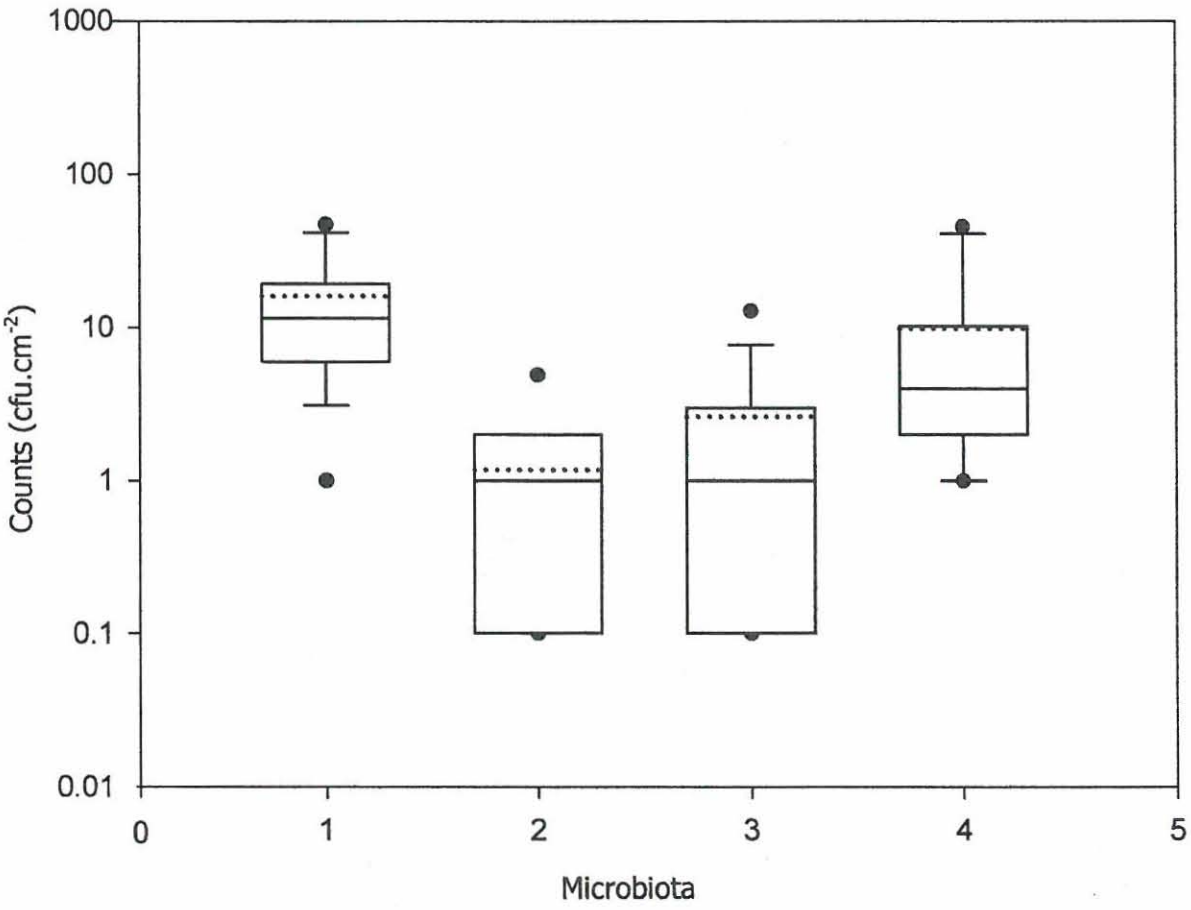

Fig. 3.4 Microbial contamination on aprons of food handlers: each box plot represents the 5th and 95th percentiles (dots below and above box), 25th and 75th percentiles (bottom and top of box), the median (solid line inside box), the mean (dotted line) and the standard deviation (short solid lines outside box) of Total Viable Counts (1), Total Coliforms (2), Enterobacteriaceae (3) and *Staphylococcus aureus* (4).

3.4.4 The use of gloves

During a survey done at the same localities, it was observed that food handlers wore protective clothing, including gloves, when customers were served (Van Tonder and Lues, 2004). No or very little documented evidence exists that food served by gloved hands is safer than food served by bare hands, which have been subjected to effective hand washing. When retail food personnel use gloves while serving food, they should realise that micro-organisms adhere to the surfaces of gloves and thus, when not changed frequently, could be sources of cross-contamination similar to unwashed hands (Snyder, 1997). However, gloves have the added disadvantage that if individuals do not wash their hands before putting on gloves, both the interior and exterior of the gloves become contaminated. Hand-washing is often neglected or omitted when gloves are used and organisms on the hands could multiply rapidly inside the moist and warm environment of the gloves (Ayçiçek *et al.*, 2004).

3.4.5 Relationships between the occurrence of organisms on hands and aprons

Spearman correlations were calculated, using SAS/STAT (1989), between organism counts on the hands and on the aprons of food handlers (Table 3.1). This was done in order to establish whether cross-contamination was apparent between hands and aprons. Although *Staphylococcus aureus* had the highest positive correlation between counts on the hands and on the aprons (r=0.56), a correlation of 0.7 and higher is regarded as a strong correlation. However, taking into account the significant P-value of 0.0001, one should assume that a moderate correlation between *S. aureus* on the hands and the aprons of food handlers is of consequence.

Table 3.1 Relationships between organism counts on hands and aprons

Organism	Spearman correlations between organism counts on hands and aprons
Total Viable Count	0.26(P=0.07)
Total Coliform Count	0.22(P=0.13)
Enterobacteriaceae	0.24(P=0.10)
Staphylococcus aureus	0.56(P=0.0001)

In conclusion, with regard to Coliforms, 32% of hands and 8% of aprons exceeded the suggested general microbial target value after cleaning of <2.5 cfu.cm^{-2} suggested by Moore and Griffith (2002). Because the delicatessens deal with ready-to-eat foods and is thus regarded as a high-risk area, the cleanliness of food contact surfaces is likely to be critical to food safety and the prevention of cross-contamination. This emphasises the importance of adequate cleaning and sanitation. Throughout the study, counts remained much lower on aprons than on hands of food handlers and therefore the latter are more likely to pose a higher risk of cross-contamination to food than aprons. Taking into consideration the limited data available regarding the limits associated with the organisms isolated in this study and the fact that the suggested *Escherichia coli* limit was only exceeded by one foodhandler, the relatively low numbers of organisms found indicate that the majority of respondents complied with proper hand-washing practices.

It was, however, alarming that in two instances (food handlers 10 and 15) these individuals had relatively high counts of all the organisms investigated in this study – one of which tested positive for the presence of *Escherichia coli*. Although the majority of food handlers thus reflected a sound knowledge and practice of personal and process hygiene, experience has learnt that it takes only one event of contamination with undesirable pathogenic microbiota to have disastrous consequences.

3.5 REFERENCES

Angelillo, I.F., Viggiani, N.M.A., Rizzo, L. and Bianco, A. (2000). Food handlers and food-borne diseases: knowledge, attitudes, and reported behaviour in Italy. *Journal of Food Protection, 63(3),* 381-385.

Ayçiçek, H., Aydoğan, H., Küçükkaraaslan, A., Baysallar, M. and Başustaoğlu, A.C. (2004). Assessment of the bacterial contamination on hands of hospital food handlers. *Food control, 15,* 253-259.

Barza, M. (2004). Efficacy and tolerability of ClO_2-generating gloves. *Clinical Infectious Diseases, 38,* 857-863.

Borch, E. and Arinder, P. (2002). Bacteriological safety issues in red meat and ready-to-eat meat products as well as control measures. *Meat Science, 62,* 381-390.

Brown, M.H., Gill, C.O., Hollingsworth, J., Nickelson II, R., Seward, S., Sheridan, J.J., Stevenson, T., Summer, J.L., Theno, D.M., Usborne, W.R. and Zink, D. (2000). The role of microbiological testing in systems for assuring the safety of beef. *International Journal of food Microbiology, 62,* 7-16.

Clayton, D.A., Griffith, D.J., Price, P. and Peters, A.C. (2002). Food handlers' beliefs and self-reported practices. *International Journal of Environmental Health Research, 12,* 25-39.

Cogan, T.A., Slader, J., Bloomfield, S.F. and Humphrey, T.J. (2002). Achieving hygiene in the domestic kitchen: the effectiveness of commonly used cleaning procedures. *Journal of Applied Microbiology, 92*, 885-892.

Collins, J.E. (2001). Impact of changing consumer lifestyles on the emergence/re-emergence of food-borne pathogens. *Emerging Infectious Diseases, 3(4),* 1-13.

Den Aantrekker, E.D., Boom, R.M. Zwietering, M.H. and Van Schothorst, M. (2003). Quantifying recontamination through factory environments – a review. *International Journal of Food Microbiology, 80(2),* 117-130.

Department of Health, South Africa. (2000). Guidelines for environmental health officers on the interpretation of microbiological analysis data of food. Directorate: Food Control. Government Printer, Pretoria.

Desmarchelier, P.M., Higgs, G.M., Mills, L., Sullivan, A.M. and Vanderlinde, P.B. (1999). Incidence of coagulase positive Staphylococcus on beef carcasses in three Australian abattoirs. *International Journal of Food Microbiology, 47,* 221-229.

De Wit, J.C. and Rombouts, F.M. (1992). Faecal micro-organisms on the hands of carriers: *Escherichia coli* as Model for *Salmonella*. *International Journal of Hygiene and Environmental Medicine, 193,* 230-236.

Domínguez, C., Gómez, I and Zumalacárregui, J. (2002). Prevalence of *Salmonella* and *Campylobacter* in retail chicken meat in Spain. *International Journal of Food Microbiology, 72,* 165-168.

Frampton, E.W., Restaino, L. and Blaszko, L. (1988). Evaluation of β-glucuronidase substrate 5-bromo-4-chloro-3indol-β-D-glucuronide (X-GLUC) in a 24-hour direct plating method for *Escherichia coli*. *Journal of Food Protection, 51,* 402-404.

García, M.L., Francisco, J.J. and Moreno, B. (1986). Nasal carriage of *Staphylococcus* species by food handlers. *International Journal of Food Microbiology, 3,* 99-108.

Genigeorgis, C.A. (1989). Present state of knowledge on staphylococcal intoxication. *International Journal of Food Microbiology, 9,* 327-360.

Gill, C.O., McGinnis, J.C. and Badoni, M. (1996). Use of total or *Escherichia coli* counts to assess the hygienic characteristics of a beef carcass dressing process. *International Journal of Food Microbiology, 31,* 181-196.

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

Ingham, S.C., Reyes, J.C.N., Schoeller, N.P. and Lang, M.M. (2000). Potential use of presumptive enterococci and staphylococci as indicators of sanitary conditions in plants making hard Italian-type cheese. *Journal of Food Protection, 63,* 1697-1701.

Jiang, X.P. and Doyle, M.P. (1999). Fate of *Escherichia coli* 0157:H7 and *Salmonella enteritidis* on currency. *Journal of Food Protection, 62,* 805-807.

Kilian, M. and Bülow, P. (1976). Rapid diagnosis of Enterobacteriaceae. *Acta Pathologica et Microbiologica Scandinavica Section B, 84,* 245-251.

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

Kusumaningrum, H.D., Van Putten, M.M. Rombouts, F.M. and Beumer, R.R. (2002). Effects of antibacterial dishwashing liquid on food-borne pathogens and competitive micro-organisms in kitchen sponges. *Journal of Food Protection, 65,* 61-65.

Legnani, P., Leoni, E., Berveglieri, M., Mirolo, G. and Alvaro, N. (2004). Hygienic control of mass catering establishments, microbial monitoring of food and equipment. *Food Control, 15(3),* 205-211.

Lynch, R.A., Elledge, B.L., Griffith, C.C. and Boatright, D.T. (2003). A comparison of food safety knowledge among restaurant managers, by source of training and experience, in Oklahoma County, Oklahoma. *Journal of Environmental Health, 66(2),* 9-14.

Manafi, M. and Kneifel, W. (1989). A combined chromogenic-fluorogenic medium for the simultaneous detection of Total Coliforms and *Escherichia coli* in water. *International Journal of Hygiene and Environmental Medicine, 189,* 225-234.

Martínez-Tomé, M., Vera, A.M. and Murcia, M.A. (2000). Improving the control of food production in catering establishments with particular reference to the safety of salads. *Food Control, 11,* 437-445.

Martley, F.G., Jayashankar, S.R. and Lawrence, R.C. (1970). An improved agar medium for the detection of proteolytic organisms in total bacterial counts. *Journal of Applied Bacteriology, 33,* 363-370.

Moore, G., Griffith, C. and Fielding, L. (2001). A comparison of traditional and recently developed methods for monitoring surface hygiene within the food industry: a laboratory study. *Dairy, Food and Environmental Sanitation, 21(6),* 478-488.

Moore, G. and Griffith, C. (2002). A comparison of surface sampling methods for detecting Coliforms on food contact surfaces. *Food Microbiology, 19,* 65-73.

Nel, S. Lues, J.F.R., Buys, E.M. and Venter, P. (2004). Bacterial populations associated with meat from the deboning room of a high throughput red meat abattoir. *Meat Science, 66,* 667-674.

Niskanen, A. and Aalto, M. (1978). Comparison of selective media for coagulase-positive enterotoxigenic *Staphylococcus aureus*. *Applied Environmental Microbiology, 35,* 1233-1236.

Portocarrero, S.M., Newman, M. and Mikel, B. (2002). *Staphylococcus aureus* survival, staphylococcal enterotoxin production and shelf stability of country-cured hams manufactured under different processing procedures. *Meat Science, 62,* 267-273.

Powell, S.C. and Attwell, R.W. (1997). The use of ATP-bioluminescence as an objective measure of food hygiene standards. *International Journal of Environmental Health Research, 7,* 47-53.

Republic of South Africa. (1999). Regulation 918 of 1999: Health Regulations governing general hygiene requirements for food premises and the transport of food, promulgated under the Health Act No. 63 of 1977. Government Printer, Pretoria.

Rippel, B. (2002). *Consumer knowledge about food safety revealed.* Consumer Alert, Washington, D.C.

SAS/STAT. (1989). User's Guide (4th ed.), Volumes 1 and 2, Version 6. Cary, NC: SAS Institute Inc.

Setiabudhi, M., Theis, M. and Norback, J. (1997). Integrating hazard analysis and critical control point (HACCP) and sanitation for verifiable food safety. *Journal of the American Dietetic Association, 97(8),* 889-891.

Scott, E. and Bloomfield, S.F. (1990). The survival and transfer of microbial-contamination via cloths, hands and utensils. *Journal of Applied Bacteriology, 68,* 271-278.

Snyder, O.P. (1997). *A "Safe Hands" hand wash program for retail food operations.* St Paul, MN: Hospitality Institute of Technology and Management.

Stadhouders, J., Hassings, F. and Van Aalsten-Van Maren, N.O. (1978). A pour-plate method for the detection and enumeration of coagulase-positive *Staphylococcus aureus* in the Baird-Parker Medium without egg-yolk. *Netz Milk Dairy Journal, 30,* 222-229.

Taylor, J.H., Brown, K.L., Toivenen, J. and Holah, J.T. (2000). A microbiological evaluation of warm air hand driers with respect to hand hygiene and the washroom environment. *Journal of Applied Microbiology, 89,* 910-919.

Van Tonder, I.S. and Lues, J.F.R. (2004). A survey of process hygiene and associated food handler practices in a retail group in the Western Cape, South Africa. D. Tech. Thesis. Bloemfontein: Central University of Technology.

Walker, E., Pritchard, C. and Forsythe, S. (2003). Food handlers' hygiene knowledge in small food businesses. *Food Control, 14,* 339-343.

CHAPTER 4

AIRBORNE MICROBIOTA ASSOCIATED WITH THE DELICATESSEN SECTIONS OF A RETAIL GROUP AND RELATIONSHIPS TO VENTILATION

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Journal of Aerosol Science

4.1 ABSTRACT

A lack of research into the airborne transmission of bacteria in food premises could be related to the fact that aerobiology is a little understood science and the threat posed by airborne microbes has been greatly underestimated. The extent of airborne contamination of foodstuffs is of particular importance in high-risk areas that are exposed to large numbers of individuals (for example customers to delicatessen sections). In this study, airborne microbiota were collected from the delicatessen sections of a retail group in order to assess the presence and distribution of bioaerosols and the relationship between the bioaerosol counts and selected physical parameters. The samples were analysed for Total Viable Counts, Total Coliforms, *Escherichia coli*, members of the family Enterobacteriaceae and *Staphylococcus aureus*. The average TVC over the sampling period was 1.34×10^2 cfu.m^{-3}; for *S. aureus*, 2.2×10^1 cfu.m^{-3}; and for Enterobacteriaceae, 2.6×10^1 cfu.m^{-3}. Since no microbiological guidelines exist in South Africa with regard to airborne microbial populations, the counts were compared to the results found in other studies and appeared relatively low. Except for two outlets, Total Coliforms and *E. coli* were undetectable. Other than Enterobacteriaceae counts that differed significantly between the three groups of visitors (below normal; normal; above normal) and TVC that differed between the two ventilation groups (extractor fan and air conditioner; extractor fan or air conditioner or fan), no statistically significant differences were found between the bioaerosol counts and the selected physical parameters of the delicatessen sections. Since the statistically significant differences that occurred were limited, and organism counts relatively low, the occurrence of airborne organisms in this study is likely to be related to environmental influences rather than the type of ventilation, temperature and number of clients visiting the outlets. Environmental

regulating mechanisms should be adapted to minimise bioaerosol counts and ventilation systems should be adequately maintained and cleaned. It is furthermore important to establish whether air-intake vents are fitted with fly screens and dust filters. Air-intake vents should furthermore be located so as to avoid the intake of air contaminated by micro-organisms, dust and aerosols.

Keywords: Bioaerosols, airborne microbiota, delicatessen.

4.2. INTRODUCTION

Bioaerosols are defined as viable airborne contaminants resulting from a biological source (Radmore, 1986; Lutgring *et al.*, 1997; Whyte *et al.*, 2001; Beggs, 2002). Emphasis should be placed on microbiological air quality because of the possibility of contamination of food products by pathogenic and spoilage organisms via the air (Cundith *et al.*, 2002). Exposure to pathogens may occur either by direct contact or indirectly through airborne particles (Sattar *et al.*, 2001; Gorman *et al.*, 2002) which may be solid, liquid, carried on another particle or suspended in a liquid droplet (Radmore, 1986). When bacteria, bacterial spores, fungi or fungal spores, antigens, toxins, viruses, plant pollens and faecal material are airborne in a food-processing plant, air can serve as a vehicle for contamination of food and can endanger both worker as well as consumer health (Radmore, 1986; Lutgring *et al.*, 1997; Cundith *et al.*, 2002). Microorganisms can enter the air through a variety of routes; for example respiratory droplets can be dispersed into the atmosphere through talking, breathing, sneezing or coughing, or released into the air from skin, hair and clothing of food handlers and consumers. Dust can furthermore be carried into the building and when water flows into the floor drains, splashing causes small droplets containing microorganisms, to become airborne (Radmore, 1986; Lutgring *et al.*, 1997; Chambers, 2001; Beggs, 2002; Cundith *et al.*, 2002; Gorman *et al.*, 2002; Ammor *et al.*, 2004).

Factors affecting the airborne dispersal of *Staphylococcus aureus* have been studied more intensively than those of other organisms and it has been shown that airborne transmission of bacteria increases the likelihood that infectious disease outbreaks could occur (Sherertz *et al.*, 2001). Likely sources of indoor airborne bacteria include

the food handler and client, although specific bioaerosol sources may develop due to microbial growth in a building's heating, ventilation and air-conditioning systems (Cundith *et al.*, 2002; Pastuszka *et al.*, 2000; Whyte *et al.*, 2001). Higher temperatures and higher relative humidity are in general more conducive to microbial survival and growth. Therefore, temperatures and relative humidity should be managed to reduce the survival and growth of airborne micro-organisms (Lutgring *et al.*, 1997).

This study was firstly aimed at investigating the presence and distribution of bioaerosols in the delicatessen sections (high-risk areas) of a prominent South African retail group. The focus was on indicator organisms related to food premises as they are easily enumerated and are generally being used to assess food hygiene. Secondly, attempts were made to reach conclusions on the origins of particular bioaerosols, taking into consideration the activities in the delicatessen, and thirdly, the environmental parameters impacting on the levels of the bioaerosols were discussed. The study was furthermore aimed at highlighting the importance of bioaerosol sampling to identify potential microbial contamination as this can significantly influence product quality, shelf-life and safety.

4.3 MATERIALS AND METHODS

The management of the selected retail outlet group in the Western Cape Province, South Africa, granted permission to collect and analyse air samples in thirty-five randomly selected delicatessen sections (75% of all outlets) after a confidentiality agreement was established.

4.3.1 Pilot study

A pilot study was conducted in an outlet not included in the actual test sample. The purpose of the pilot study was to determine the most suitable calibration parameter for the air sampler as well as to determine the time requirements, as it was important that the time required for collection was not disruptive to the normal duties (Walker *et al.*, 2003).

4.3.2 Sampling protocol

Each delicatessen was visited once during working hours (week days between 10:00 and 14:00) without previous notification, and all samplings were collected in duplicate. The collected samples were stored and transported at 0ºC before incubation. Upon entering each outlet, the manager was interviewed before commencement of the sample collection in aspects such as the type of air conditioning system used in the delicatessen, the number of persons who had visited the outlet thus far on that particular day, whether it was a normal day as far as the number of clients was concerned, and what the average number of clients was that visited the outlet per day.

4.3.3 Bioaerosol sampling procedures and enumeration of bacteria

The air temperature in the delicatessen was measured using a thermometer (Testo 926). A single stage microbial air sampler was used to collect samples by impaction onto 55 mm Rodac plates (MERCK; SAS Super 90; Clark *et al.*, 1983; Donham *et al.*, 1986; Haglind and Rylander, 1987; Donham *et al.*, 1989; Cormier, 1990; Heedrich,

1991; Thorne *et al.*, 1992; Theron *et al.*, 2004). All removable components of the air sampler were pre-autoclaved and disinfected with 70% ethanol between sampling runs. The air sampler was pre-calibrated at 180 $L.min^{-1}$ prior to sampling. Colonies were differentiated on appearance and colour (Martley *et al.*, 1970; Stadhouers *et al.*, 1978; Manafi and Kneifel, 1989).

Before the results were calculated, the positive-hole method was applied to the results from the air sampler for corrections of microbial coincidence. The probable count (Pr) was then used to calculate the colony-forming units per cubic metre of air sampled (Macher, 1989; Theron *et al.*, 2004).

Total Viable Counts

For the enumeration of Total Viable Counts, Plate Count Agar plates were incubated at 35°C for 24 hours (MERCK, Martley *et al.*, 1970).

Total Coliforms, Escherichia coli and members of the family Enterobacteriaceae

Chromocult Coliform Agar plates were incubated at 35-37°C for 24 hours and typical coliform colonies were salmon to red in colour, whilst typical *Escherichia coli* colonies were dark-blue to violet in colour and other Enterobacteriaceae colonies colourless (MERCK, Kilian and Bülow, 1976; Frampton *et al.*, 1988; Manafi and Kneifel, 1989). *Escherichia coli* (ATCC 25922) and *Enterobacter aerogenes* (ATCC 15038) were used as positive controls whereas a blank plate was used as negative control.

Staphylococcus aureus

Baird Parker Agar plates were incubated at 35ºC for 24-48 hours and typical *Staphylococcus aureus* colonies (black colonies with white margins surrounded by clear zones) were enumerated. The colonies were confirmed using the coagulase test (Staphytect test kit, Oxoid) (MERCK, Niskanen and Aalto, 1978; Stadhouders *et al.*, 1978). *Staphylococcus aureus* (ATCC 25923) was used as positive control and a blank plate as negative control.

4.3.4 Statistical Analysis

Categorical variables were described by frequencies and percentages. Continuous variables were described by means and standard deviations or medians and percentiles where applicable. When comparing organism counts with other studies, the averages were to be used.

The outlets were categorized into two ventilation groups: those with an extractor fan as well as an air conditioner (Group 1) and those with only an extractor fan, air conditioner or fan alone (Group 2). The organism counts, average number of clients visiting per day and air temperature between the two types of ventilation groups used, were compared by the Mann-Whitney test and 95% non-parametric confidence intervals where statistical significance was found (Altman *et al.*, 2000; SAS/STAT, 1989). The number of clients who had visited the outlet up to a specific time on specific days, were categorized into three groups, namely below normal (Group 1), normal (Group 2) and above normal (Group 3). This information was provided by the manager. The organism counts of the three groups were compared according to the

Kruskal-Wallis test, as well as ANOVA and 95% simultaneous confidence intervals for the mean difference, as no non-parametric method exists for the latter (SAS/STAT, 1989).

Data were analysed in collaboration with the Department of Biostatistics, University of the Free State using Statistical Analysis Systems (SAS/STAT, 1989) and Confidence Interval Analysis. Reported data are the means of duplicate repetitions at each sampling point (Theron *et al.*, 2004).

4.4 RESULTS AND DISCUSSION

4.4.1 Total Viable Counts

The distribution of Total Viable Counts in the delicatessen sections is shown in Fig. 4.1(A) and ranged between 1.5×10^{1} cfu.m^{-3} (the lowest count, outlet 34) and 4.19×10^{2} cfu.m^{-3} (the highest count, outlet 1). Although very little data is available on bioaerosols in food premises in general, Shale *et al.* (2004) performed a survey on the distribution of staphylococci in bioaerosols which indicated that the average TVC enumerated in various red meat abattoirs were: 1.3×10^{2} cfu.m^{-3}; 1×10^{3} cfu.m^{-3}; 3×10^{2} cfu.m^{-3} and 3.1×10^{2} cfu.m^{-3} respectively. These counts did not exceed the guideline which was suggested by Jensen and Shafer (1998), however, Figure 4.2 shows that these counts are considerably higher when compared with the mean of 1.34×10^{2} cfu.m^{-3} in this study.

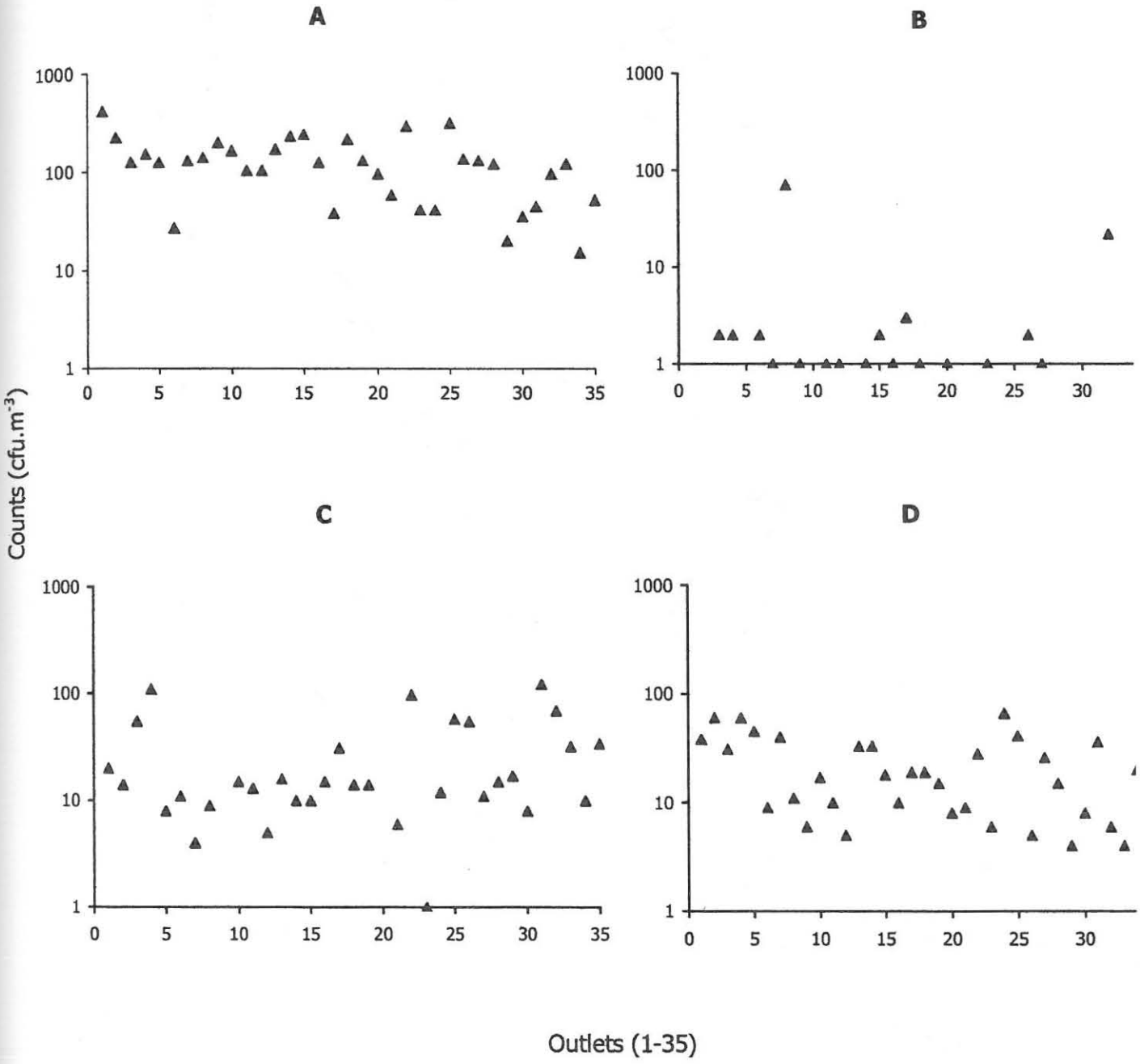

Fig. 4.1 The patterns of Total Viable Counts (A), Total Coliforms (B), Enterobacteriaceae (C) a *Staphylococcus aureus* (D) in the air of delicatessen sections of a retail group

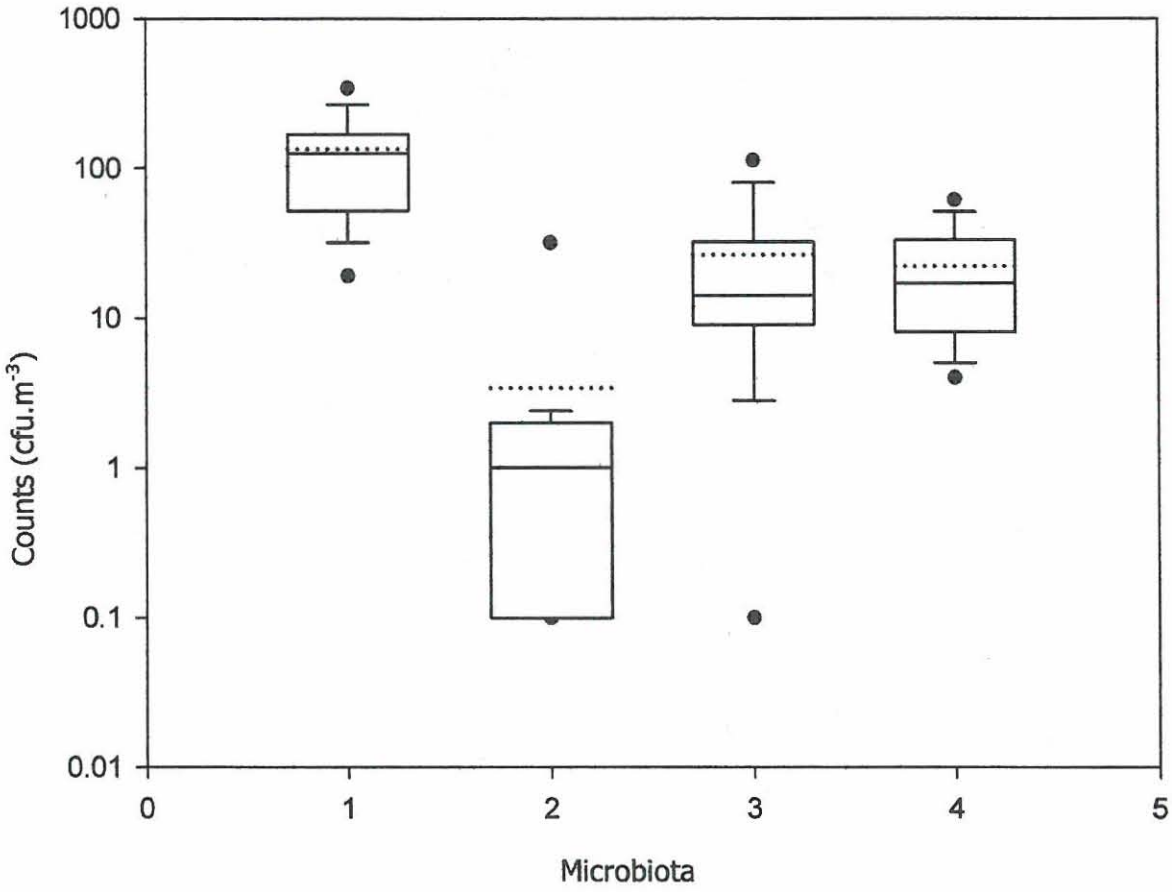

Fig. 4.2 Occurence of airborne microbial populations in the air delicatessens: each box plot represents the 5th and 95th percentiles (dots below and above box), 25th and 75th percentiles (bottom and top of box), the median (solid line inside box), the mean (dotted line), and the standard deviation (short solid lines outside box) of Total Viable Counts (1), Total Coliforms (2), Enterobacteriaceae (3) and *Staphylococcus aureus* (4)

4.4.2 Total Coliform Count, *Escherichia coli* and members of the family Enterobacteriaceae

The presence of enteric bacteria, such as Total Coliforms and *Escherichia coli* has been widely accepted as an indicator of faecal contamination and therefore an indicator of the possible presence of pathogens of enteric origin (Department of Health, 2000). As shown in Figure 4.1(B), Total Coliforms were undetected in 33 outlets and isolated from only two outlets: outlet 8 (7.1×10^1 cfu.m^{-3}) and outlet 32 (2.2×10^1 cfu.m^{-3}). Although *E. coli* is an acknowledged indicator for faecal contamination and for the possible presence of enteric pathogens (Gill *et al.*, 1996), the distribution of *E. coli* in this study can be considered negligible.

Diarrhoea caused by enterobacteria is a common problem in the United States, where each person in the general population has an average of 1.5 episodes of diarrhoea each year. Enterobacterial infections are furthermore one of the two leading killers of children in developing countries (Frey, 2004). Enterobacterial infections are disorders of the digestive tract and related organ systems, caused by a group of Gram-negative, rod-shaped bacteria called Enterobaceriaceae (Frey, 2004). Prevalence of high numbers of Enterobacteriaceae usually stem from faecal contamination and their occurrence in high numbers may indicate, amongst other, poor hygienic practices of workers (Department of Health, 2000). For the purpose of this study, Enterobacteriaceae are defined as members of the genera *Salmonella*, *Shigella*, *Yersinia*, *Proteus* and *Klebsiella* (excluding Total Coliform Counts and *E. coli*) amongst others, and therefore present a holistic view of the presence of these organisms in the air (Nel *et al.*, 2004). *Salmonella* sp. can be carried in contaminated

aerosols or on dust particles and dust can continue to harbour viable *Salmonella* even after cleaning and disinfection (Gast *et al.*, 1998).

With the exception of four outlets where no airborne Enterobacteriaceae were detected, the levels of these organisms ranged from 5 cfu.m^{-3} to 1.22 x 10^{2} cfu.m^{-3} (Fig. 4.1C). A study done by Theron *et al.* (2004) regarding the quantification of bioaerosols in automated chicken egg production plants indicated an average bioaerosol concentration of 6.6 x 10^{1} cfu.m^{-3} for culturable presumptive *Salmonella*. This count is much higher than the mean value of 2.6 x 10^{1} cfu.m^{-3} found in this study (Fig. 4.2). According to SABS 049 (2001), the air of food premises should be clean and free from excessive levels of bacteria. It is also essential to eliminate or control conditions that could lead to the spreading of airborne or foot-borne soil.

4.4.3 *Staphylococcus aureus*

The distribution of *Staphylococcus aureus* in the air of the delicatessens was undetectable in 2 outlets and the remainder ranged from 5 cfu.m^{-3} to 6.6 x 10^{1} cfu.m^{-3} (Fig. 4.1D). A study done by Shale *et al.* (2004) on the distribution of staphylococci in bioaerosols associated with red meat abattoirs showed average counts of 8 cfu.m^{-3}; 1.6 x 10^{2} cfu.m^{-3}; 3 x 10^{1} cfu.m^{-3} and 2.4 x 10^{1} cfu.m^{-3}. These counts are much higher when compared to the results of this study, with a mean value of 2.2 x 10^{1} cfu.m^{-3} (Fig. 4.2). According to Jensen and Schafer (1998), and Shale *et al.* (2004) relatively low numbers of *S. aureus* do not necessarily indicate a clean and healthy environment as counts of less than 1 x 10^{2} cfu.m^{-3} bacterial aerosols have been shown to be unhealthy for immuno-suppressed individuals even in cases where those aerosols are regarded as ubiquitous.

Staphylococcus aureus is often encountered as part of the normal microbiota of the human skin, the upper respiratory tract and the intestinal tract. Staphylococci have previously been isolated from the air, dust, sewage and food, and on food equipment, animals and environmental surfaces (Wieser and Busse, 2000; O'Brien, 2002; Nel *et al.*, 2004). Transmission of the organism to food is frequently achieved by direct contact with an infected food handler, but it may also be airborne (Bachert *et al.*, 2002). Large numbers of *Staphylococcus aureus* can be dispersed into the air from skin and clothing through friction and movement (Sherertz *et al.*, 2001). Furthermore, the detection of high levels of *Staphylococcus* microorganisms are an indication of over-crowding and inadequate ventilation (Jensen and Schafer, 1998).

4.4.4 Relationships between bioaerosol counts and selected physical parameters

According to the Health Regulations (Republic of South Africa, 1999), a food premises should be effectively ventilated to facilitate the effective removal of polluted or stale air from the food handling area to the extent that air contaminants that could contaminate food are effectively removed. In this study, general information regarding each outlet was collected which included: temperature; type of air conditioning used; number of clients that visited the outlet thus far on the particular day of sampling; whether it was a normal day as far as the number of clients was concerned or not; and the average number of clients that visited the outlet per day (Table 4.1 and Table 4.2). This data was collected to determine the relationships between the bioaerosol counts and selected physical parameters of the delicatessen sections. Such relationships were statistically calculated in an attempt to cast light on these

Table 4.1 General information collected from outlets (*n*=35)

	Temperature (°C)	Number of clients today *	Average number of clients/day
Minimum	18	63	200
Maximum	25	2000	5792
Average	21.91	869	2676
Standard Deviation	1.57	643	1307

* day of sampling

Table 4.2 Ventilation groups identified in the outlets (n=35)

Extractor fan (%) (Group 2)	Air conditioner (%) (Group 2)	Extractor fan and air conditioner (%) (Group 1)	Fan(%) (Group 2)
57.14	2.86	37.14	2.86

parameters that had the most profound influence on the bioaerosols and could thus provide solutions as to their adjustment or optimisation.

No statistically significant difference in the average number of clients visiting per day could be found between the two ventilation groups (P=0.88). The median (interquartile range) of group 1: extractor fan and air conditioner (n=13) was 2692 (2500-3000) and for group 2: extractor fan or air conditioner or fan (n=22) was 2500 (200-3501). No statistically significant difference in air temperature (P=0.22) could be found between the three categories of number of clients thus far on the day of sampling. Furthermore, no difference between the type of ventilation group used and the above categories existed (P=0.52) and air temperature was found not to differ between the two ventilation groups (P=0.36). Since no relationship occurred between the above variables, organism counts were compared separately between the three categories of clients and two ventilation groups. With regard to Total Viable Counts, statistically significant differences were found between the two ventilation groups (Group 1: extractor fan and air conditioner and Group 2: extractor fan or air conditioner or fan). The median values were 52 and 132 respectively, with a P-value of 0.04, and a 95% non-parametric confidence interval [4; 108]. With regard to the number of persons visiting the outlets thus far on the particular day of sampling, no significant difference was found (P=0.64). In this study, no significant difference could similarly be found with regard to the levels of *Staphylococcus aureus* between the two different ventilation groups (P=0.75) and the number of persons visiting the outlets thus far on the particular day of sampling (P=0.23).

When comparing Total Coliforms to the variables listed in Table 4.1 and Table 4.2, no statistically significant difference could be found between the two ventilation

groups (Mann-Whitney P=0.01) or the number of persons visiting the outlets thus far on the particular day of sampling (P=0.35). When comparing the Enterobacteriaceae counts between the two ventilation groups no statistically significant difference was found (P=0.67). However, the counts differed significantly between the three groups of visitors when comparing them parametrically (P<0.0001) and non-parametrically (P=0.008). The mean Enterobacteriaceae counts were 10.3 cfu.cm^{-3} for Group 1 (below normal day); 26.04 cfu.cm^{-3} for Group 2 (normal day) and 109.5 cfu.cm^{-3} for Group 3 (above normal day).

Since no method for calculating simultaneous confidence intervals for the median difference between the three groups exists, 95% simultaneous confidence intervals for the mean differences were calculated. According to these confidence intervals, no statistically significant difference could be detected between those outlets which had a below normal day (Group 1) and those which had a normal day (Group 2). When comparing the busiest outlets (Group 3) with the two other outlets separately, statistically significant differences were found, with the average difference in counts between the busiest outlets (Group 3) and the below normal outlets (Group 1) higher than the average difference between the busiest outlets (Group 3) and the normal outlets (Group 2) (Table 4.3).

The above mentioned inferential statistics suggest that abnormally busy days lead to statistically significant higher counts when compared to normal and below normal days. This should however be interpreted with caution, as only two outlets had an abnormally busy day and the groups were compared according to parametric confidence intervals. No statistically significant differences occurred between the bioaerosol counts and the selected physical parameters of the delicatessen sections,

Table 4.3 Comparisons of Enterobacteriaceae counts between the three categories of visitors

Groups compared			Difference between means	Simultaneous 95% confidence intervals	
* 3	minus	2	83.46(109.5-26.04)	42.42	124.49
3	minus	1	99.20(109.5-10.3)	56.09	142.32
** 2	minus	1	15.74(26.04-10.3)	-5.34	36.83

* When repeating the study in another sample in the same population, the certainty is 95% that the difference in Enterobacteriaceae counts (busiest outlet minus normal outlet) will be between 42.42 and 124.49. This means that one can be 95% sure that the Enterobacteriaceae counts in the busiest outlets will be at least 42.42 counts higher than in the normal outlets and it can be as much as 124.49 counts higher

** The value of zero is included in the confidence interval indicating that there is no statistical significant difference between the normal and below normal groups

except for the Total Viable Counts that differed significantly between the two ventilation groups and Enterobacteriaceae counts that differed significantly between the three groups of visitors. With regard to Total Viable Counts and the two ventilation groups, counts could be influenced by factors such as building maintenance as well as bacterial or fungal growth in the environment. According to Krieg and Holt (1984), Enterobacteriaceae are distributed worldwide and are found in soil, water, fruits, vegetables, grains, flowering plants and trees, and in animals from insects to man. It is therefore likely to believe that visitors could carry bioaerosol contaminants on clothes or skin.

Since the only statistically significant relationships between bioaerosol counts and the selected physical parameters of the delicatessen sections found in this study were with regard to (1) Total Viable Counts and the two ventilation groups and (2) Enterobacteriaceae counts and the three groups of visitors, the occurrence of these organisms is likely to be related to environmental influences rather than the type of ventilation, temperature and number of clients visiting the outlets. Environmental regulating mechanisms should be adapted in order to minimise bioaerosol counts and ventilation systems should be adequately maintained and cleaned. It is furthermore important to establish whether air-intake vents of ventilation systems are at least one metre above the internal floor levels as well as one metre above outside surfaces and whether such air-intake vents are fitted with fly screens and dust filters. Air-intake vents should in addition be located so as to avoid the intake of air contaminated by micro-organisms, dust, aerosols, etc. (SABS 049, 2001).

4.5 REFERENCES

Altman, D.G., Machin, D., Bryant, T.N. and Gardner, M.J. (2000). *Statistics with confidence* (2nd ed.). Bristol.

Ammor, S., Chevallier, I., Laguet, A., Labadie, J., Talon, R. and Dufour, E. (2004). Investigation of the selective bacterial effect of several decontaminating solutions on bacterial biofilms including useful, spoilage and/or pathogenic bacteria. *Food Microbiology, 21(1)*, 11-17.

Bachert, C., Gevaent, P. and Van Cauwenberge, P. (2002). *Staphylococcus aureus* enterotoxins: a key in airway disease? *Allergy, 57*, 480-487.

Beggs, C. (2002). *The use of engineering measures to control airborne pathogens in hospital buildings.* School of Civil Engineering. Leeds University: Leeds.

Chambers, H.F. (2001). The changing epidemiology of *Staphylococcus aureus*. *Emerging Infectious Diseases 7*, 178-182.

Clark, S., Rylander, R. and Larson, L. (1983). Airborne bacteria, endotoxins and fungi in dust in poultry and swine buildings. *American Industrial Hygiene Association Journal, 44*, 537-541.

Cormier, Y., Tremblay, G., Meriaux, A., Brochu, G. and Lavoie, J. (1990). Airborne microbial contents in two types of swine confinement buildings in Quebec. *American Industrial Hygiene Association Journal, 51*, 304-309.

Cundith, C.J., Kerth, C.R., Jones, W.R., McCaskey, T.A. and Kuhlers, D.L. (2002). Air-cleaning system effectiveness for control of airborne microbes in a meat-processing plant. *Journal of Food Science, 67(3),* 1170-1174.

Department of Health, South Africa. (2000). Guidelines for environmental health officers on the interpretation of microbiological analysis data of food. Directorate: Food Control. Government Printer, Pretoria.

Donham, K.J., Haglind, P., Peterson, Y., Rylander, R. and Belin, L. (1989). Environmental and health studies of farm workers in Swedish swine confinement buildings. *British Journal of Industrial Medicine, 46*, 31-37.

Donham, K.J., Popendorf, W., Palmgren, U. and Larson, L. (1986). Characterization of dusts collected from swine confinement buildings. *American Journal of Industrial Medicine, 10*, 294-297.

Frampton, E.W., Restaino, L. and Blaszko, L. (1988). Evaluation of β-glucuronidase substrate 5-bromo-4-chloro-3indol-β-D-glucuronide (X-GLUC) in a 24 hour direct plating method for *Escherichia coli*. *Journal of Food Protection, 51*, 402-404.

Frey, R.J. (2004). Enterobacterialinfections. Available: http://www.ehendrick.org/healthy/00488.htm Accessed 2004-05-08.

Gast, R.K., Mitchell, B.W., and Holt, P.S. (1998). Airborne transmission of *Salmonella enteritidis* infection between groups of chicks in controlled-environment isolation cabinets. *Avian diseases 42*, 315-320.

Gill, C.O., McGinnis, J.C. and Badoni, M. (1996). Use of total or *Escherichia coli* counts to assess the hygienic characteristics of a beef carcass dressing process. *International Journal of Food Microbiology, 31*, 181-196.

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

Haglind, P. and Rylander, R. (1987). Occupational exposure and lung measurements among workers in swine confinement buildings. *Journal of Occupational Medicine, 29*, 904-907.

Heedrich, D., Brouwer, R., Biersteker, K. and Boleij, J.S.M. (1991). Relationship of airborne endotoxins and bacteria levels in pig farms with the lung function and respiratory symptoms of farmers. *International Archives of Occupational and Environmental Health, 62*, 595-601.

Jensen, P.A. and Schafer, M. (1998). Sampling and characterizing of bioaerosols. *NIOSH Manual of Analytical Methods.* Section J, pp82-100.

Kilian, M. and Bülow, P. (1976). Rapid diagnosis of Enterobacteriaceae. *Acta Pathologica et Microbiologica Scandinavica Section B, 84*, 245-251.

Krieg, N.R. and Holt, J.G. (1984). *Bergey's Manual of Systematic Bacteriology.* Volume 1. Williams & Wilkens, Baltimore, U.S.A.

Lutgring, K.R., Linton, R.H., Zimmerman, N.J., Peugh, M. and Heber, A.J. (1997). Distribution and quantification of bioaerosols in poultry slaughtering plants. *Journal of Food Protection, 60(7)*, 804-810.

Macher, J. (1989). Positive hole correction of multiple-jet impactors for collecting viable micro-organisms. *American Industrial Hygiene Association Journal, 50*, 561-565.

Manafi, M. and Kneifel, W. (1989). A combined chromogenic-fluorogenic medium for the simultaneous detection of total coliforms and *Escherichia coli* in water. *International Journal of Hygiene and Environmental Medicine, 189*, 225-234.

Martley, F.G., Jayashankar, S.R. and Lawrence, R.C. (1970). An improved agar medium for the detection of proteolytic organisms in total bacterial counts. *Journal of Applied Bacteriology, 33*, 363-370.

Nel, S., Lues, J.F.R., Buys, E. and Venter, P. (2004). Bacterial populations associated with meat from the deboning room of a high throughput red meat abattoir. *Meat Science, 66*, 667-674.

Niskanen, A. and Aalto, M. (1978). Comparison of selective media for coagulase-positive enterotoxigenic *Staphylococcus aureus*. *Applied Environmental Microbiology, 35*, 1233-1236.

O'Brien, S. (2002). *Staphylococcus aureus*. Available: http://users.aber.ac.uk/smo1/staphylococcus%20aureus.doc Accessed 2004-05-08.

Pastuszka, J.S., Kyaw Tha Paw, U., O. Lis, D., Wlazlo, A. and Ulfig, K. (2000). Bacterial and fungal aerosol in indoor environment in Upper Silesia, Poland. *Atmospheric Environment 34*, 3833-3842.

Radmore, K. (1986). A microbiological study of the air in dairy processing and packaging plants. M.Sc. Thesis, unpublished.

Republic of South Africa. (1999). Regulation 918 of 1999: Health Regulations governing general hygiene requirements for food premises and the transport of food, promulgated under the Health Act No. 63 of 1977. Government Printer, Pretoria.

SABS 049. (2001). *South African Bureau of Standards, Code of Practice: Food Hygiene Management* (3rd ed.). Pretoria.

SAS/STAT. (1989). User's Guide (4th ed.), Volumes 1 and 2, Version 6. Cary, NC: SAS Institute Inc.

Sattar, S.A., Springthorpe, S., Mani, S., Gallant, M., Nair, R.C., Scott, E. and Kain, J. (2001). Transfer of bacteria from fabrics to hands and other fabrics: development and application of a quantitative method using *Staphylococcus aureus* as model. *Journal of Applied Microbiology, 90,* 962-970.

Shale, K., Lues, J.F.R., Buys, E. and Venter, P. (2004). The distribution of staphylococci bioaerosols from red meat abattoirs. *Food Microbiology, 22,* 433-438.

Sherertz, R.J., Bassetti, S. and Bassetti-Wyss, B. (2001). "Cloud" Health-Care Workers. *Emerging Infectious Diseases, 7(2),* 241-244.

Stadhouders, J., Hassings, F. and Van Aalsten-Van Maren, N.O. (1978). A pour-plate method for the detection and enumeration of coagulase-positive *Staphylococcus aureus* in the Baird-Parker Medium without egg-yolk. *Netz Milk Dairy Journal, 30,* 222-229.

Theron, H., Lues, J.F.R. and Venter, P. (2004). The quantification of bioaerosols in automated chicken egg production plants. *Accepted for publication: Poultry Science.*

Thorne, P.S., Kiekhaefer, M.S., Whitten, P. and Donham, K.J. (1992). Comparison of bioaerosol sampling methods in barns housing swine. *Applied Environmental Microbiology, 58,* 2543-2551.

Walker, E., Pritchard, C. and Forsythe, S. (2003). Food handlers' hygiene knowledge in small food businesses. *Food Control, 14,* 339-343.

Wieser, M. and Busse, H.J. (2000). Rapid identification of *Staphylococcus epidermidis. International Journal of Systematic and Evolutionary Microbiology, 50,* 1087-1093.

Whyte, P., Collins, J.D., McGill, K., Monahan, C. and O'Mahony, M. (2001). Distribution and prevalence of airborne micro-organisms in the commercial poultry processing plants. *Journal of Food Protection, 64*, 388-391.

CHAPTER 5

ASSESSING RELATIONSHIPS BETWEEN MICROBIOTA AND FOOD HANDLER PRACTICES IN DELICATESSEN SECTIONS: A NOVEL APPROACH

Epidemiological research data provide a useful indication of the types of malpractice contributing to food-borne illnesses, although such data does not always tell us why or how these incidents occur – the so-called underlying causes (Clayton *et al.*, 2002). In the present study, the interactions between microbiota and food handler practices were investigated in order to establish exact relationships between practices and microbial contamination. The benefits of such comparisons include, amongst others, the possibility of consultation with managers concerning practices that have definite effects on patterns of microbial contamination so that corrective action can be introduced accordingly. Furthermore, such information adds to the understanding of the effects of handling and process activities on microbial contamination and proliferation. The microbiota analysed included Total Viable Counts, Total Coliforms, *Escherichia coli*, members of the Family Enterobacteriaceae and *Staphylococcus aureus.* Variables were described by means, standard deviations, medians and percentiles. Various groups of food handler practices were identified and compared with microbial counts on hands and/or aprons of food handlers by means of the Kruskal-Wallis and Mann-Whitney tests (SAS/STAT, 1989). This data was collected and interpreted in Chapters 2 and 3 of this study and the variables selected for comparison were those that emanated as possible points of concern. Selected variables were compared based on their expected effects/influences on one another. For example, it is well documented that practices related to toilet use might influence the numbers of faecal-related organisms associated with food handlers, and the level of personal hygiene is certainly likely to impact on the prevalence of *Staphylococcus* sp.

The Health Regulations (Republic of South Africa, 1999) prescribe that a hand-washing facility and hot and/or cold water together with a supply of soap be

available for the washing of hands by workers on a food premises. A simple wash with soap and water has shown to be sufficient to remove large numbers of salmonella organisms on contaminated hands (Cruickshank, 1990). In Table 5.1, the organism counts on hands were compared with the three practices of hand washing as discussed in Chapter 2, which included: cold water, soap and a nailbrush (Group 1); hot water, soap and a nailbrush (Group 2) and hot and cold water and soap (Group 3). The *P*-values remained above 0.01 (Table 5.1) and therefore no statistically significant differences could be found between the numbers of organisms (Total Viable Counts [P=0.41], Total Coliforms [P=0.50], *Escherichia coli* [P=0.14], members of the Family Enterobacteriaceae [P=0.18] and *Staphylococcus aureus* [P=0.55]) and the three means of hand washing (Group 1: cold water, soap and a nailbrush; Group 2: hot water, soap and a nailbrush; Group 3: hot and cold water and soap). Therefore the various means of hand washing identified in this study appeared to be equally effective. A simple wash with hot and/or cold water and soap was found to be sufficient and the use of nailbrushes showed no effect. The possibility should be borne in mind, however, that respondents who indicated that they used nail brushes when washing their hands, might have failed to do so on the particular day of sampling.

Cleaning of surfaces should remove food residues and dirt which could be sources of contamination (Codex Alimentarius, 1997). The organism counts on hands were consequently compared with the means of cleaning of surfaces in the delicatessens (Table 5.2). In this study, two means of cleaning of surfaces were assessed. Group 1 was identified as using cold water and detergent and Group 2 as using hot water and detergent. No statistically significant differences were found between the two groups for Total Viable Counts (P=0.38), Total Coliforms (P=0.68), *Escherichia coli*

Table 5.1 Differences amongst organism counts on hands: three means of hand washing

Groups	* *n*	$\bar{X}$	SD	Min/Max	Median (Inter-quartile range)	*P*
Total Viable Counts						
Group 1	8	40	33	7-88	32(12-67)	0.41
Group 2	22	26	20	5-78	29(6-36)	
Group 3	20	22	15	2-59	21(10-34)	
Coliforms						
Group 1	8	3	3	0-8	2(1-4)	0.50
Group 2	22	3	4	0-13	1(0-7)	
Group 3	20	2	4	0-13	1(0-4)	
Escherichia coli						
Group 1	8	0	0	0	0	0.14
Group 2	22	0	2	0-8	0	
Group 3	20	0	0	0	0	
Enterobacteriaceae						
Group 1	8	6	7	0-18	4(1-12)	0.18
Group 2	22	5	5	0-16	5(1-8)	
Group 3	20	3	5	0-16	1(0-6)	
Staphylococcus aureus						
Group 1	8	38	31	3-98	33(14.5-55)	0.55
Group 2	22	26	25	2-88	14(7-50)	
Group 3	20	29	25	2-90	22(9-44)	

* *n*=number of respondents; $\bar{X}$ =mean organism count (all organisms enumerated as cfu.cm^2); SD=Standard Deviation; Interquartile range: 25th-75th percentiles, *P* =Significance

Table 5.2 Differences amongst organism counts on hands: means of cleaning surfaces

Groups	* *n*	$\bar{X}$	SD	Min/Max	Median (Inter-quartile Range)	*P*
Total Viable Counts						
Group 1	11	24	22	5-78	20(6-35)	0.38
Group 2	39	28	21	5-88	24(10-38)	
Coliforms						
Group 1	11	3	4	0-13	1(0-5)	0.68
Group 2	39	8	4	0-13	1(0-4)	
Escherichia coli						
Group 1	11	0	0	0	0	0.37
Group 2	39	0	1	0-8	0	
Enterobacteriaceae						
Group 1	11	4	5	0-16	1(0-6)	0.60
Group 2	39	5	5	0-18	3(1-8)	
Staphylococcus aureus						
Group 1	11	19	18	2-63	14(7-23)	0.17
Group 2	39	32	27	2-98	25(10-52)	

* *n*=number of respondents; $\bar{X}$=mean organism count (all organisms enumerated as cfu.cm^2); SD=Standard Deviation; Interquartile range: 25th-75th percentiles, *P*=Significance

(P=0.37), Enterobacteriaceae (P=0.60) or *Staphylococcus aureus* (P=0.17). These results indicated that the temperature of the water used for cleaning of surfaces did not play a significant role (when used with detergent) with regard to organism counts found on hands.

Food hygiene training is fundamentally important and food handlers should boast the necessary knowledge and skills to enable them to handle food hygienically (Codex Alimentarius, 1997). Clayton *et al.* (2002) suggest that there is no simple link between training, knowledge and food safety practices and the barriers preventing food handlers from implementing food safety practices need to be taken into consideration when strategies are developed to change food handling practices. In Table 5.3, the organism counts on aprons were compared between the respondents who indicated that they had received training in personal hygiene and those who had never received training in aspects of personal hygiene. No statistically significant differences were found for Total Viable Counts, Total Coliforms, *Escherichia coli* or *Staphylococcus aureus* between respondents who had and those who never had received training in personal hygiene (P>0.01). However, a statistically significant difference occurred with regard to Enterobacteriaceae counts on aprons (P=0.01) between respondents who had received and those who never had received such training. It was, however, interesting to note that respondents who had received training proved to have higher Enterobacteriaceae counts on their aprons in particular. The maximum values of the organism counts were also much higher for respondents who had received training in personal hygiene (Table 5.3). Although one would expect respondents who had received training to have lower organism counts on their aprons, it may be possible that such individuals are more aware of the wiping of hands and utensils against aprons.

Table 5.3 Differences amongst organism counts on aprons and differences amongst organism counts on hands: training in personal hygiene

Groups	* *n*	$\bar{X}$	SD	Min/Max	Median (Inter-quartile Range)	*P*
Total Viable Counts						
Aprons	42	16	15	1-79	13(6-19)	0.98
	8	16	13	4-43	11(8-22)	
Hands	42	26	20	2-88	25(9-36)	0.59
	8	32	28	6-88	20(14-49)	
Coliforms						
Aprons	42	1	2	0-9	1(0-1)	0.10
	8	2	2	0-6	1(1-3)	
Hands	42	3	4	0-13	1(0-5)	0.83
	8	2	2	0-5	1(1-3)	
Escherichia coli						
Aprons	42	0	0	0	0	1
	8	0	0	0	0	
Hands	42	0	1	0-8	0	0.46
	8	0	0	0	0	
Enterobacteriaceae						
Aprons	42	3	5	0-29	1(1-3)	0.01
	8	0	1	0-2	0(0-1)	
Hands	42	4	5	0-16	3(1-6)	0.62
	8	7	7	0-18	5(1-14)	
Staphylococcus aureus						
Aprons	42	10	14	1-62	4(2-9)	0.76
	8	11	15	1-45	7(2-11)	
Hands	42	25	21	2-71	16(7-41)	0.06
	8	53	36	5-98	48(25-89)	

* *n*=number of respondents; $\bar{X}$=mean organism count (all organisms enumerated as cfu.cm^2); SD=Standard Deviation; Interquartile range: 25th-75th percentiles; *P*=Significance

In addition, Table 5.3 compares the organism counts on hands between respondents who had received training in personal hygiene and those who had never received training in personal hygiene. No statistically significant differences were found for Total Viable Counts (P=0.59), Total Coliforms (P=0.83), *Escherichia coli* (P=0.46), Enterobacteriaceae (P=0.62) or *Staphylococcus aureus* (P=0.06) between respondents who indicated that they had received training in personal hygiene and those who indicated that they had received no training. Because organism counts on hands were relatively low as indicated in Chapter 3, one would assume that respondents who had never received training in personal hygiene followed, through observation, the example of those who had received training. This might explain the fact that no statistically significant differences occurred as mentioned above (P>0.01).

Training in food hygiene will only be effective if systems are in place to encourage food handlers to implement good practice, and when the effectiveness of a training program is dependent on the attitude of managers and the hygiene culture of an organisation (Clayton *et al.*, 2002). In Table 5.4, the differences amongst organism counts on aprons are shown in relation to general hygiene training. Forty-two respondents indicated that they had received training in general hygiene, while seven respondents indicated that they had never received training (Chapter 2). Except for Enterobacteriaceae counts (P=0.01) that differed significantly between the two groups, no statistically significant differences were found for organism counts between respondents who indicated that they had received training and those who never had received training in general hygiene (Table 5.4). Enterobacteriaceae counts were found to be higher on aprons of respondents who indicated that they had received training in general hygiene and the maximum organism count values

Table 5.4 Differences amongst organism counts on aprons and differences amongst organism counts on hands: training in general hygiene

Groups	* *n*	$\bar{X}$	SD	Min/Max	Median (Inter-quartile Range)	*P*
Total Viable Counts						
Aprons	42	17	16	1-79	13(6-19)	0.66
	7	12	8	4-26	10(6-17)	
Hands	42	26	20	2-88	25(9-36)	0.94
	7	29	28	6-88	17(13-39)	
Coliforms						
Aprons	42	1	2	0-9	1(0-1)	0.10
	7	2	2	0-6	1(1-3)	
Hands	42	3	4	0-13	1(0-5)	0.79
	7	2	2	0-5	1(1-4)	
Escherichia coli						
Aprons	42	0	0	0	0	1
	7	0	0	0	0	
Hands	42	0	1	0-8	0	0.46
	7	0	0	0	0	
Enterobacteriaceae						
Aprons	42	3	5	0-29	1(1-3)	0.01
	7	0	1	0-2	0	
Hands	42	5	5	0-16	3(1-7)	0.98
	7	6	7	0-18	1(0-14)	
Staphylococcus aureus						
Aprons	42	10	14	1-62	4(2-9)	0.85
	7	6	5	1-12	6(1-10)	
Hands	42	24	21	2-71	16(7-41)	0.10
	7	54	39	5-98	45(10-90)	

* *n*=number of respondents; $\bar{X}$ =mean organism count (all organisms enumerated as cfu.cm^2); SD=Standard Deviation; Interquartile range: 25th-75th percentiles; *P*=Significance

were also higher. When organism counts on hands were compared between respondents who had received training in general hygiene and those who had never received general hygiene training, no statistically significant differences could be found ($P>0.01$) (Table 5.4). If the training received were sufficient, one would have expected to find significantly lower organism counts on the hands of those respondents who had received training in general hygiene.

The Codex Alimentarius (1997) and the Health Regulations (Republic of South Africa, 1999) specify that food handlers should maintain a high degree of personal cleanliness and should wear suitable and clean protective clothing which should at all times during the handling of food be in such a clean condition and of such design and material that it cannot contaminate food. Table 5.5 shows the relationships amongst organism counts on aprons and the frequency of replacing aprons (Group 1 is defined as respondents who replaced their aprons with clean ones once per day and Group 2 as respondents who replaced their aprons with clean ones two to more than five times per day). No statistically significant differences were found for Total Viable Counts, Total Coliforms, *Escherichia coli*, Enterobacteriaceae or *Staphylococcus aureus* between respondents who replaced their aprons once per day (Group 1) and those who had replaced their aprons two to more than five times per day (Group 2) (Table 5.5). Because no statistically significant differences were found for organism counts on aprons between respondents who replaced their aprons once per day and those replacing it two to more than five times per day, this data suggests that aprons should only be replaced when dirty, but at least once per day.

Table 5.5 Differences amongst organism counts on aprons: replacing of aprons

Groups	* *n*	$\bar{X}$	SD	Min/Max	Median (Inter-quartile Range)	*P*
Total Viable Counts						
Group 1	18	13	10	1-43	11(6-19)	0.51
Group 2	32	18	17	1-79	12(9-20)	
Coliforms						
Group 1	18	1	1	0-2	0(0-1)	0.08
Group 2	32	1	2	0-9	1(0-2)	
Escherichia coli						
Group 1	18	0	0	0	0	1
Group 2	32	0	0	0	0	
Enterobacteriaceae						
Group 1	18	2	3	0-11	1(1-2)	0.86
Group 2	32	2	6	0-29	1(0-3)	
Staphylococcus aureus						
Group 1	18	11	17	1-62	3(2-10)	0.57
Group 2	32	9	13	1-46	5(2-10)	

* *n*=number of respondents; $\bar{X}$=mean organism count (all organisms enumerated as cfu.cm^2); SD=Standard Deviation; Interquartile range: 25th-75th percentiles; *P*=Significance

According to local legislation, no food handler is allowed to touch ready-to-consume non-prepacked food with his or her bare hands, unless it is unavoidable for preparation purposes, in which case such food should be handled in accordance with good manufacturing practices (Republic of South Africa, 1999). Transfer of bacteria from contaminated surfaces or hands to cooked food is a contributing factor in many outbreaks of food poisoning and the importance of cross-contamination should not be underestimated (Tebbutt, 1984). The difference amongst organism counts on aprons in relation to the replacing of gloves is shown in Table 5.6. Four respondents replaced their gloves two to five times per day, while forty-six respondents replaced their gloves more than five times per day (Chapter 2). No statistically significant differences were found for Total Viable Counts (P=0.39); Total Coliforms (P=0.75), *Escherichia coli* (P=1), Enterobacteriaceae (P=0.97) or *Staphylococcus aureus* (P=0.29) between those respondents replacing their gloves two to five times per day and those who replaced their gloves more than five times per day (Table 5.6). In addition, with regard to the relationship between organism counts on hands and the replacing of gloves (two to five times per day and more than five times per day), no statistically significant differences were found (P>0.01). Although the organism counts on aprons and on hands in relation to the replacing of gloves showed no statistically significant differences, it should be kept in mind that gloves can be sources of cross-contamination just as much as unwashed hands, and the importance of replacing gloves frequently should be emphasised.

It became evident from the data in this chapter that the only relationship between microbiota and food handler practices identified in this study, was with regard to training in personal and general hygiene which showed in two instances (Enterobacteriaceae on aprons) that training actually had a detrimental effect on the

Table 5.6 Differences amongst organism counts on aprons and differences amongst organism counts on hands: replacing of gloves

Groups	* *n*	$\bar{X}$	SD	Min/Max	Median (Inter-quartile Range)	*P*
Total Viable Counts						
Aprons	4	10	3	6-14	9(8-12)	0.39
	46	17	15	1-79	13(6-20)	
Hands	4	32	34	6-78	23(6-59)	0.99
	46	26	20	2-88	24(10-36)	
Coliforms						
Aprons	4	2	2	0-4	1(0-3)	0.75
	46	1	2	0-9	1(0-1)	
Hands	4	1	1	0-1	1(0-1)	0.17
	46	3	4	0-13	1(0-5)	
Escherichia coli						
Aprons	4	0	0	0	0	1
	46	0	0	0	0	
Hands	4	0	0	0	0	0.64
	46	0	1	0-8	0	
Enterobacteriaceae						
Aprons	4	3	4	0-8	2(0-6)	0.97
	46	3	5	0-29	1(0-2)	
Hands	4	5	3	1-8	5(3-7)	0.59
	46	5	5	0-18	2(1-8)	
Staphylococcus aureus						
Aprons	4	11	8	2-21	9.5(5.5-15.5)	0.29
	46	10	15	1-62	4(2-9)	
Hands	4	27	42	2-90	8(3-51)	0.31
	46	29	25	2-98	22(11-47)	

* *n*=number of respondents; $\bar{X}$=mean organism count (all organisms enumerated as cfu.cm^2); SD=Standard Deviation; Interquartile range: 25th-75th percentiles; *P*=significance

level of hygiene. Thus, some results from this study suggest that the particular training provided by the service provider in personal and general hygiene did not necessarily have the required effect. Therefore, in this study, the presence of organisms on hands and aprons could be related to influences other than the means of hand washing, the means of cleaning surfaces, training in personal and general hygiene and the replacing of aprons and gloves. Such influences might include, amongst others, bioaerosol contamination as well as contaminated surfaces. Several studies (Tebbutt, 1992; Kirby and Gardiner, 1997; Powell *et al.*, 1997; Mortlock *et al.*, 2000; Clayton *et al.*, 2002; Walker *et al.*, 2003; Worsfold and Griffith, 2003) have indicated that although training might bring about an increased knowledge of food safety, this does not always result in a positive change. The type and effectiveness of training needs to be addressed by, amongst others, accreditation of training service providers (for example with SAQA) and provision of standardised training material, and curricula. Standards or legislation regarding accreditation of food safety trainers in South Africa are currently either still lacking or not enforced satisfactorily. In cases where personnel received training, it is advisable that records be kept with information such as attendance registers, type of training (skills training or general food safety training), duration of training and proof that at least 80% of trainees understood the information (verbal or written exams or observation during the production process). This information is important and may be useful to prove the effectiveness of such training.

5.1 REFERENCES

Clayton, D.A., Griffith, D.J., Price, P. and Peters, A.C. (2002). Food handlers' beliefs and self-reported practices. *International Journal of Environmental Health Research, 12*, 25-39.

Codex Alimentarius. (1997). *Food hygiene: Basic Texts.* Rome.

Cruickshank, J.G. (1990). Food handlers and food poisoning: training programmes are best. *British Medical Journal, 300*, 207-208.

Kirby, M.P. and Gardiner, K. (1997). The effectiveness of hygiene training for food handlers. *International Journal of Environmental Health Research, 7*, 251-258.

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

Powell, S.C., Attwell, R.W. and Massey, S.J. (1997). The impact of training on knowledge and standards of food hygiene: a pilot study. *International Journal of Environmental Health Research, 7*, 329-334.

Republic of South Africa. (1999). Regulation 918 of 1999: Health Regulations governing general hygiene requirements for food premises and the transport of food, promulgated under the Health Act No. 63 of 1977. Government Printer, Pretoria.

SAS/STAT. (1989). User's Guide (4th ed.), Volumes 1 and 2, Version 6. Cary, NC: SAS Institute Inc.

Tebbutt, G.M. (1984). A microbiological study of various food premises with an assessment of cleaning and disinfection practices. *Journal of Hygiene, 92,* 365-375.

Tebbutt, G.M. (1992). An assessment of food-hygiene training and knowledge among staff in premises producing or selling high-risk foods. *International Journal of Environmental Health Research, 2,* 131-137.

Walker, E., Pritchard, C., and Forsythe, S. (2003). Food handlers' hygiene knowledge in small food businesses. *Food Control, 14,* 339-343.

Worsfold, D. and Griffith, C.J. (2003). A survey of food hygiene and safety training in the retail catering industry. *Nutrition and Food Science, 33(2),* 68-79.

CHAPTER 6

CONCLUSIONS

"Part of the secret of success in life is to eat what you like and let the food fight it out inside" (Mark Twain). When this quote was made about 100 years ago, little did people know about the challenges confronting the food industry in the next millennium in terms of safety and security. Consumers nowadays demand good quality products at a reasonable cost and because of the variety of retail industries that currently trade, constant competition exists between retail outlets. Another major challenge that the food industry in South Africa faces is the growing percentage of immuno-compromised individuals in the country. Such individuals are more prone to infections, including food-borne illnesses, which may result in severe illness and even death. This study has endeavoured to add to the understanding, and to contribute to the improvement, of process hygiene and food handler practices in the retail food industry, consequently ensuring safer food for consumers. The outcome will be communicated to the management of the Company studied in this survey in order that they may implement the recommendations proposed.

6.1 THE PERSONAL AND GENERAL HYGIENE PRACTICES OF FOOD HANDLERS

In Chapter 2 of this study a structured questionnaire was used to interview selected food handlers in the delicatessen sections of thirty-five outlets of a prominent retail group with regard to personal and general hygiene and training. The main foci were: status of food handlers; hand-washing and hand-drying facilities available in rest rooms; practices of food handlers regarding the frequency and means of hand-washing; practices of food handlers during the preparation of food, the reporting of illness, the cleaning and washing of surfaces; information regarding the formal training

of food handlers in personal and general hygiene and practices of food handlers relating to the wearing of protective clothing.

The results indicated that the majority of food handlers were aware of recommended food safety practices as they adhered to good personal and general hygiene practices. There were, however, a few issues of concern highlighted which emanated from the survey. The respondents indicated, for example, that not all of them had received training in personal, general and process hygiene. As the untrained staff worked in the outlet alongside trained staff they might, therefore, be expected to have acquired an elementary knowledge of hygiene. Where supervision was not adequate, incidences occurred where respondents wore jewellery, had long fingernails and reported that when injured, they wear dressings that are not moisture-proof. Further, the reporting of illness and/or injuries to management, as well as the lack of action taken by management when such illnesses and/or injuries were reported, was noted. A formal cleaning schedule was not used in all the outlets.

Food handlers should have the necessary knowledge and skills to enable them to handle food hygienically and all personnel should be aware of their roles and responsibilities in protecting food from contamination. Food hygiene training is therefore fundamentally important (Codex Alimentarius, 1997), as well as the accreditation of training service providers.

6.2 MICROBIAL CONTAMINATION ON HANDS AND APRONS OF FOOD HANDLERS

Chapter 3 of this study deals with the microbial contamination, including Total Viable Counts, Total Coliforms, *Escherichia coli*, members of the Family Enterobacteriaceae and *Staphylococcus aureus*, on the hands and on the aprons of food handlers and the relationship between the occurrences of organisms on these surfaces. Total Viable Counts were found to be present on 98% of hands and 84% of aprons sampled and, without exception, conformed to the national standard of 1×10^2 cfu.cm^{-2}. With regard to Coliforms, 32% of food handlers' hands and 8% of food handlers' aprons exceeded the suggested general microbial target value of <2.5 cfu.cm^{-2} after cleaning (Moore and Griffith, 2002). The detection of Coliforms is widely used as a means of measuring the effectiveness of sanitation programmes, and counts ranged between 2 cfu.cm^{-2} and 1.3×10^1 cfu.cm^{-2} (Chapter 3). *Escherichia coli* exceeded the limit of 1 cfu.cm^{-2} on only one food handler's hands. Enterobacteriaceae was present on hands (44%) and aprons (16%) and counts ranged between negligible and 1.8×10^1 cfu.cm^{-2} on hands, and between negligible and 2.9×10^1 cfu.cm^{-2} on aprons, while *Staphylococcus aureus* was present on hands (88%) and on aprons (48%) and counts ranged between 5 cfu.cm^{-2} and 9.8×10^1 cfu.cm^{-2} for hands and between negligible and 6.2×10^1 cfu.cm^{-2} for aprons.

No statistically significant relationship existed between the occurrence of organisms on hands and their occurrence on aprons. Therefore, even though microbial counts were higher on hands than on aprons, the latter were not likely to be cross-contaminated by hands. Because hands had higher organism counts, they might pose a higher risk for cross-contamination to food than aprons do. Taking into

consideration the limited data available on the limits of the organisms analysed in this study, the relatively low numbers of organisms found throughout indicate compliance with proper hand-washing practices.

6.3 AIRBORNE MICROBIAL POPULATIONS ASSOCIATED WITH THE DELICATESSEN SECTIONS AND THEIR RELATIONSHIP TO VENTILATION

The focus in Chapter 4 was the occurrence and distribution of Total Viable Counts, Total Coliforms, *Escherichia coli*, members of the family Enterobacteriaceae and *Staphylococcus aureus* in the air of the delicatessen sections as indicators of levels of microbial contamination. A microbial air sampler was used for the collection of samples and the temperature in each delicatessen section was measured. Information was obtained from the manager of each outlet with regard to selected physical parameters of each delicatessen which included the type of ventilation system used. The relationships between the bioaerosol counts and the selected physical parameters of the delicatessen sections were consequently determined using inferential statistics.

Although no microbiological guidelines exist in South Africa with regard to airborne microbiota, the counts appeared to be relatively low when compared with results found in similar studies. The average Total Viable Counts over the sampling period was 1.34×10^2 cfu.m^{-3}; for *Staphylococcus aureus*, 2.2×10^1 cfu.m^{-3}; and for Enterobacteriaceae, 2.6×10^1 cfu.m^{-3}. Numbers of *Escherichia coli* in the air were found to be negligible – an observation that agrees with a study done by Griffiths and DeCosemo (1994) who found that *E. coli* is a relatively delicate micro-organism

which could easily be damaged during aerosolisation and is not adapted for survival in the open air. Members of the Total Coliforms were only detectable in two of the thirty-five outlets.

Statistically significant differences were found between the bioaerosol counts and selected physical parameters of the delicatessen sections. These include the Enterobacteriaceae that differed significantly between the three groups of visitors (Group 1: below normal, Group 2: normal and Group 3: busiest outlets) and the Total Viable Counts that differed between the two ventilation groups (Group 1: extractor fan and air conditioner, Group 2: extractor fan or air conditioner or fan). It emanated that the occurrence of organisms were more likely to be related to influences other than the mentioned physical parameters of the delicatessen sections, for example environmental influences such as air-intake of ventilation systems. Abnormally busy days also lead to significantly higher counts when compared to normal and below normal days and therefore it is advisable that, where possible, the number of food handlers working a specific shift be managed according to the number of clients visiting an outlet during a specific period.

It is also recommended that an extractor fan and air conditioner be used rather than an extractor fan or air conditioner or fan, and that a positive air flow from the high-risk areas outward be maintained. There are a variety of room air cleaning devices currently available such as high efficiency particulate air (HEPA) filters which reduce the microbial level in the room air. They have the advantage of being relatively cheap and can be strategically positioned to protect staff.

6.4 RELATIONSHIPS BETWEEN MICROBIOTA AND FOOD HANDLER PRACTICES

In Chapter 5, the interactions between microbiota and food handler practices were investigated in order to establish whether a relationship exists between practices and organism counts. If such relationships could be outlined, it would enable the identification of specific methodologies and corrective actions to kerb the proliferation of targeted microbiota. Organisms included Total Viable Counts, Total Coliforms, *Escherichia coli*, members of the Family Enterobacteriaceae and *Staphylococcus aureus*. Different groups of food handler practices were identified in Chapter 2 and compared with the mentioned organism counts on hands and/or aprons of food handlers as discussed in Chapter 3 and included: the three means of hand washing and means of cleaning surfaces; training in personal and general hygiene; and replacing of aprons and gloves.

The organism counts on hands were compared with the three means of hand washing (cold water, soap and a nailbrush; hot water, soap and a nailbrush; and hot and cold water and soap) and no statistically significant differences were found. Organism counts on hands were consequently compared to the means of cleaning of surfaces in the delicatessen (cold water and detergent and hot water and detergent) and, similarly, no statistically significant differences existed. Although significant differences were found between Enterobacteriaceae counts on aprons of respondents who had received training in personal hygiene and training in general hygiene and those who had no training in personal hygiene and no training in general hygiene, the presence of organisms on hands and aprons should be related to influences other than the means of hand washing and cleaning of surfaces,

training in personal and general hygiene and the replacing of aprons and gloves. The organism counts on hands and aprons in this study were relatively low and the majority of the respondents adhered to good hygiene practices. Therefore the presence of organism counts on hands and aprons should rather be related to bioaerosol contamination as well as contaminated surfaces than training in personal and general hygiene. Although the above statements appear contradictory, in both instances (training in personal hygiene and training in general hygiene), it was surprising to note that organism counts on the aprons of respondents who had received training were in fact higher than on the aprons of those who had received no training. Thus, no mere simple relationships seem to exist between training and food safety practices and aspects such as the quality of training have emanated as being of considerable importance. The SABS 049 (2001), as well as the Health Regulations (Republic of South Africa, 1999), prescribes that management should arrange for all food handlers to receive adequate and continued training in the hygienic handling of food and in personal hygiene so that they know which precautions to take to preclude contamination of food. Furthermore, the Codex Alimentarius (1997) specifies that periodic assessments of training be made in order to ensure that procedures are being carried out effectively.

Statistically significant differences were neither found between organism counts on aprons and the frequency of replacing aprons, nor between the organism counts on hands and aprons in relation to the replacing of gloves.

6.5 CONCLUDING REMARKS

Food hygiene and safety have never before enjoyed such a high profile within the food industry in South Africa. New legislation, for example the regulations relating to the application of the Hazard Analysis and Critical Control Point system which was recently promulgated under the Foodstuffs, Cosmetics and Disinfectants Act (Act 54 of 1972), brought about new responsibilities regarding the hygienic handling of food. However, the enforcement of legislation in itself cannot ensure safe food – there should be commitment from all levels of staff, including management. Media-based hygiene monitoring, as used in this study, requires incubation time for results to be obtained. By the time remedial actions are implemented, customers could already be placed at risk and therefore a need exists for monitoring techniques that could provide results in time for remedial action to be effectively implemented. Except in the case of Total Viable Counts where a national standard is prescribed by the Health Regulations (Republic of South Africa, 1999), there are no other prescribed standards, and this study has emphasised the need to quantify target microbial values for hands of food handlers and for surfaces in food handling premises with regard to the organisms sampled for in this study.

As people from lower economic classes with low education levels are frequently employed as food handlers, a major challenge in the food industry is to motivate food handlers to apply what they have learned regarding food hygiene. Food hygiene training as well as refresher training is fundamentally important and periodic assessments of the effectiveness of training programmes should be made. Routine supervision or checks should also be done in order to ensure that procedures are being carried out effectively. As indicated in Chapter 5, only Enterobacteriaceae

counts on aprons showed statistically significant differences between respondents who had received personal hygiene training and those who had no training in personal hygiene and between respondents who had received general hygiene training and those who never received training in general hygiene. Therefore the applicability of the Family Enterobacteriaceae as a hygiene indicator should be assessed.

In view of the current competition between food retailers to provide food which is safe, high in quality and wholesome, the need for medical examinations of food handlers has become an issue of increasing concern and needs to be addressed. Although HIV/AIDS is largely irrelevant as a food-borne hazard, it might impact on the food industry with regard to food handlers' health, their performance, absence from work, etcetera. Therefore it is necessary to give consideration to the impact of the disease in the food industry. Emphasis should furthermore be placed on the immediate reporting of illnesses by food handlers to management who, in turn, should assure food handlers that their absence (when necessary) will not result in loss of employment or wages.

With regard to the bioaerosol monitoring conducted in this study, the aim was to contribute to the knowledge base concerning bioaerosol contamination in retail outlets as this is not currently covered by South African legislation. The box plots used in Chapters 3 and 4 indicated similar distribution patterns of microbial populations found on hands, aprons and in the air. Since the majority of the respondents complied with good hygiene practices, the occurrence of organisms on hands and aprons might be related to contamination by airborne microbial populations as well as contaminated surfaces rather than hygiene practices and

training. The modern lifestyle has brought about a growing demand for ready-to-eat meals and it is therefore suggested that bioaerosol monitoring be conducted in delicatessen sections on at least a six-monthly basis in order to monitor whether ventilation systems are still effective and sufficient. Air-intake vents of ventilation systems should also be monitored and fitted with fly screens and dust filters. In addition, a need exists for the development of guidelines to indicate acceptable limits of exposure to airborne micro-organisms. The methodology also needs to be refined. The SABS 049 (2001), stipulates specific requirements with regard to ventilation and air quality: for example, the microbial quality of the air shall be monitored, where appropriate, to control the risk of food contamination and to prevent condensation on walls, ceilings and overhead structures under normal operating procedures.

6.6 RECOMMENDATIONS TO GOVERNANCE AND AUDIT BODIES

As mentioned earlier in this document, literature is relatively limited with regard to bioaerosol contaminants in food processing and catering environments and little, if any, reference is made to exact numbers and guidelines for airborne microbial loads. The only available data refers to good manufacturing processes towards a clean environment (Jensen and Schafer, 1998; SABS 0409, 2001). Suggestions will therefore be made as to such limits and guidelines. In Table 6.1, exposure limits with regard to bioaerosols in delicatessens and similar areas are proposed. Only Total Viable Counts, Enterobacteriaceae and *Staphylococcus aureus* are included and Coliforms and *Escherichia coli* can be regarded as negligible as counts found in this study were either undetectable or very low. *Escherichia coli* is not adapted for survival in the open air and therefore the focus should be on naturally occurring micro-organisms which survive well in the environment. The proposed exposure

Table 6.1 Proposed limits of indicator organisms for high-risk retail environments *

Organism	Limit ($cfu.m^{-3}$)
Total Viable Counts	1.5×10^2
Enterobacteriaceae	4.0×10^1
Staphylococcus aureus	3.5×10^1

* The limits have been proposed keeping in mind the data gathered in this study, the ecology and survival of the various microbial groups, generally accepted good manufacturing practices, number of clients and related literature available on the topic

limits for Total Viable Counts (1.5×10^2 cfu.m^{-3}), Enterobacteriaceae (4.0×10^1 cfu.m^{-3}) and *Staphylococcus aureus* (3.5×10^1 cfu.m^{-3}) are based upon the mean values of the respective organisms found in this study. It is further proposed that these limits be used as "acceptable limits" in legislation or relevant guidelines in order to establish whether a selected high-risk retail environment meets legal requirements or complies with guidelines.

6.7 RECOMMENDATIONS TO INDUSTRY

- Whilst formal training might ensure greater consistency and quality, improper training could present a greater risk to food safety than no training at all. Therefore industry should keep records in order to prove the effectiveness of training and appoint only accredited service providers.
- Only properly trained staff should be allowed to work in the delicatessen, and as training is not a once-off activity, refresher training as indicated in the Codex Alimentarius (1997) should also form part of the training programme.
- Management should see training as one part of a broader food hygiene control strategy, based upon the principles of the HACCP system. Food hygiene training for management should be mandatory in order for them to be able to judge potential risks and to take the necessary action to remedy deficiencies, which includes action to be taken when illness and/or injuries of food handlers occur.
- Periodic assessments of the effectiveness of training should be made. Managers can do weekly to bi-weekly spot checks on the general hygiene of the delicatessen and personal hygiene of the food handlers and supervisors in

order to ensure that, for example, fingernails are kept short, jewellery is removed and moisture-proof dressings are worn in cases of injury.

- Each outlet should have a formal cleaning schedule. Although such cleaning schedules are required under pre-requisite programs and good manufacturing practices, a considerable number of outlets studied employed a "clean-as-you-go" methodology.
- The number of food handlers working a specific shift should be varied according to the number of clients visiting an outlet during a specific period in order to ensure that hygiene practices are not compromised.
- Regular outlet and supplier audits should be performed by certified auditors.
- Extractor fans as well as air conditioners should be used in all the outlets rather than using either an extractor fan, air conditioner or fan. Air flow should be effectively regulated and controlled and a positive air flow from the high-risk areas outward should be maintained.
- Bioaerosol monitoring should be conducted in delicatessen sections on at least a six-monthly basis in order to monitor whether ventilation systems are still effective and sufficient.
- Air-intake vents of ventilation systems should also be monitored and fitted with fly screens and dust filters.

6.8 FUTURE RESEARCH

As indicated by the results of this study, the following were identified as possible future research projects:

- a study to determine the effectiveness of hygiene training for food handlers in delicatessen sections with regard to ready-to-eat foods;
- research to determine the barriers and problems which may be preventing food handlers from implementing good practice;
- further studies to propose acceptable levels of indicator organisms on the hands of food handlers and on the surfaces of delicatessen sections;
- investigations into the direct relationships of airborne contamination to the safety of ready-to-eat foods;
- a study to statistically compare the bacteriological quality of cleaned and sanitised food contact surfaces with the hands and aprons of food handlers;
- studies into the family Enterobacteriaceae in particular, to assess the characteristics of the group as well as its applicability as hygiene indicator;
- expansion of the study to other retail groups and provinces of South Africa.

6.9 REFERENCES

Codex Alimentarius. (1997). *Food hygiene: Basic Texts.* Rome.

Griffiths, W.D. and DeCosemo, G.A.L. (1994). The assessment of bioaerosols: a critical review. *Journal of Aerosol Science, 25(8)*, 1425-1458.

Jensen, P.A. and Schafer, M. (1998). Sampling and characterizing of bioaerosols. *NIOSH Manual of Analytical Methods.* Section J, pp82-100.

Moore, G. and Griffith, C. (2002). A comparison of surface sampling methods for detecting Coliforms on food contact surfaces. *Food Microbiology, 19,* 65-73.

SABS 049. (2001). South African Bureau of Standards, Code of Practice: Food Hygiene Management (3rd ed.). Pretoria.

Republic of South Africa. (1999). Regulation 918 of 1999: Health Regulations governing general hygiene requirements for food premises and the transport of food, promulgated under the Health Act No. 63 of 1977. Government Printer, Pretoria.

APPENDIXES

Figure 4.3 An example of a typical delicatessen section

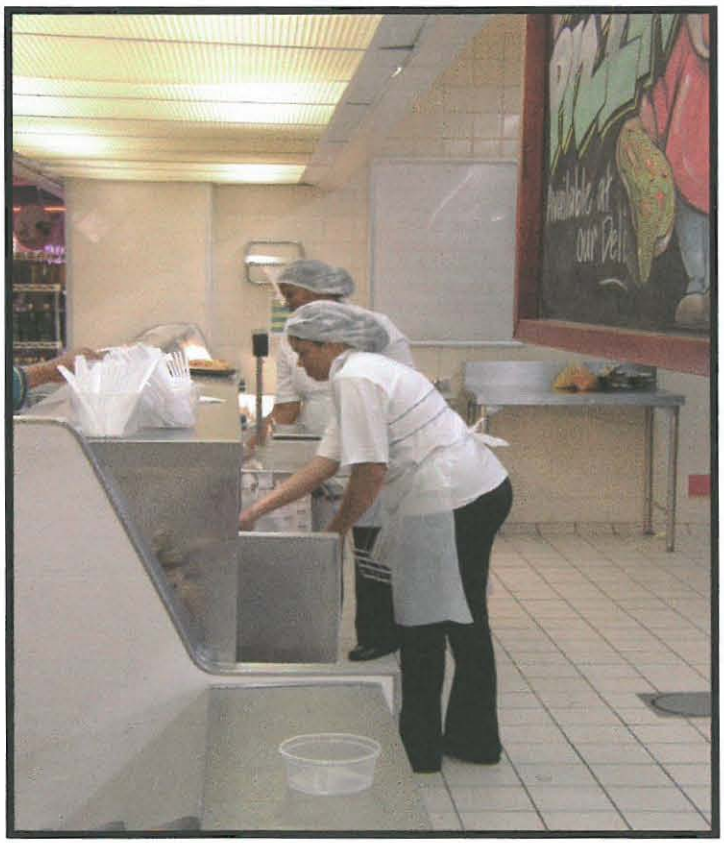

Figure 4.4 Picture showing food handlers during serving of customers

Figure 4.5 Illustration of a food handler wearing protective gloves during serving of ready-to-eat food

Figure 4.6 An analyst using an agar-plate to take samples of hands

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APPENDIX A

A SURVEY OF PROCESS HYGIENE AND ASSOCIATED FOOD HANDLER PRACTICES IN A RETAIL GROUP IN THE WESTERN CAPE, SOUTH AFRICA

QUESTIONNAIRE

Thank you for taking part in this confidential survey. The aim of this survey is to determine your practices regarding personal and general hygiene and training at work. Your answers are confidential and will not be used against you, as no names are recorded. You are requested to mark your answer/s with "X" in the blocks provided.

Official Use

Outlet number: ☐☐☐ 1-3

SECTION A

PERSONAL HYGIENE

1. How often are hands washed? **(Ask all)**

Never	☐	☐ 4
Immediately, prior to the commencement of each work shift	☐	☐ 5
At the beginning of the day's work or after a rest period	☐	☐ 6
After every visit to a latrine or urinal	☐	☐ 7
Every time you blow your nose or touch your hair, nose or mouth	☐	☐ 8
After handling a handkerchief, money, a refuse container or refuse	☐	☐ 9
After handling raw vegetables, fruit, eggs, meat or fish and before handling ready-to-use food	☐	☐ 10
After you have smoked or on return to the food premises **(N/A=9)**	☐	☐ 11
Other (specify)	☐	☐ 12

2. Referring to question 1, with what do you usually wash your hands? **(Let them answer)**

Only wipe with cloth	1	☐ 13
Only cold water	2	
Only hot water	3	
Cold water, soap and a nailbrush	4	
Hot water, soap and a nailbrush	5	
Other (specify)	6	

3. Which of the following are available to dry your hands with? **(Ask all)**

Air dryer		14
Nothing		15
Towel / Cloth		16
Disposable hand-drying material		17
Apron / Clothes		18
Other (specify)		19

4. What do you usually use to dry your hands? **(Let them answer)**

Air dryer	1	20
Nothing	2	
Towel / Cloth	3	
Disposable hand-drying material	4	
Apron / Clothes	5	
Other (specify)	6	

5. Which of the following protective clothing do you wear? **(Ask all) (Not provided = 9)**

Plastic apron		21
Overall		22
Hairnet / Hat		23
Gloves		24
Gum boots		25
Other (specify)		26

6. When is protective clothing taken home to be washed? **(Let them answer)**

Never	1	27
Each day	2	
Sometimes (specify)	3	

7. How many times per day do you replace your apron with a clean one?

Once a day	1	28
Twice a day	2	
2-5 Times a day	3	
More than 5 times a day	4	
Never	5	
Do not wear apron	8	
No apron provided	9	

8. How often do you wear gloves?

Only during serving of ready-to-consume foods to customers	1	29
Only when handling cold meat	2	
Always during serving and handling of ready-to-consume food	3	
Never	4	
Other (specify)	5	
No gloves provided	9	

9. When do you remove your gloves?

Never	1	30
Sometimes (specify)	2	
Each time after serving ready-to-consume foods to customers	3	
Each time after serving and handling of ready-to-consume food	4	
Do not wear gloves	8	
No gloves provided	9	

10. What do you do with your glove(s) when you take them off?

Put them away safely	1	31
Leave them on the counter until you need them again	2	
Lend them to another staff member	3	
Throw them away	4	
Other (specify)	5	

11. How many times per day do you replace your gloves with clean ones?

Once a day	1	32
Twice a day	2	
2-5 Times a day	3	
More than 5 times a day	4	
Never	5	
Do not wear gloves	8	
No gloves provided	9	

12. While preparing food, do you do one or more of the following? **(Ask all) (Observe while asking)**

Chew gum		33
Eat		34
Smoke or use tobacco		35
Touch mouth, tongue, nose, eyes, etc.		36
Spit, sneeze or cough on or near food		37
Wear jewellery (rings, watches, bracelets)		38
Wear dressings that are not moisture-proof		39
Wear Cutex on fingernails		40
Keep fingernails long		41

13. How often do you experience the following illnesses?

	Once/year (1)	2-5 times/ year (2)	5-10 times /year (3)	More (4)	Never (5)	
Diarrhoea						42
Vomiting						43
Cold/Flu						44
Fever						45
Coughing						46
Cut/bruised hands						47
Specify other						48

14. Do you report own illness to management?

Yes, always	1	49
No, never	2	
Yes, sometimes	3	

14.1 If yes to question 14, what action is taken by management?

No action		50
Medical examination		51
Get sick leave		52
Other (specify)		53

15. What action do you take when you cut yourself?

Nothing, continue with open wound	1	54
Report to management and cover with moisture-proof dressing	2	
Other (specify)	3	

16. Is there adequate supervision to ensure that personnel practise personal hygiene?

Yes	1	55
No	2	

17. Do you undergo compulsory medical examinations at work?

Yes	1	56
No	2	

17.1 If yes to question 17, how often?

Once a month	1	57
Once every three months	2	
Once every six months	3	
Once a year	4	
Other (specify)	5	

SECTION B

GENERAL HYGIENE

18. How often are working surfaces cleaned and washed?
(Let them answer)

Never		58
Daily, before commencing with work		59
Daily, after work is finished		60
Between shifts		61
During and / or immediately after the handling of food		62
Other (specify)		63

19. With what are surfaces cleaned / washed?

Cold water	1	64
Cold water and detergent	2	
Hot water	3	
Hot water and detergent	4	
Other (specify)	5	

20. Do you adhere to a formal cleaning schedule?

Yes	1	65
No	2	
If no, specify		66

21. How often do you encounter one or more of the following?

	Daily (1)	Weekly (2)	Monthly (3)	Seasonal (4)	Annually (5)	Never (6)	
Rats & Mice							67
Flies							68
Cock-roaches							69
Specify Other							70

22. Are the following available in toilets / rest rooms? **(Ask all)**

A hand-washing facility and cold and / or hot water		71
Soap		72
Plastic nail brushes		73
Disposable hand-drying material		74
Air dryer		75
Other (specify)		76

23. What action do you take if food falls on the floor?
(Let them answer)

Notify management		77
Pick up and continue		78
Pick up and wash off with clean water		79
Pick up and dispose of		80
Leave on the floor (no action)		81
Contaminated area trimmed off		82
Other (specify)		83

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SECTION C

TRAINING

24. Have you had any formal training in personal hygiene?

Yes	1	1
No	2	
If yes, give details		2 3

25. Do you feel that your training in personal hygiene is adequate?

Yes	1	4
No	2	

26. Have you had any formal training in general hygiene?

Yes	1	5
No	2	
If yes, give details		6 7

27. Do you feel that your training in general hygiene is adequate?

Yes	1	8
No	2	

28. While preparing food, which of the following is good practice? **(Ask all)**

Spit in an area where food is handled	1	9
Smoke or use tobacco in an area where food is handled	2	
Lick your fingers when you are handling food	3	
Wash hands with soap and water at the beginning of the day's work or after a rest period	4	
Cough or sneeze over food	5	
Inflate bags or other wrappings by mouth	6	
Use a hand washbasin for the cleaning of your hands and simultaneously for the cleaning of equipment	7	

SECTION D

GENERAL

29. How old are you?

18 - 21 years	1	10
22 - 30 years	2	
>30 -40 years	3	
Older than 40 years	4	

30. What is your highest educational qualification?

Lower than matric	1	11
Matric	2	
After school qualifications (specify).....	3	

31. How long have you been working in the Delicatessen / how much experience do you have?

Less than 3 months	1	12
3 - 6 months	2	
>6 - 12 months	3	
More than a year	4	

32. Do you work in the Delicatessen full-time?

Yes	1	13
No	2	
If no, specify		14-15

33. Do you allow visitors in the preparation area?

Yes	1	16
No	2	

34. How many hours have you already worked in this shift in the Delicatessen today?

Less than an hour	1	17
1 - 2 hours	2	
>2 - 3 hours	3	
More than 3 hours	4	

35. When last did you change your glove(s) for clean ones?

Less than an hour ago	1	18
1 - 2 hours ago	2	
>2 - 3 hours ago	3	
More than 3 hours ago	4	

36. When last did you change your apron for a clean one?

Less than an hour ago	1	19
1 – 2 hours ago	2	
>2 – 3 hours ago	3	
More than 3 hours ago	4	

37. How busy were you thus far today during your shift in the Delicatessen?

Not so busy	1	20
Relatively busy	2	
Very busy	3	
Extremely busy	4	

Worker number: [ ] 21

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BYLAE A

'N ONDERSOEK NA DIE PROSESHIGIëNE EN GEASSOSIEERDE PRAKTYKE VAN VOEDSELHANTEERDERS IN 'N KLEINHANDELAFSETGROEP IN DIE WES-KAAP, SUID AFRIKA

VRAELYS

Baie dankie dat u deelneem aan hierdie vertroulike ondersoek. Die doel van hierdie ondersoek is om u praktyk met betrekking tot persoonlike en algemene higiëne en opleiding by die werk te bepaal. U antwoorde is vertroulik en sal nie teen u gebruik word nie, aangesien geen name aangeteken word nie. U word versoek om u antwoord/e met 'n "X" in die toepaslike blokkies aan te teken.

Amptelike gebruik

Ondernemingnommer: ☐☐☐ 1-3

AFDELING A

PERSOONLIKE HIGIëNE

1. Hoe dikwels word hande gewas? **(Vra almal)**

Nooit	☐	☐ 4
Onmiddellik voor die aanvang van elke werkskof	☐	☐ 5
Aan die begin van die dagtaak of na 'n rusperiode	☐	☐ 6
Na elke besoek aan 'n latrine of urinaal	☐	☐ 7
Elke keer nadat jy jou neus gesnuit het of met jou hare, neus of mond in aanraking was	☐	☐ 8
Nadat jy 'n sakdoek, geld, vullishouer of vullis hanteer het	☐	☐ 9
Nadat jy rou groente, vrugte, eiers, vleis of vis hanteer het en voordat jy verbruiksklaar voedsel hanteer	☐	☐ 10
Nadat jy gerook het of by jou terugkeer na die voedselperseel **(Nvt=9)**	☐	☐ 11
Ander (spesifiseer)	☐	☐ 12

2. Met verwysing na vraag 1, waarmee was u gewoonlik u hande? **(Laat hulle antwoord)**

Vee slegs af met 'n doek	1	☐ 13
Slegs koue water	2	
Slegs warm water	3	
Koue water, seep en 'n naelborsel	4	
Warm water, seep en 'n naelborsel	5	
Ander (spesifiseer).....	6	

3. Watter van die volgende is beskikbaar vir die afdroog van u hande?
(Vra almal)

Droër		14
Niks		15
Handdoek/doek		16
Wegdoenbare handeafdroogmateriaal		17
Voorskoot/klere		18
Ander (spesifiseer)……..		19

4. Wat gebruik u gewoonlik vir die afdroog van u hande?
(Laat hulle antwoord)

Droër	1	20
Niks	2	
Handdoek/doek	3	
Wegdoenbare handeafdroogmateriaal	4	
Voorskoot/klere	5	
Ander (spesifiseer)……	6	

5. Watter van die volgende beskermende klere dra u?
(Vra almal) (Nie verskaf = 9)

Plastiek voorskoot		21
Oorpak		22
Haarnet/hoed		23
Handskoene		24
Rubberstewels		25
Ander (spesifiseer) ……		26

6. Wanneer word beskermende klere huis toe geneem om gewas te word?
(Laat hulle antwoord)

Nooit	1	27
Elke dag	2	
Somtyds (spesifiseer)……..	3	

7. Hoeveel keer per dag vervang u u voorskoot met 'n skoon een?

Een keer per dag	1	28
Twee keer per dag	2	
2-5 keer per dag	3	
Meer as 5 keer per dag	4	
Nooit	5	
Dra nie 'n voorskoot nie	8	
Geen voorskoot word verskaf nie	9	

8. Hoe dikwels dra u handskoene?

Slegs wanneer verbruiksklaar kos aan klante bedien word	1	29
Slegs wanneer koue vleis hanteer word	2	
Altyd gedurende die bediening en hantering van verbruiksklaar kos	3	
Nooit	4	
Ander (spesifiseer).....	5	
Handskoene word nie verskaf nie	9	

9. Wanneer verwyder u u handskoene?

Nooit	1	30
Somtyds (spesifiseer).....	2	
Elke keer nadat verbruiksklaar kos aan klante bedien is	3	
Elke keer na die bediening en hantering van verbruiksklaar kos	4	
Dra nie handskoene nie	8	
Handskoene word nie verskaf nie	9	

10. Wat doen u met u handskoen(e) wanneer u dit uittrek?

Bêre dit op 'n veilige plek	1	31
Laat dit op die toonbank totdat dit weer benodig word	2	
Leen dit vir 'n ander personeellid	3	
Gooi dit weg	4	
Ander (spesifiseer).....	5	

11. Hoeveel keer per dag vervang u u handskoene met skoon handskoene?

Een keer per dag	1	32
Twee keer per dag	2	
2-5 keer per dag	3	
Meer as 5 keer per dag	4	
Nooit	5	
Dra nie handskoene nie	8	
Handskoene word nie verskaf nie	9	

12. Doen u enige van die volgende tydens die voorbereiding van voedsel? **(Vra almal) (Observeer tydens ondervraging)**

Kou kougom		33
Eet		34
Rook tabak		35
Raak aan u mond, tong, neus, oë, ens.		36
Spoeg, snuif en hoes u op of naby kos		37
Dra juweliersware (ringe, horlosies en armbande)		38
Dra verbande wat nie vogdig is nie		39
Dra naelpolitoer op vingernaels		40
Dra vingernaels lank		41

13. Hoe dikwels ervaar u self die volgende siektes?

	Een keer/jaar (1)	2-5 keer/ jaar (2)	5-10 keer/ jaar (3)	Meer (4)	Nooit (5)	
Diarree						42
Braking						43
Verkoue/ griep						44
Koors						45
Hoes						46
Hande wat raakgesny of vel-af is						47
Spesifiseer ander …… ……						48

14. Rapporteer u hierdie siektes aan die bestuur?

Ja, altyd	1	49
Nee, nooit	2	
Ja, somtyds	3	

14.1 Indien u ja geantwoord het op vraag 14, watter stappe word dan deur die bestuur geneem?

Geen stappe		50
Mediese ondersoek		51
Siekverlof word gegee		52
Ander (spesifiseer).....		53

15. Wat doen u as u uself raaksny?

Niks, gaan voort met oop wond	1	54
Rapporteer aan bestuur en bedek met vogdigte verband	2	
Ander (spesifiseer).....	3	

16. Bestaan daar voldoende supervisie om te verseker dat personeel persoolike higiëne beoefen?

Ja	1	55
Nee	2	

17. Ondergaan u verpligte mediese ondersoeke by die werk?

Ja	1	56
Nee	2	

17.1 Indien u ja geantwoord het op vraag 17, hoe dikwels?

Een keer per maand	1	57
Een keer elke drie maande	2	
Een keer elke ses maande	3	
Een keer per jaar	4	
Ander (spesifiseer).....	5	

AFDELING B

ALGEMENE HIGIëNE

18. Hoe dikwels word werksoppervlaktes skoongemaak en gewas?
(Laat hulle antwoord)

Nooit		58
Daagliks, voordat werk begin		59
Daagliks, nadat werk voltooi is		60
Tussen skofte		61
Tydens en / of onmiddellik na die hantering van voedsel		62
Ander (spesifiseer)……..		63

19. Waarmee word oppervlaktes skoongemaak / gewas?

Koue water	1	64
Koue water en wasmiddel	2	
Warm water	3	
Warm water en wasmiddel	4	
Ander (spesifiseer) ……	5	

20. Hou u by 'n formele skoonmaakskedule?

Ja	1	65
Nee	2	
Indien nee, spesifiseer ……		66

21. Hoe dikwels ondervind u een van die volgende?

	Daag-liks (1)	Week-liks (2)	Maande-liks (3)	Seisoe-naal (4)	Jaarliks (5)	Nooit (6)	
Rotte en muise							67
Vlieë							68
Kokke-rotte							69
Spesifi-seer ander ……							70

22. Is die volgende beskikbaar by toilette / ruskamers? **(Vra almal)**

Handewasgeriewe en koue en / of warm water		71
Seep		72
Plastiek naelborsels		73
Wegdoenbare handeafdroogmateriaal		74
Droër		75
Ander (spesifiseer).....		76

23. Watter stappe neem u wanneer kos op die vloer val?
(Laat hulle antwoord)

Stel die bestuur in kennis		77
Tel dit op en gaan voort		78
Tel dit op en was dit af met skoon water		79
Tel dit op en keur af		80
Laat dit op die vloer lê (geen aksie)		81
Sny besmette area af		82
Ander (spesifiseer).....		83

AFDELING C
OPLEIDING

24. Het u enige formele opleiding in persoonlike higiëne?

Ja	1	1
Nee	2	
Indien ja, verskaf besonderhede		2
		3

25. Is u van mening dat u opleiding in persoonlike higiëne voldoende is?

Ja	1	4
Nee	2	

26. Het u enige opleiding in algemene higiëne?

Ja	1	5
Nee	2	
Indien ja, verskaf besonderhede.....		6
		7

27. Is u van mening dat u opleiding in algemene higiëne voldoende is?

Ja	1	8
Nee	2	

28. Tydens die voorbereiding van voedsel, watter van die volgende is goeie praktyk? **(Vra almal)**

Binne 'n area waar voedsel hanteer word spuug	1	9
Rook of tabak gebruik in 'n area waar voedsel hanteer word	2	
Lek jou vingers af wanneer jy voedsel hanteer	3	
Was hande met seep en water aan die begin van die dagtaak of na 'n rusperiode	4	
Hoes of nies oor voedsel	5	
Blaas sakkies of ander omhulsels met jou asem op	6	
'n Handewasbak vir die skoonmaak van jou hande en tegelykertyd vir die reiniging van toerusting gebruik	7	

AFDELING D
ALGEMEEN

29. Hoe oud is u?

18 - 21 jaar	1	10
22 - 30 jaar	2	
>30 -40 jaar	3	
Ouer as 40 jaar	4	

30. Wat is u hoogste vlak van onderwys?

Laer as matriek	1	11
Matriek	2	
Na-skoolse kwalifikasies (spesifiseer).....	3	

31. Hoe lank werk u reeds in die delikatesse-afdeling/ hoeveel ondervinding het u?

Minder as 3 maande	1	12
3 - 6 maande	2	
>6 - 12 maande	3	
Meer as 'n jaar	4	

32. Werk u voltyds in die delikatesse-afdeling?

Ja	1	13
Nee	2	
Indien nee, spesifiseer.....		14-15

33. Laat u besoekers toe in die voorbereidingsarea?

Ja	1	16
Nee	2	

34. Hoeveel ure het u reeds vandag in hierdie skof in die delikatesse-afdeling gewerk?

Minder as 'n uur	1	17
1 – 2 ure	2	
>2 – 3 ure	3	
Meer as 3 ure	4	

35. Wanneer laas het u u handskoene vervang met skoon handskoene?

Minder as 'n uur gelede	1	18
1 - 2 ure gelede	2	
>2 - 3 ure gelede	3	
Meer as 3 ure gelede	4	

36. Wanneer laas het u u voorskoot omgeruil vir 'n skoon een?

Minder as 'n uur gelede	1	19
1 - 2 ure gelede	2	
>2 - 3 ure gelede	3	
Meer as 3 ure gelede	4	

37. Hoe besig was u tot dusver vandag tydens u skof in die delikatesse-afdeling?

Nie so besig nie	1	20
Relatief besig	2	
Baie besig	3	
Uitermatig besig	4	

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