A STUDY TO ASSESS THE CHANGES IN HYGIENE OF FOOD PREMISES FOLLOWING A SPECIFIC HEALTH EDUCATION PROGRAMME.

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Thesis submitted in fulfilment of the requirements for the Masters Diploma in Technology (Public Health) in the School of Life Sciences at the Cape Technikon.

I declare that this thesis is my own work. It is submitted for the Masters Diploma in Technology (Public Health), to the Cape Technikon, Cape Town and has not been submitted before for any diploma or examination at any other Technikon.

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S. ARTHUR LUYT **DATE**

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

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LIST OF TABLES

LIST OF GRAPHS

ABSTRACT

In order to evaluate a health education programme for food handlers at a meat plant, a bakery/confectionery and a catering premises, changes in hygiene were assessed by the bacteriological analysis of swabs for hygiene indicator organisms from food contact surfaces.

In this evaluation three phases were established on the basis of bacteriological assessment prior to, during and after the education programme.

The first phase involved the establishment of a base line for hygiene indicator organisms prior to the education programme by taking 5 sets of bacteriological swabs over a two month period at each of the three premises, each swab set consisting of 14 swabs of food contact surfaces making a total of 210 swabs.

During this time the food hygiene educational needs of the employees were assessed and on this basis a set of three video taped presentations were produced relating respectively to personal hygiene, environmental hygiene and food handling practices.

The second phase consisted of the implementation of a health education programme involving consecutive tutorial sessions at one month intervals during which the video taped programme was presented. At this stage a further 5 sets of bacteriological swabs was taken at each of the premises.

The third phase involved the assessment of hygiene shortly after completion of the education programme by taking a final 5 sets of bacteriological swabs of food contact surfaces at each of the premises over a further two month period.

Statistically significant reductions in a number of the indicator organisms were observed during the course of the study.

1. INTRODUCTION

1.1. Overview

Health education of food handlers is said to improve hygiene of food premises and thereby minimize the risk of foodborne disease (1).

The World Health Organisation (WHO) Expert Committee on Food Safety states that the education of food handlers in food hygiene practices is a more effective preventive measure to control and minimize the risk of foodborne diseases than the medical examination of food handlers (2).

Other studies indicate that most outbreaks of foodborne disease could have been prevented if all food handlers had understood the importance of unfailing adherence to correct food hygiene practices (3).

Hygiene, by definition, relates to the absence of pathogenic organisms and indicator organisms. (4).

Indicator organisms used to evaluate hygiene thus have a potential use in the indirect evaluation of the effectiveness of health education programmes at food premises.

A field study of this potential use is the subject of the present dissertation.

Microbiological monitoring at food premises as a valuable means of assessing hygiene is supported by the WHO Study group on foodborne diseases with reference to food contact surfaces (5), and by Collins and Lyne with reference to utensils and crockery (6).

Numerous studies have demonstrated that poor personal hygiene, poor cleaning and improper food handling practices lead to certain pathogenic and indicator organisms being transmitted to foodstuffs from hair (8), from the nose (9), from clothing and from the hands of food handlers (10, 15). Cross contamination from raw to cooked food has been seen to occur by means of utensils and containers (11, 12,); by equipment, surfaces, and other objects in food preparation areas (13-19).

A wide variety of food contact surfaces can therefore be bacteriologically swabbed to assess the hygiene of food premises.

1.2 Study Objectives

While health education of food handlers in South Africa is carried out by the Department of National Health and Population Development, South African Defence Force, Regional Service Councils and the majority of Local Authorities, little has been done to evaluate health education in an objective way.

A literature search from the Medline Data Base of the Medical Information Dissemination System of the Institute for Biomedical Communication, retrospective to 1974, failed to retrieve published studies using quantifiable indicators of food hygiene.

The aim of this study is to investigate changes in hygiene of food premises by objective measurement of quantifiable indicators in order to evaluate the effectiveness of a specific health education programme for food handlers.

2. MATERIALS AND METHOD

This study brings together two important principles of public health, namely:

(i) the application of microbiological techniques to test for indicator organisms as a measure of hygiene practice in premises in which food is handled.

(ii) the use of health education as an interventive measure in the improvement of hygiene in food premises, and the objective measurement of the efficacy of such intervention by using hygiene indicator organisms.

Although a case-control study involving the observed changes in hygiene at the study premises as compared to changes occurring at a control premises over the same period would have been desirable, it was not possible to satisfactorily match premises. This was mainly due to diversity of food handling functions, health education undertaken before this study, different ambient temperatures, differences in surfaces, the range of food handlers employed and the different base line microorganism load at each of the premises.

The study is thus of a descriptive nature, the lack of a control being compensated for as far as possible by:

(i) the evaluation and comparison of three different food premises, namely: a meat plant, a bakery/ confectionery and a catering premises.

(ii) the monitoring of a variety of hygiene indicators instead of one, namely: plate count, Coliforms, *Escherichia coli*, Enterococci, Salmonella/Shigella, *Staphylococcus aureus* and *Clostridium perfringens*. Results were used to establish hygiene profiles of each of the three selected premises.

(iii) The establishment of a separate base line contamination level for each type of hygiene indicator organism prior to execution of the health education programme. This base line could be used to evaluate the extent of changes in hygiene of the food premises occurring during and after the education programme.

2.1. HEALTH EDUCATION PROGRAMME

The aim of the education programme was to inform and encourage food handlers to accept and apply good food hygiene practices at the three selected premises.

The education programme was divided into three main food hygiene topics according to the assessed educational needs of the target group, namely:

(i) Personal hygiene
(ii) Environmental hygiene
(iii) Food handling practices.

2.1.1. **Educational Medium**

The feasibility of various instructional methods was considered. Factors taken into consideration during this selection are itemised below:

2.1.1.1. Lectures

Lectures on food hygiene principles comprising individual talks from previously prepared notes were feasible. Lectures could be conducted at the workplace of the target group.

A lecture involves a central figure who transmits knowledge by verbal and other means to a group. This has been cynically defined as "a process by which facts are transmitted from the notebook of the instructor to the notebook of the student without passing through the mind of either" (40).

Advantages and disadvantages of lectures are said to be as follows (20):

Advantages:

(i) Lectures lend themselves to inspire and motivate.

(ii) They are useful for transmitting factual information.

(iii) The are highly suitable as a supplementary teaching method.

(iv) They have economic advantage as a method of instruction.

Disadvantages:

(i) Students are passive during a lecture.

(ii) A lecture makes no provision for individual differences of students.

(iii) There is no opportunity for student questions or feedback by lecturer.

(iv) The facts are very soon forgotten by students.

(v) There is a gradual decrease in the students' attention during the lecture.

(vi) Doubt exists of the effectiveness of lectures to develop attitudes and values.

The lecture was not selected to be used alone owing to the two main disadvantages, namely: students' inactivity during a lecture and the lack of provision for individual differences of students.

2.1.1.2. **Discussions**

Discussions involve a teaching method midway between the extremes of class teaching on the one hand and individual instruction on the other (41).

Advantages and disadvantages of the discussion method are said to be as follows (42):

Advantages:

(i) Discussions involves student actively in their own learning.

(ii) Provides for the setting of individual and social objectives.

(iii) Possesses inherent motivation value.

(iv) Students gain confidence during discussions and interests are increased.

(v) Assists the development of students ability for critical thought in instruction.

(vi) Useful for imparting factual knowledge.

Disadvantages:

(i) Must relate to things already known and experienced by the students.

(ii) Must hold the interest of the students.

(iii) Students must consider the effort of further discussion worthwhile.

(iv) Material must be sufficiently new to arouse interest.

(v) The subject must be such as to make a satisfactory discussion possible in the time available.

Discussions, offer a method of instruction that could overcome the two main defects of the lecture method; namely: the students' inactivity in the learning experience and the lack of provision for individual differences of students.

They provide the lecturer leading the discussion with the opportunity to build on existing knowledge and experience of the group and to guide and control the progress of the discussion in matters relevant to the subject (42).

Two types of discussion commonly used are tutorials and seminars, although other types of discussion, including buzz groups, brainstorming, role playing, and case studies have application in specialized situations.

Of these, it was believed that the tutorial type of discussion would be most suitable. A tutorial is a teaching session involving a high degree of inter action between tutor and student in small groups. Here the tutor is in control, as in traditional kinds of teaching and his presence and status influence the degree and direction of discussions of a small group while keeping the atmosphere as informal as possible (42).

Supported by suitable educational technology, tutorials can be held regularly over a considerable period using the same tutor to ensure continuity for a series of tutorials. This type of discussion was seen to be suitable for the food hygiene education programme as it would allow all food handlers to contribute to the education process, providing a means of active versus passive learning.

In contrast with the tutorial the seminar is an occasional group discussion less systematic in sequence and content and not forming an integral and regular part of an education programme. This method was therefore not considered to be suitable (41).

2.1.1.3. Demonstrations

Demonstrations involve the showing and explaining of a subject by an instructor to a person or a small group (22).

Advantages and disadvantages are said to be as follows (25):

Advantages:

(i) Individual attention is given to students.

(ii) Demonstrations provide for individual differences of students.

(iii) Students are actively involved.

(iv) Provides the opportunity for student questions and feedback by the instructor/lecturer.

(v) There is an increase in the students' attention and interest.

Disadvantages:

(i) Must relate to a subject that is suitable for demonstrations.

(ii) Effective only with individuals or small groups.

Demonstrations consisting of showing and explaining food hygiene principles were theoretically acceptable for small groups at their workplace. In practice this could, however, not be incorporated in the food hygiene education programme as demonstrations would have made exacting demands on the personnel and finances at the selected premises.

2.1.1.4. Guided Field Tours

This would entail group visits to appropriate premises in the field to observe on-the-job situations under special guidance (22).

The advantages and disadvantages are said to be as follows (25):

Advantages:

(i) Individual attention is given to students.

(ii) Guided field tours provide common work related experiences for the group.

(iii) They help focus attention on subject.

(iv) They provide opportunity for student questions and feedback to tour guides.

(v) They stimulate interest and attention.

Disadvantages:

(i) They must relate to a subject suitable for guided tours.

(ii) They are effective in small groups making exacting demands on personnel and finances.

This method was not acceptable to management of the selected premises as such tours would have disrupted their normal business functions.

.1.1.5. Visual Presentation

Visual presentation involves the use of pictures, slides, graphs and drawings to illustrate certain aspects of a subject, to clarify problems and to emphasise content of the learning material and includes still pictures, filmstrip and film projector, slides and slide projector, and overhead projector with transparencies (23):

Advantages and disadvantages are as follows (23):

Advantages:

(i) Visual presentations are easy to integrate into the framework of a verbal lecture presentation.

(ii) They stimulate interest and attention.

(iii) They can illustrate certain aspects of the subject to clarify problems and to emphasise aspects of the lecture.

(iv) They focus students attention on the subject matter.

Disadvantages:

(i) To be effective they need careful integration with other methods of presentation.

(ii) Visual presentations must be specific to the target group and would have to be produced specially for the intended programme.

Visual presentation was appropriate for the food hygiene educational programme.

2.1.1.6. Audio Presentation

This method was designed mainly for the support of presentations which already have a visual component, such as biology where the laboratory plays an important role (43).

Such presentations consist mainly of records, cassettes and taped recordings of the subject matter (23).

The method on its own was inappropriate to the subject food hygiene which required a more demonstrative approach and was therefore not considered suitable.

2.1.1.7. Audio/Visual (A/V) Presentation

A/V presentation embraces all aids and techniques which simultaneously involve auditory and visual input and is effective in the presentation of various specialised demonstrations (21).

Advantages and disadvantages of A/V presentation are said to be as follows (24):

Advantages:

(i) Existing audio, visual, graphic and other training materials and features can easily be incorporated.

(ii) Information can be presented in a visually effective way using moving images, colour, speech, music, sound effects, graphics and captions rendering information more vivid and memorable.

(iii) Equipment is portable and brings the classroom to the target group.

(iv) A/V presentation offers manipulated views of difficult-to-observe scientific experiments through photomicrography extending the limits of human vision by combining the characteristics of the microscope with the camera.

(v) It motivates students and promotes interest as it is an accepted and enjoyed medium.

(vi) Educational officers presenting the A/V presentation often learn new approaches, new techniques and/or new ideas on the subject. This was a major fringe benefit which provided a type of in-service training.

(vii) The A/V video taped medium of instruction can be used very effectively in the presentation of various specialised demonstrations and can be incorporated in other forms of presentations such as tutorials (20).

Disadvantages (21):

(i) The effectiveness of A/V presentations depends on careful planning and preparation of educational material. This is also necessary to justify the work and costs involved..

(ii) Suitable follow-up work is necessary.

(iii) Effective only if selected subject matter is used and presented to selected groups.

(iv) Traditional methods of teaching give better results than A/V presentations for language subjects and certain other social sciences.

Food hygiene being a specialised subject in the public health field and requiring a demonstrative approach for selected groups such as food handlers, it was decided to select the tutorial type of educational method, technologically supported by A/V presentation which included all the mentioned advantages.

2.1.2. Video Material

Having selected the method, the writer was presented with three choices regarding the video programmes; based on:

1. selecting available relevant materials or
2. modifying existing materials or
3. designing new materials.

2.1.2.1. Selecting Available Material

Existing available video material that suitably guided and allowed the target group to meet the objectives could be used and would save both time and money. However, just as there must be a match between the target group and the objectives, there must also be a match between the target group and the instructional materials (25). Thus the suitability of existing material in terms of the following factors had to be taken into account:

(i) the language medium.
(ii) the vocabulary level.
(iii) the reading and/or listening level.
(iv) the phrases, idioms and linguistic style.
(v) the accent of the narrator.
(vi) the illustrative material level.

(vii) the cultural background.

In this regard Heinich, Molenda and Russel emphasise, "As instructors, ... we must keep in mind that our ability to make *sense out of film conventions is an acquired skill*" (25).

Some insight into the kind of difficulties that may be encountered in the instructional situation because of student inability to understand film conventions can be gleaned from the experiences of film makers involved with adults who are unfamiliar with standard film conventions.

While producing instructional films designed to help the people better their skills in farming, housing and sanitation in rural Iran, it was noted that in the United States film makers could show a man walking out of a door in lower Manhattan and immediately pick him up in another shot at Time Square. In Iran this technique was not possible. Viewers there insisted that the man be shown making the journey to Time Square (25).

Similar inabilities to understand film conventions were experienced with a rural African audience (26).

No matter how good the available material might be on other counts, it would be of little benefit if it did not communicate properly and transmit information clearly enough to enable the target group to attain the objectives.

The researcher found that available video instructional materials did not match the requirements of the target group nor the objectives of the food hygiene education programme.

In South Africa it has been reported that, "Almost all programmes are imported from the United States of America. American programmes, which are in the majority, use idiom and language forms which can cause difficulty to even English - speaking South Africans, and much more to those for whom English is a second or third language" (27).

2.1.2.2. Modifying Existing Materials

An alternative approach was to modify available video - taped material to match the target group and the objectives. However this was not feasible owing to existing copyright on all available material. Even if permission was obtained to modify them, the time and expense involved in re-recording narration so as to use the appropriate language, vocabulary level and linguistic style and re-filming illustrative and visual material to match the experience and interpretation level of the target group would have been as costly and time consuming as designing new material. Local problems would not have been addressed and the videos would have only ended up as modified pale copies of imported material (27).

2.1.2.3. Designing New Material

The researcher therefore decided to design new video-taped materials suitable for both the target group and the objectives. This was an expensive and time consuming process, but did allow for the preparation of material to match the target group and the objectives of the educational programme. At the same time local problems and conditions could be addressed using the locally accepted language.

In designing the new educational video programme the following factors were taken into account:

(i) The language preference of the food handlers at the three selected premises was ascertained during interviews with each target group and established as being 90% Afrikaans.

(ii) The vocabulary, reading and comprehension skills as well as linguistic style were also assessed during interviews with members of each target group.

(iii) To match the illustrative materials to the experience level of food handlers, arrangements were made to record all illustrative and visual material at local food premises. These included meat plants, bakery/ confectioners, restaurants and other catering establishments. This enabled the target group to relate to the visual instructional material.

(iv) Educational needs that were assessed by the author during the first phase of the study were included in the educational material.

2.1.2.4. **Video-Programmes**

The researcher wrote three separate video scripts covering each of the three main food hygiene topics and designed the education programme making use of a presenter with narrations, coloured illustrations, graphs and other visual material as well as background music.

Some details of each video are as follows:

2.1.2.5. **VIDEO 1:**

Personal Hygiene

Personal hygiene formed the subject matter of the first section of the programme and consisted of one 12 minute video.

The video explained and demonstrated three main food hygiene areas ie: personal hygiene, environmental hygiene and food handling practices and then continued to expand on personal hygiene principles including:

(i) the role of hands in transmitting microorganisms to foodstuffs.

(ii) prevention of such transmission.

(iii) the personal health of foodhandlers with a simple introduction to recognition of potentially hazardous diseases.

(iv) personal hygiene of hands, hair and body of food handlers relating to cleanliness, the undesirability of sores and cuts.

(v) the use of protective clothing.

The first video ended with reinforcement of the main personal hygiene principles and their importance in preventing food poisoning and food spoilage.

2.1.2.6. **VIDEO 2:**

Environmental Hygiene

Environmental hygiene formed the subject matter of the second section of the programme and consisted of a 10 minute video.

It started with the reinforcement of the main personal hygiene principles of the first video and then continued to demonstrate and expand on the hygiene and cleaning of the workplace, including:

(i) food contact surfaces ie. working surfaces, utensils, containers and equipment.

(ii) the multiplication of microorganisms on dirty surfaces.

(iii) a cleaning plan.

(iv) cleaning of specific surfaces, including sinks, wash-hand basins, floors, walls, doors, windows, storage facilities and refrigerators.

(v) the proper use of the correct detergents and disinfectants.

This second video ended with a summary of the main principles of environmental hygiene.

2.1.2.7. **VIDEO 3:**

Food Handling Practices

Food handling practices formed the subject matter of the third and final section of the programme and consisted of a 11 minute video.

It began with the reinforcement of the main principles of personal hygiene and environmental hygiene of the first two videos. It then continued to expand on and demonstrate food handling practices such as:

(i) safe and proper handling of foodstuffs to prevent contamination before, during and after preparation.
(ii) proper storage and handling of raw and cooked foodstuffs.
(iii) contamination of cooked foodstuffs by raw foodstuffs, contact surfaces, hands and cleaning cloths.
(iv) proper use of protective clothing.
(v) protection of foodstuffs by temperature control.
(vi) pest control importance.
(vii) microorganism control.

This final video session ended with the reinforcement of the main principles of personal hygiene, environmental hygiene and food handling practices that were required to control spoilage of foodstuffs and prevent food poisoning.

Considerable technical expertise was required to record and edit each video. Such expertise was made available by the Media Production Centre of the Cape Technikon in Cape Town.

All scripting, production and direction was carried out by the researcher.

A copy of the video programme is available at the video division of the Zonnebloem library of the Cape Technikon.

2.1.3. Presentation of Education Programme

The presentation of the educational material at the selected premises was done by the researcher in the form of a video supported tutorial.

An attempt was made to present the three videos to the total population of food handlers employed at each of the three selected premises. However the total number of food handlers present at each session varied due to absenteeism of food handlers from work on the dates of the tutorial sessions as shown in Table 1.

TABLE I

EDUCATIONAL PRESENTATION DURING THE SECOND PHASE

Selected Premises	Tutorial Sessions	Date Presented	Food Handlers	
			Total	Attendance
Meat Plant	1st x 2	1989/03/17	32	32
	2nd x 2	1989/04/13	32	23
	3rd x 2	1989/08/02	32	30
Bakery/ Confectionery	1st x 4	1989/06/13	71	71
	2nd x 4	1989/07/18	71	70
	3rd x 4	1989/08/08	71	63
Catering premises	1st x 2	1989/01/16	30	30
	2nd x 2	1989/04/25	30	25
	3rd x 2	1989/08/03	30	25

The following characteristics applied to the tutorial sessions:

(i) Small groups of food handlers attended each session.

(ii) Sessions were held at the workplace of the food handlers.

(iii) The duration of each session was 30 minutes.

(iv) Sessions were held during the second phase of the study.

(v) Sessions were held at minimum intervals of one month as shown in Table I.

(vi) Before presentation food handlers were informed of the food hygiene topic to be dealt with.

(vii) Each presentation was followed by group discussions sharing views, problems and ideas on the food hygiene topic. This effectively turned the video presentation into video-tutorial sessions.

The time-base for presentation of the educational programme was sufficient for informal reinforcement of the educational material after each video presentation.

Reinforcement of salient and relevant principles concerning personal hygiene, environmental hygiene and food handling practices, was effected on a person-to-person basis during inspections of the selected premises following each tutorial session.

Reinforcement was also built into the programme by the repetition of all salient information in the introduction and conclusion of the second and third video presentations. Further reinforcement was effected during the group discussions following each video presentation.

Equipment and facilities to present the programme were made available at each of the selected premises. This made it possible for the programme to be presented to food handlers at their workplace, enabling them to identify and relate the information more readily with their own work environment.

2.1.4. SELECTED FOOD PREMISES

The education programme was presented to all food handlers at three selected premises.

These premises were selected for the following reasons:

(i) they were each large premises with a diversity of food handling functions which permitted the researcher to study hygiene under various food handling conditions.

(ii) these premises produced a broad spectrum of food products.

(iii) they each differed in their,

(a) cleaning programme

(b) existing food hygiene education method

The three premises selected were as follows:

2.1.4.1. Meat Plant

The meat plant processed and manufactured meat products. This meat plant was situated in an old building not specially designed or suited for the function of a meat plant.

It consisted of a main room in which deboning, mincing, grinding and filling functions were performed. A cooking area existed on the one side of this room. A separate area was used for packing products. Refrigeration rooms were available for the storage of raw materials and cooked products. The necessary toilet and cloakroom facilities were provided.

No proper production flow line existed and cross flow of raw and cooked products occurred on almost a continuous basis during production and storage. Adherence to a proper cleaning programme was not maintained.

Hygiene aspects and food handling practices required a lot of attention as food hygiene education was neglected.

2.1.4.2. **Bakery/Confectionery**

The bakery/confectionery manufactured bread and cake products. This was a newly established manufacturing plant, situated in a fairly new building specially equipped and adapted for the bakery/confectionery function. It consisted of a large hall with the floor area divided up into specialised working areas for: mixing, moulding, baking, packing, storage and dispatching. Separate dry storage and refrigeration storage rooms were available for raw materials and cooked products. The necessary toilet and cloakroom facilities were provided.

A good production flow line and a daily cleaning programme existed. Personal hygiene and food hygiene education were attended to on an *ad hoc* basis by management.

2.1.4.3. **Catering Premises**

The caterer included restaurant, food take-away, baking and general kitchen processes. It was well established in a premises specially designed and equipped for this purpose.
It consisted of a large open plan working area. A variety of ovens and cooking stoves was centred in the middle of the working area and provided with a proper mechanically operated extraction canopy. The remaining open floor space was divided up into specialised working areas for preparation of raw material and the handling and packing of final food products. Separate refrigeration, deep freezing, dry storage and dispatch rooms were available for raw materials and final products. The necessary toilet and cloakroom facilities were provided.

A good flow line and 'clean as you go' programme existed.

Food hygiene education was provided by an independent hygiene consultancy firm on a regular basis over a two year period leading up to this study.

2.2. THE BACTERIOLOGICAL SWABS

Microbiological monitoring of food contact surfaces at the meat plant, the bakery/confectionery and the catering premises was carried out by means of analysis of bacteriological surface swabs and hygiene profiles for each of the selected premises established.

2.2.1. Swabbing Methods:

The sterile cotton wool swab method used for surface swabbing was in accordance with the prescribed method in Schedule A of the South African Code of Practice For Taking Bacteriological Samples (28).

This method was preferred to the agar sausage or agar syringe method (29), or the agar contact plate method referred to as the Replicate Organism Direct Agar Contact (Rodac Method)(31), or the acetate adhesive tape method (31).

The main reason for preference is that the cotton wool swab method can adapt to a variety of surface areas whether smooth, irregular, confined or enclosed and can provide information on the number as well as the type of microorganisms existing on an environmental surface (32).

Direct agar surface contact methods cannot be applied to a wide variety of surface situations, only to surfaces that are smooth, flat or slightly curved with a fairly uniform contamination level. Recovery rates are in any event relatively low in comparison to the cotton wool swab method (30). Furthermore, quantitative determination of the organism is limited by the type of agar medium as the use of selective and differential agar media is usually required for the culture of different types of organisms.

A further drawback of direct surface contact methods is that they do not distinguish between single cells and clumps of cells on a surface. Quantitative data are not as accurate as those obtained by the cotton wool swab method because the swab tends to break up clusters of cells, thus providing data more representative of a true cell count (31).

In this study a broad sampling approach was needed to develop a microbiological profile of the hygiene of each premises. The "assessment swabbing" technique of swabbing several similar sites with a single swab was thus used (6).

This technique involves the swabbing of several similar sites with the same swab rather than swabbing single sites with a single swab. This is known to average out variations in counts between similar areas and ensure high recovery of organisms (33). Swabbing of at least three areas has been shown to minimise statistical variations in recovery rates and ensure better results than other swabbing techniques (34).

The use of one swab for five of the same articles and similarly one swab per five predetermined surfaces of 5x5 cm^2 each, including cutting tables, chopping boards and other food contact surfaces, has been described by Collins and Lyne in their laboratory technique series (6).

Swabbing single sites with a single swab or the "clinical swabbing" technique, is normally effective in detecting a specific type of contamination to pin point its locality on a food production flow line.

To identify individual equipment or hands that were contaminated was, however, not the purpose of this study, but instead the purpose was to assess the hygiene of a food premises holistically, and thus the process described in 2.2.2. was applied.

2.2.2. **Surface Swabbing** :

Four similar articles or components were selected as prescribed in Schedule A (28) and a single swab used to sample an area of 25 cm^2 of each giving a total sampled area of 100 cm^2 per swab.

The method of sampling by means of swabbing was as follows:

(i) A swab was removed from its sterile tube holder and moistened with Ringer's Solution from a Mc Cartney bottle.

(ii) Excess moisture was expressed from this swab on the inside of the bottle before removal.

(iii) Each group of articles was then swabbed and the swab immediately replaced in the same bottle. The protruding portion of the stick above the neck of the bottle was broken off and the screw top replaced.

This is known as the "wet swabbing" technique.

(iv) Immediately afterwards a swab was taken over the same areas with a second sterile dry swab which was then placed in a second bottle of Ringer's Solution.

This is known as the "dry swabbing" technique.

(v) In each case both bottles were suitably marked so as to identify the areas from which the sample was taken and to distinguish the wet from the dry swab.

All plate counts per swab were converted from 100 cm^2 surface area to represent one cm^2 of permitted surface area as prescribed in the regulations (36).

Each set of swabs consisted of 14 swabs as shown in Table II.

TABLE II

TOTAL SWABS AND SURFACES per SET OF SWABS

SURFACE	SWAB AREA	TOTAL SWABS WET	DRY
1 group of four **containers**	100 cm^2	1	1
1 group of four **utensils**	100 cm^2	1	1
1st group of four **equipment areas**	100 cm^2	1	1
2nd group of four **equipment areas**	100 cm^2	1	1
1st group of four **working surfaces**	100 cm^2	1	1
2nd group of four **working surfaces**	100 cm^2	1	1
1st group of four **hands**		1	-
2nd group of four **hands**		1	-
TOTALS: 32 SURFACES		**14**	

All food contact surfaces had been cleaned the previous night and swabs were taken the following morning before use of the surfaces.

Swabbing thus evaluated the efficacy of terminal cleaning procedures and not the levels of contamination caused by use of the surfaces or concurrent cleaning or disinfection.

2.2.3. **Hand Swabbing**

Swabs were also taken from hands of a random selection of twenty foodhandlers during each of the three phases of the study.

The total foodhandler population at each of these premises was as follows:

Meat Plant - 32 foodhandlers

Bakery/Confectionery - 71 foodhandlers

Catering Premises - 30 foodhandlers

Swabs were taken from a total of 180 foodhandlers during the research study.

The method of hand swabbing is not set out in the Code of Practice for Taking Bacteriological Samples (28).

Method of hand swabbing was as follows:

(i) A swab was removed from its sterile tube holder and moistened with Ringer's Solution from a separate McCartney bottle.

(ii) Excess moisture was expressed from this swab on the inside of the bottle before removal.

(iii) Four hands were then swabbed with the same moistened swab.

(iv) Swabbing started on the outer edge of the thumb moving up to the tip of the thumb then down the inner edge to the thumb web, then continued in this manner over the index, middle, ring and small finger.

(v) The underside of each finger of the same hand was then swabbed starting at the point of each finger and moving down to the palm of the hand.

(vi) After swabbing, the swab was immediately replaced in its sterile tube holder.

(vii) "Dry swabbing" of hands was not carried out.

2.2.4. **General Precautions**

During swabbing the following precautions were taken:

(i) similar angle, pressure and rotation for each swab was maintained

(ii) contamination by coughing, sneezing or talking over the swab and contact surface was avoided.

The total number of swabs taken during the three phases and total number of food contact surfaces tested are shown in Table III.

TABLE III

TOTAL SWABS AND SURFACES

PHASE	SWABS				SURFACES
	Wet	Dry	Hands	Total	Total
1	88	88	30	206	468
2	90	90	30	210	463
3	90	90	30	210	479
Totals	268	268	90	626	1 410

2.2.5. **Swabbing Phases**

Swabs of food contact surfaces were taken in each of the three consecutive phases for analysis in order to establish a microbiological profile of changes in hygiene for each of the selected premises.

Table IV shows the chronological order of taking the swabs.

Hygiene profiles were established during these phases for each of the three food premises as shown in Appendices 1, 2 and 3.

2.2.5.1 **PHASE 1**

The objective of the first phase was to establish a base line for each hygiene indicator organism **before** the education programme was presented to foodhandlers.

This involved the taking of 15 sets of swabs i.e. 5 sets of swabs at each of the three premises as shown in Table V.

2.2.5.2. **PHASE 2**

During the second phase the education programme was presented to foodhandlers and a further 15 sets of similar surface swabs were concurrently taken i.e. 5 sets of swabs at each premises as shown in Table VI.

2.2.5.3. **PHASE 3**

After presentation of the education programme a final 15 sets of similar surface swabs were taken i.e. 5 sets of swabs at each premises as shown in Table VII.

DATES OF
BACTERIOLOGICAL SWAB SETS
TAKEN AT SELECTED PREMISES

TABLE IV

MEAT PLANT	PHASE 1 DATE	PHASE 2 DATE	PHASE 3 DATE
1st set	89/01/11	89/03/29	89/08/16
2nd set	89/01/24	89/04/11	89/08/23
3rd set	89/02/08	89/04/25	89/08/30
4th set	89/02/21	89/05/17	89/09/13
5th set	89/03/14	89/05/24	89/09/26

BAKERY/ CONFECTIONERY	PHASE 1 DATE	PHASE 2 DATE	PHASE 3 DATE
1st set	89/04/25	89/06/20	89/08/15
2nd set	89/05/03	89/07/04	89/08/22
3rd set	89/05/16	89/07/18	89/08/29
4th set	89/05/23	89/08/01	89/09/12
5th set	89/06/06	89/08/08	89/09/19

CATERING PREMISES	PHASE 1 DATE	PHASE 2 DATE	PHASE 3 DATE
1st set	89/01/11	89/03/21	89/08/16
2nd set	89/01/24	89/04/05	89/08/23
3rd set	89/02/07	89/04/19	89/08/30
4th set	89/02/22	89/05/17	89/09/20
5th set	89/03/15	89/05/24	89/09/27

TABLE V

SWABS AND SETS OF SWABS FOR PHASE 1 OF THE EDUCATION PROGRAMME			
PREMISES	**DATE**	**SETS**	**TOTAL SWABS WET & DRY**
Meat Plant	89/01/11 to 89/03/14	5	66
Bakery/Confectionery	89/04/25 to 89/06/06	5	70
Catering	89/01/11 to 89/03/15	5	70
Totals		15	206

TABLE VI

SWABS AND SETS OF SWABS FOR PHASE 2 OF THE EDUCATION PROGRAMME			
PREMISES	**DATE**	**SETS**	**TOTAL SWABS WET & DRY**
Meat Plant	89/03/29 to 89/05/24	5	70
Bakery/Confectionery	89/06/20 to 89/08/08	5	70
Catering	89/03/21 to 89/05/24	5	70
Totals		15	210

TABLE VII

SWABS AND SETS OF SWABS FOR PHASE 3 OF THE EDUCATION PROGRAMME			
PREMISES	**DATE**	**SETS**	**TOTAL SWABS WET & DRY**
Meat Plant	89/08/16 to 89/09/26	5	70
Bakery/Confectionery	89/08/15 to 89/09/19	5	70
Catering Premises	89/08/16 to 89/09/27	5	70
Totals		15	210

2.2.6. Microbiological Analysis of Swabs:

Standard microbiological techniques (35) were used by the Orange Street Laboratory of the SAIMR, to detect and confirm the following spectrum of hygiene indicators and pathogens:

2.2.6.1. Plate Count

Plate count refers to the total number of aerobic mesophyllic micro-organisms and is also known as the 'total viable' or Standard Plate count or Aerobic Plate Count.

Regulation prescribes that there shall not be more than 100 organisms per cm^2 in accordance with acknowledged bacteriological methods of investigation of food contact surfaces (36). High mesophyllic counts increase the probability of the occurrence of pathogens (37).

In one study it was shown that when plate count exceeded 100 organism per cm^2 per item for crockery, cutlery and utensils, coliform and *Escherichia coli* organisms were detected in every swab sample taken (19).

2.2.6.2. **Coliforms**

The coliform group comprises all of the aerobic and facultative anaerobic gram-negative, non spore-forming, rod-shaped bacteria that *ferment lactose with gas formation within 48 hr* at 37°C and include *Escherichia*, *Klebsiella* and *Enterobacter*. They are lactose-positive members of the family Enterobactericeae (7).

Enterobacteriaceae are used as indicator organisms to check the housekeeping and hygiene practices in many food-processing plants (18).

Coliforms are a good indicator of inadequate cleaning and disinfecting of utensils, equipment, machinery or food contact surfaces, but need not necessarily be faecal in origin. They should not, however be present. Their presence in large numbers indicates the opportunity for multiplication of Salmonellae, Shigellae, Staphylococci or other mesophyllic and potentially pathogenic organisms (37).

Coliforms have been shown to be useful indicators of hygiene in large commercial kitchen environments (17).

2.2.6.3. *Escherichia coli*

Suspect Coliform colonies were further examined by means of the modified Eijkman test as prescribed in the Foodstuffs, Cosmetics and Disinfectants Act (Act 54 of 1972) for *Escherichia coli* (38).

Their presence is an indication of faecal contamination suggesting inadequate cleaning and disinfecting and suggests that enteric pathogens may have reached food contact surfaces as a result of poor personal hygiene. They should not be present.

2.2.6.4. **Enterococci**

This group comprises all group D Streptococci, i.e. *Streptococcus faecalis* and *Streptococcus faecium*.

They have relatively high resistance to drying, freezing, high temperature, salt concentration, detergents, or disinfectants. Found in human and animal faeces, they are useful indicators of hygiene practices in food premises, particularly regarding cleansing and disinfection of food contact surfaces. Their presence implies conditions which could permit the presence of many other undesirable species of organisms owing to poor cleaning, poor disinfecting and poor personal hygiene (37).

2.2.6.5. ***Salmonella sp***

and

2.2.6.6. ***Shigella sp***

These include enteropathogenic types being non lactose fermenting members of Enterobacteriaceae and their presence is due to poor personal hygiene and inadequate cleaning of food contact surfaces. They indicate possible faecal contamination and may be found to be present even if tests for coliforms are negative (37).

The *Salmonella* group of organisms reach food directly or indirectly from animal excreta at time of slaughter or from human excreta. In food premises they can be transferred from raw to cooked food *via* hands, surfaces, equipment such as chopping blocks, cutting boards, electrical saws, slicing machines, other equipment, a variety of utensils and cloths (4).

An outbreak caused by the consumption of non-fat dried milk containing *Salmonella* was attributed to poorly designed and constructed equipment and incomplete cleaning which resulted in product accumulations going undetected (14).

Food-borne Shigellosis outbreaks are usually characterised by the involvement of infected food handlers at some point in the chain of infection. Contaminated fomites such as water glasses and utensils have been found to be involved (37).

2.2.6.7. ***Staphylococcus aureus***, is usually an indication of contamination from the nose, skin (especially hands), or mouths of food handlers owing to poor personal hygiene but inadequate cleaning of food contact surfaces may also result in a reservoir of the organism. Many are toxin producing and grow readily in slightly acid foods where they give off a potent enterotoxin as they grow, which may be involved in food poisoning outbreaks (13).

It has been reported that the incorrect thawing of foodstuffs, unsatisfactory cleaning of kitchen equipment and food contact surfaces as well as cross contamination from raw to cooked foodstuffs including handling of raw and cooked foodstuffs on the same surfaces are high risk practices in outbreaks (16).

In man, the principal source of *Staphylococcus aureus* is the nose. The average carrier rate in British hospital nurses examined over a period of several weeks showed that 80% to 90% were nasal carriers on one or more occasions (9).

Clothing of nasal carriers frequently harbours *Staphylococcus aureus*. Air is very readily contaminated with dust-borne bacteria from clothing when a person dresses or undresses. In a British study it was observed that two-thirds of nasal carriers had sufficient *Staphylococcus aureus* on their skin and the front of their clothes to render them as staphylococcal donors (11).

Food preparation equipment may transfer *Staphylococcus aureus* from contaminated foods to previously uncontaminated foodstuffs. A case is reported where a slab of roast pork was contaminated with *Staphylococcus aureus* and sliced, followed by slicing uncontaminated meat on the same slice machine. This organism was subsequently isolated from 41 consecutive slices of the previously uncontaminated meat. *Staphylococcus aureus* was also isolated from cloths rubbed over the slicer blade. This contaminated cloth readily spread the organism to other equipment, utensils and working surfaces (12).

2.2.6.8. ***Clostridium perfringens***

Certain strains of type A of this organism are known to cause food-borne disease in man. Their spores are markedly heat-resistant requiring 1/2 to 1 hour at 100° C to destroy 90% of spores. Main food vehicles are uncured meat or meat products including prepared meat dishes.

Meat and poultry may be contaminated with *Clostridium perfringens* during slaughtering as well as during processing operations. This contamination can be carried over to food preparation equipment and surfaces. Transfer of *Clostridium perfringens* from raw foodstuffs to cooked foodstuffs *via* hands, surfaces, equipment, utensils, containers and apparatus, must receive special attention in preventing perfringens food poisoning (37).

2.2.7. **Recording of Results**

Bacteriological analysis of swab samples was carried out for the presence in 0,1ml of Ringer's solution of for each of the hygiene indicator organisms namely : coliforms, *Escherichia coli*, enterococci, *Salmonella sp*, *Shigella sp*, *Staphylococcus aureus* and *Clostridium perfringens*.

All total viable organism counts higher than 100 organisms per cm^2 per swab sample were recorded as positive.

2.2.8. Statistical Method

To establish whether any significant difference existed between these three phases of the study, bacteriological results of the numbers of swabs were subjected to the statistical chi-square test:

$$(\chi^2\text{-test})$$

$$\chi^2 = \Sigma \frac{(O-E)^2}{E}$$ where O = observed frequency

E = expected frequency

(i) between Phase 1 and Phase 2

(ii) between Phase 2 and Phase 3

(iii) between Phase 1 and Phase 3.

2.2.9. WATER SAMPLES

To assess the role of water as a potentially confounding variable in the study, a bacteriological sample of the Municipal water supply to the meat plant, the bakery/confectionery and the catering premises was taken together with each set of swabs. These water samples were submitted to the Orange Street Laboratory of the SAIMR, where the standard method for presumptive and differential tests for coliform and *Escherichia coli* were carried out (39).

The main reason for analyzing the water supply is that water constituted a major component in the cleaning processes at these food premises.

3. RESULTS

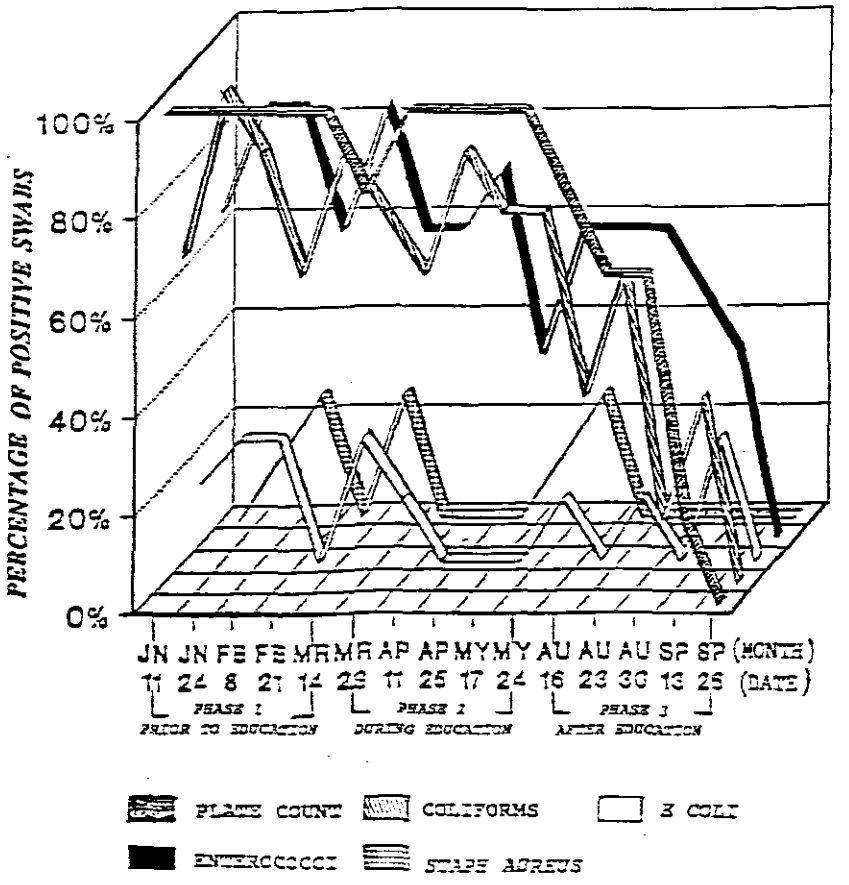
3.1 RESULTS EXPRESSED BY TYPE OF PREMISES

3.1.1. MEAT PLANT

Comparison of the percentage of swabs found to be positive for each type of indicator organism by phase of the education programme at the meat plant are shown in Figure 1 below and summarised in Appendix 1.

FIGURE 1

PERCENTAGE OF POSITIVE SWABS DETECTED AT MEAT PLANT BY PHASE OF THE EDUCATION PROGRAMME



3.1.1.1. **PLATE COUNT**

A reduction in the number of positive swabs for plate count occurred between phase 1 and phase 2, although not statistically significant.

A statistically significant reduction in the number of positive swabs for counts occurred between phase 2 and phase 3, ($p < 0,01$) and between phase 1 and phase 3, ($p < 0,01$).

3.1.1.2. **COLIFORM**

A reduction in the number of positive swabs for coliforms occurred between phase 1 and phase 2, although not statistically significant.

A statistically significant reduction in the number of positive swabs for coliforms occurred between phase 2 and phase 3, ($p < 0,01$) and between phase 1 and phase 3, ($p < 0,01$).

3.1.1.3. ***ESCHERICHIA COLI***

An increase in the number of positive swabs for *Escherichia coli* occurred between phase 2 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for *Escherichia coli* occurred, however, between phase 1 and phase 2, ($p < 0,05$) and between phase 1 and phase 3, ($p < 0,05$).

3.1.1.4. **ENTEROCOCCI**

A reduction in the number of positive swabs for enterococci occurred between phase 2 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for enterococci occurred between phase 1 and phase 2, ($p < 0,05$) and between phase 1 and phase 3, ($p < 0,01$).

3.1.1.5. ***STAPHYLOCOCCUS AUREUS***

A reduction in the number of positive swabs for *Staphylococcus aureus* occurred between phase 1 and phase 2 and between phase 2 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for *Staphylococcus aureus* occurred between phase 1 and phase 3, ($p < 0,01$).

3.1.1.6. *CLOSTRIDIUM PERFRINGENS*

An increase in the number of positive swabs for this organism was noted between phase 1 and phase 2, although not statistically significant.

A reduction in the number of positive swabs for *Clostridium perfringens* occurred, however, between phase 2 and phase 3 although not statistically significant.

No change in the number of positive swabs for *Clostridium perfringens* occurred between phase 1 and phase 3 as only one positive swab was detected in each of these phases.

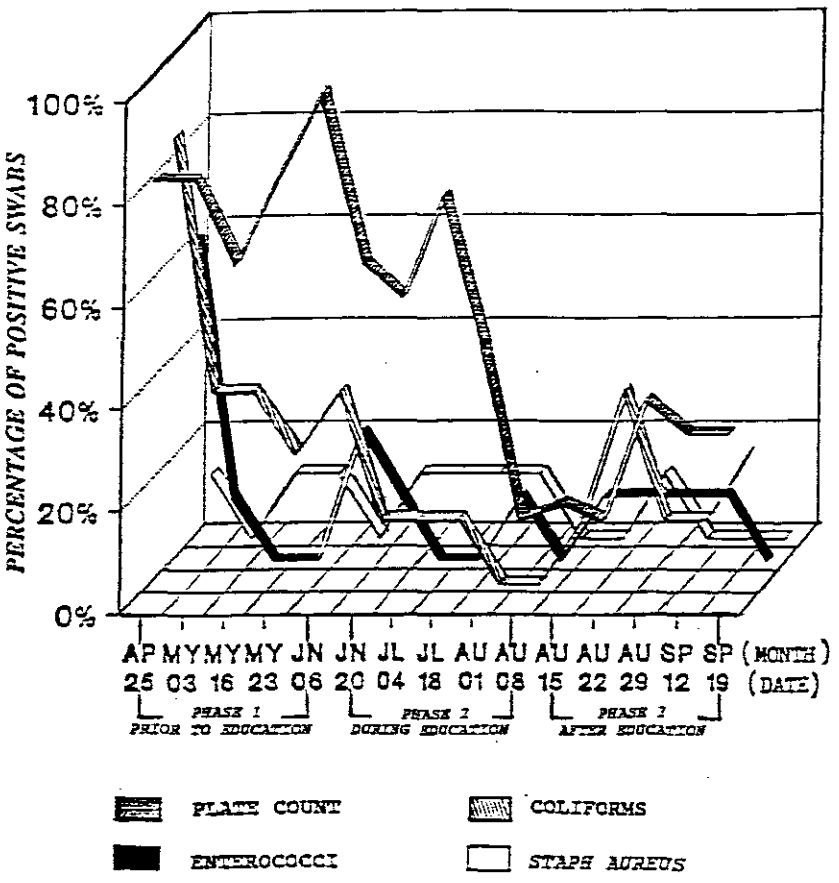
This organism is not reflected on Fig. 1 as a total of only four positive swabs was recorded for *Clostridium perfringens* during the three phases of the research study.

3.1.2. BAKERY/CONFECTIONERY

Comparison of the percentage of swabs found to be positive for each type of indicator organism by phase of the education programme at the bakery/confectionery is shown in Figure 2 below and summarised in Appendix 2.

FIGURE 2

PERCENTAGE OF POSITIVE SWABS
DETECTED AT BAKERY/CONFECTIONERY
BY PHASE OF THE EDUCATION PROGRAMME



3.1.2.1. **PLATE COUNT**

A reduction in the number of positive swabs for plate count occurred between phase 2 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for plate count occurred between phase 1 and phase 2, ($p < 0,05$) and between phase 1 and phase 3, ($p < 0,01$).

3.1.2.2. **COLIFORMS**

An increase in the number of positive swabs for coliforms was noted between phase 2 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for coliforms occurred, however, between phase 1 and phase 2, ($p < 0,01$) and between phase 1 and phase 3, ($p < 0,05$).

3.1.2.3. **ENTEROCOCCI**

An increase in the number of positive swabs for enterococci was noted between phase 2 and phase 3, although not statistically significant.

A reduction in the number of positive swabs for *enterococci* occurred, however, between phase 1 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for enterococci occurred between phase 1 and phase 2, ($p < 0,05$).

3.1.2.4. *STAPHYLOCOCCUS AUREUS*

No change in the number of positive swabs for *Staphylococcus aureus* occurred between phase 1 and phase 2.

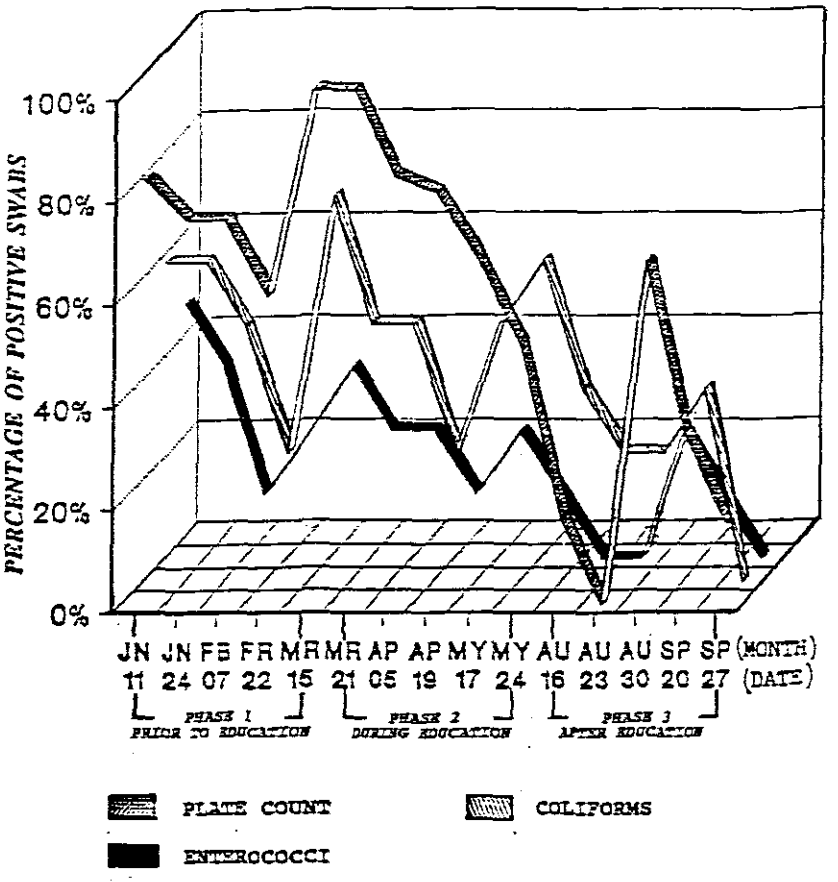
A reduction in the number of positive swabs for *Staphylococcus aureus* occurred between phase 1 and phase 3, and between phase 2 and phase 3, although not statistically significant.

3.1.3. CATERING PREMISES

Comparison of the percentage of swabs found to be positive for each type of indicator organism by phase of the education programme at the catering premises is shown in Figure 3 below and summarised in Appendix 3.

FIGURE 3

PERCENTAGE OF POSITIVE SWABS
DETECTED AT CATERING PREMISES
BY PHASE OF THE EDUCATION PROGRAMME



3.1.3.1. PLATE COUNT

A reduction in the number of positive swabs for plate count occurred between phase 1 and phase 2, although not statistically significant.

A statistically significant reduction in the number positive swabs for of plate counts occurred between phase 1 and phase 3, ($p < 0,01$) and between phase 2 and phase 3, ($p < 0,01$).

3.1.3.2. COLIFORMS

A reduction in the number of positive swabs for coliforms occurred between phase 1 and phase 2, although not statistically significant.

A statistically significant reduction in the number of positive swabs for coliforms occurred between phase 2 and phase 3, ($p < 0,05$) and between phase 1 and phase 3, ($p < 0,01$).

3.1.3.3. **ENTEROCOCCI**

A reduction in the number of positive swabs for enterococci occurred between phase 1 and phase 2 and between phase 2 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for enterococci occurred between phase 1 and phase 3, ($p < 0,01$).

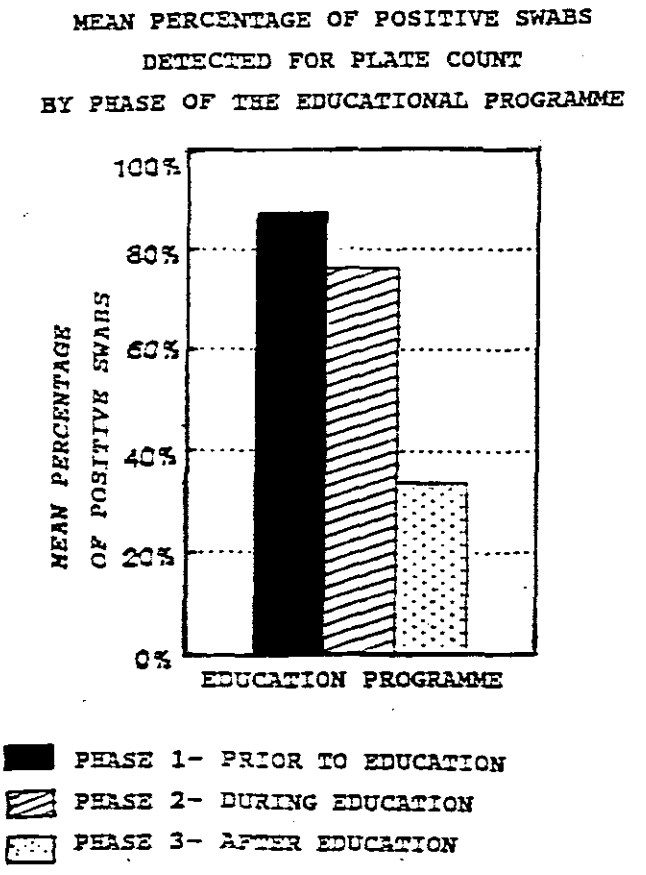
3.2 RESULTS EXPRESSED BY TYPE OF INDICATOR ORGANISMS

Comparison of the mean percentage of swabs found to be positive for each type of indicator organism by phase of the education programme is shown in Figure 4 to Figure 8. These data are summarised in Appendix 4.

3.2.1. PLATE COUNT

Comparison of the mean percentage of positive swabs for plate count by phase of the education programme is shown in Figure 4.

FIGURE 4



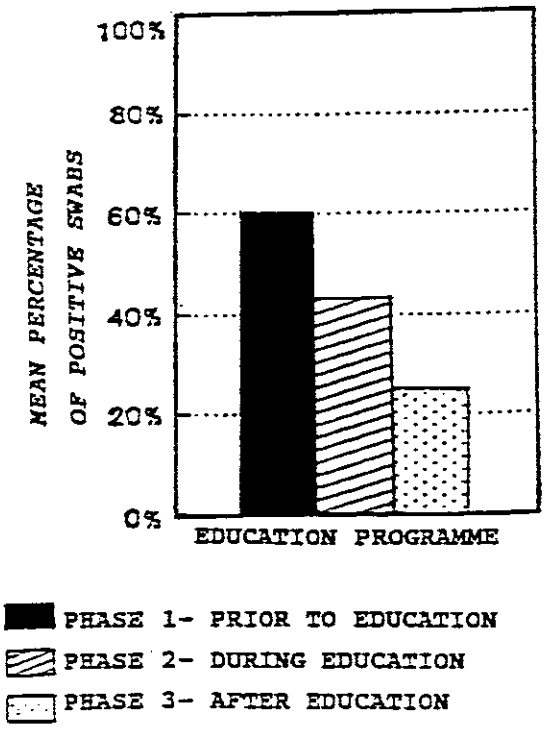
A statistically significant reduction in the number of positive swabs for plate count occurred between phase 1 and phase 2, ($p < 0,05$) between phase 1 and phase 3, ($p < 0,01$) and between phase 2 and phase 3, ($p < 0,01$)

3.2.2. COLIFORMS

Comparison of the mean percentage of positive swabs for coliforms by phase of the education programme is shown in Figure 5.

FIGURE 5

MEAN PERCENTAGE OF POSITIVE SWABS
DETECTED FOR COLIFORMS
BY PHASE OF THE EDUCATION PROGRAMME

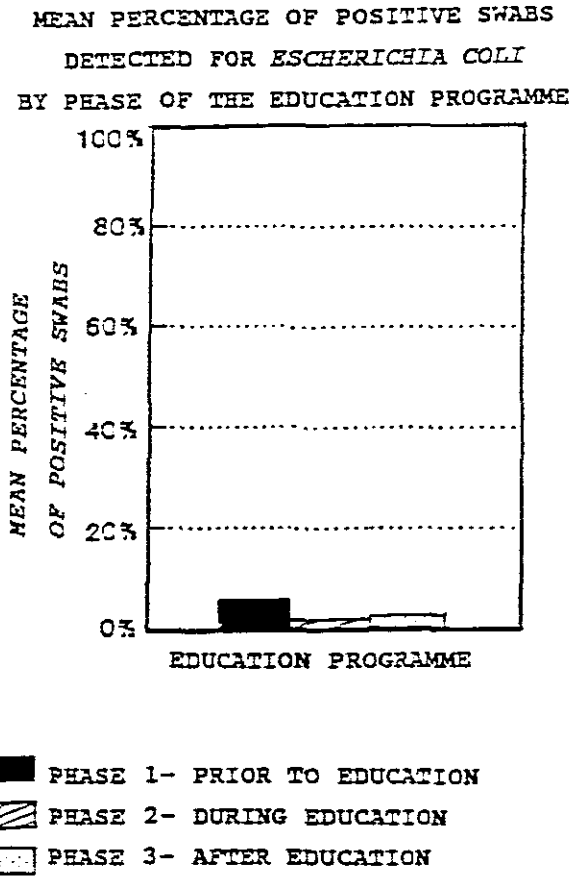


A statistically significant reduction in the number of positive swabs for coliforms occurred between phase 1 and phase 2, ($p < 0,01$) between phase 2 and phase 3, ($p < 0,01$) and between phase 1 and phase 3, ($p < 0,01$).

3.2.3. *ESCHERICHIA COLI*

Comparison of the mean percentage of positive swabs for *Escherichia coli* by phase of the education programme is shown in Figure 6.

FIGURE 6



An increase in the number of positive swabs was noted between phase 2 and phase 3, although not statistically significant. A reduction in the number of positive swabs for *Escherichia coli* organisms occurred, however, between phase 1 and phase 3, although not statistically significant.

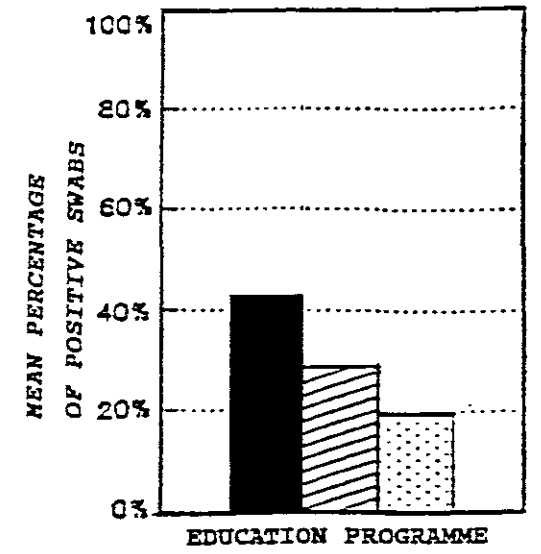
A statistically significant reduction in the number of positive swabs for *Escherichia coli* organisms occurred between phase 1 and phase 2, ($p < 0,05$).

3.2.4. *ENTEROCOCCI*

Comparison of the mean percentage of positive swabs for enterococci by phase of the education programme is shown in Figure 7.

FIGURE 7

MEAN PERCENTAGE OF POSITIVE SWABS
DETECTED FOR ENTEROCOCCI
BY PHASE OF THE EDUCATIONAL PROGRAMME



PHASE 1- PRIOR TO EDUCATION
PHASE 2- DURING EDUCATION
PHASE 3- AFTER EDUCATION

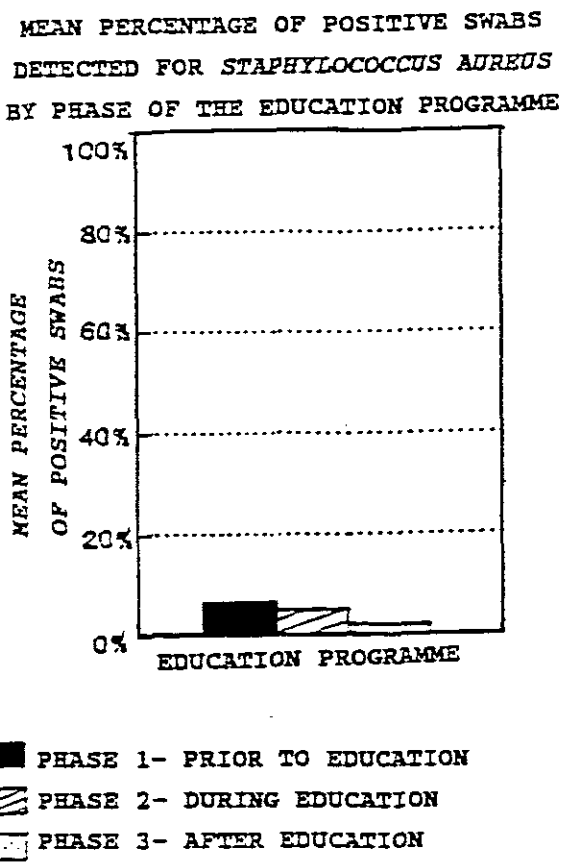
A reduction in the number of positive swabs for enterococci occurred between phase 2 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for enterococci occurred between phase 1 and phase 2, ($p < 0,05$) and between phase 1 and phase 3, ($p < 0,01$).

3.2.5. *STAPHYLOCOCCUS AUREUS*

Comparison of the mean percentage of positive swabs for *Staphylococcus aureus* by phase of the education programme is shown in Figure 8.

FIGURE 8



A reduction in the number of positive swabs for *Staphylococcus aureus* organisms occurred between phase 1 and phase 2 as well as between phase 2 and phase 3, although not statistically significant.

A statistically significant reduction in the number of positive swabs for *Staphylococcus aureus* organisms occurred between phase 1 and phase 3, ($p < 0,05$).

3.2.6. *CLOSTRIDIUM PERFRINGENS*

An increase in the number of positive swabs was noted between phase 1 and phase 2, although not statistically significant.

A reduction in the number of positive swabs for *Clostridium perfringens* organisms occurred, however, between phase 1 and phase 3 and between phase 2 and phase 3, although not statistically significant.

3.2.7. *SALMONELLA SP* and *SHIGELLA SP*

Salmonella and Shigella organisms were not detected on any of the swabs taken during the research study.

3.3. BACTERIOLOGICAL REPORTS ON WATER SAMPLES

The probable number of organisms per 100 ml of water for coliform and *Escherichia coli* taken together with each set of swabs is shown in Appendices 5, 6 and 7.

No coliform or *Escherichia coli* were isolated in the 45 water samples taken at the selected premises.

This conforms with the definition of "pure water" as defined in Regulation R.185 (36).

4. DISCUSSION

In order to evaluate the specific health education programme for food handlers at the meat plant, the bakery/confectionery and the catering premises, the results of the bacteriological analysis of swabs obtained during phase 1, 2 and 3 were compared.

Hygiene profiles based on the total numbers of positive swabs for each type of indicator were established before the education programme during phase 1, and after the education programme during phase 3 at each of the selected premises.

4.1 Meat Plant

The hygiene profile established at the meat plant before the education programme reflected positive identification of six out of the possible spectrum of eight types of indicators monitored. When comparing this hygiene profile with the hygiene profile established in phase 2 during the education programme, statistically significant reductions of five of these indicators were observed. Percentage comparisons are shown in Appendix 8.

Further comparisons of the hygiene profile before and after the education programme revealed a further reduction in five of the indicators identified. Percentage comparisons are shown in Appendix 9.

These comparisons reflect the following improvement of the hygiene profile following the education programme;

(i) Statistically significant reductions ($p < 0,01$) occurred in plate count, *coliforms*, *enterococci* and *Staphylococcus aureus* organisms.

(ii) Statistically significant reduction ($p < 0,05$) of *Escherichia coli* organisms occurred.

(iii) A reduction of *Clostridium perfringens* organisms occurred although not significant at the same statistical levels.

4.2 Bakery/Confectionery

The hygiene profile established at the bakery/confectionery before the education programme reflected positive identification of four out of the possible spectrum of eight types of indicators monitored. When comparing this hygiene profile with the hygiene profile established in phase 2 during the education programme, statistically significant reductions of three of these indicators were observed. Percentage comparisons are shown in Appendix 8.

Further comparisons of the hygiene profile before and after the education programme revealed further statistically significant reductions of two of the indicators identified. Percentage comparisons are shown in Appendix 9.

These comparisons reflect the following improvement of the hygiene profile on completion of the education programme;

(i) Statistically significant reductions ($p < 0,01$) occurred in plate count.

(ii) Statistically significant reductions ($p < 0,05$) occurred in coliforms and enterococci.

(iii) A reduction of *Staphylococcus aureus* organisms occurred although not significant at the same statistical levels.

4.3 Catering Premises

The hygiene profile established at the catering premises before the education programme reflected positive identification of three out of the possible spectrum of eight types of indicators monitored. When comparing this hygiene profile with the hygiene profile established in phase 2 during the education programme, statistically significant reductions of all three of these indicators were observed. Percentage comparisons are shown in Appendix 8.

Further comparisons of the hygiene profile before and after the education programme revealed a further reduction in all three of the indicators identified. Percentage comparisons are shown in Appendix 9.

These comparisons reflect the following improvement of the hygiene profile after the education programme;

(i) Statistically significant reductions ($p < 0,01$) occurred in all three positive results namely; plate count, coliforms and enterococci.

4.4 Indicator Organisms

Comparisons of the number of swabs found to be positive for each type of indicator before and after the education programme revealed the following reductions for each type of organism;

(i) **Plate count:** Statiscally significant reduction ($p < 0,01$) occurred.

(ii) **Coliforms:** Statistically significant reduction ($p < 0,01$) occurred.

(iii) **Enterococci:** Statistically significant reduction, ($p < 0,01$) occurred.

(iv) ***Escherichia coli:*** a reduction occurred although not significant at the same statistical levels.

(v) ***Staphylococcus aureus:*** Statistically significant reduction ($p < 0,05$) occurred.

(vi) ***Clostridium perfringens:*** a reduction occurred although not significant at the same statistical levels.

(vii) Although **Salmonella** and **Shigella** were not identified during all three phases of this study, this should be no reason for complacency as the presence of indicators showed potential for contamination by faecal pathogens.

4.5 General

Comparison of the hygiene profiles before the education programme of the three selected premises revealed that there was a difference in the variety and contamination levels of indicators identified. This could be due to the following diversities;

(i) difference in food hygiene education given prior to this study.
(ii) difference in cleaning methods previously employed.
(iii) different microorganism load at each of these premises.
(iv) difference in foodstuffs handled.

These differences are important and warrant further investigation.

In this study useful microbiological profiles of food premises were established by monitoring a spectrum of various types of hygiene indicators

The 'assessment-swabbing-technique' which consisted of a broad sampling approach of swabbing several similar sites with the same swab, provided a bigger surface control area of each surface type.

These results reflect a favourable response by the food handlers at the meat plant, the bakery/confectionery and the catering premises to the specific food hygiene education programme.

5. CONCLUSION

The study outlines a methodology for quantifying changes in hygiene relating to food contact surfaces and hands at food premises, following a specific health education programme.

The study thus provides a method for the indirect objective evaluation of the effectiveness of specific health education programmes, which are usually only qualitatively, and thus subjectively, evaluated.

Limitations of the methodology together with compensations used in this study have been discussed and include:

(1) Difficulties finding suitably matched control premises because of a large number of potentially confounding variables. This was partially compensated for by the evaluation and comparison of three different food premises.

(2) The need for a much longer study to establish a meaningful base line. This was partially compensated for by establishing a separate base line for contamination levels over a spectrum of eight hygiene indicators instead of one.

While statistically significant reductions in the number of positive swabs for several indicators were observed, there was a difference in the response shown by different indicators at different premises to the specific educational programme which is of interest and warrants further investigation.

Food handlers responded favourably to health education based on the video-assisted tutorial programme which reflected their actual work situations, problems, conditions, environment and language, suggesting an effective method for future health education programmes at food premises.

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HYGIENE PROFILES BASED ON THE PERCENTAGE OF POSITIVE SWABS DETECTED AT THE MEAT PLANT BY PHASE OF THE EDUCATION PROGRAMME

PHASE 1

Set No.	DATE	PLATE COUNT	COLIFORM	*E COLI*	ENTERO COCCI	*STAPH AUREUS*
1	89/01/11	100%	66.7%	16.7%	66.7%	0.0%
2	89/01/24	100%	100%	25.0%	87.5%	12.5%
3	89/02/08	100%	87.5%	25.0%	87.5%	25.0%
4	89/02/21	100%	62.5%	0.0%	62.5%	0.0%
5	89/03/14	100%	87.5%	25.0%	87.5%	25.0%
	MEAN	100%	81.6%	18.4%	78.9%	13.2%

PHASE 2

Set No.	DATE	PLATE COUNT	COLIFORM	*E COLI*	ENTERO COCCI	*STAPH AUREUS*
6	89/03/29	83.0%	75.0%	12.5%	62.5%	0.0%
7	89/04/11	100%	62.5%	0.0%	62.5%	0.0%
8	89/04/25	100%	87.5%	0.0%	75.0%	0.0%
9	89/05/17	100%	75.0%	0.0%	37.5%	12.5%
10	89/05/24	100%	75.0%	12.5%	62.5%	25.0%
	MEAN	96.6%	75.0%	5.0%	60.0%	7.5%

PHASE 3

Set No.	DATE	PLATE COUNT	COLIFORM	*E COLI*	ENTERO COCCI	*STAPH AUREUS*
11	89/08/16	83.0%	37.5%	0.0%	62.5%	0.0%
12	89/08/23	67.0%	62.5%	12.5%	62.5%	0.0%
13	89/08/30	67.0%	12.5%	0.0%	50.0%	0.0%
14	89/09/13	17.0%	37.5%	25.0%	37.5%	0.0%
15	89/09/26	0.0%	0.0%	0.0%	0.0%	0.0%
	MEAN	46.7%	30.0%	7.5%	42.5%	0.0%

HYGIENE PROFILES BASED ON THE PERCENTAGE OF POSITIVE SWABS DETECTED AT THE BAKERY/ CONFECTIONERY BY PHASE OF THE EDUCATION PROGRAMME

PHASE 1

Set No.	DATE	PLATE COUNT	COLIFORM	ENTERO COCCI	*STAPH AUREUS*
1	89/04/25	83.0%	87.5%	62.5%	12.5%
2	89/05/03	83.0%	37.5%	12.5%	0.0%
3	89/05/16	67.0%	37.5%	0.0%	12.5%
4	89/05/23	83.0%	25.0%	0.0%	12.5%
5	89/06/06	100%	37.5%	25.0%	0.0%
	MEAN	83.3%	45.0%	20.0%	7.5%

PHASE 2

Set No.	DATE	PLATE COUNT	COLIFORM	ENTERO COCCI	*STAPH AUREUS*
6	89/06/20	67.0%	12.5%	12.5%	0.0%
7	89/07/04	60.0%	12.5%	0.0%	12.5%
8	89/07/18	80.0%	12.5%	0.0%	12.5%
9	89/08/01	50.0%	0.0%	12.5%	12.5%
10	89/08/08	17.0%	0.0%	0.0%	0.0%
	MEAN	53.8%	7.5%	5.0%	7.5%

PHASE 3

Set No.	DATE	PLATE COUNT	COLIFORM	ENTERO COCCI	*STAPH AUREUS*
11	89/08/15	20.0%	12.5%	12.5%	0.0%
12	89/08/22	17.0%	37.5%	12.5%	12.5%
13	89/08/29	40.0%	12.5%	12.5%	0.0%
14	89/08/12	33.0%	12.5%	12.5%	0.0%
15	89/09/19	33.0%	25.0%	0.0%	0.0%
	MEAN	28.6%	20.0%	10.0%	2.5%

HYGIENE PROFILES BASED ON THE PERCENTAGE OF POSITIVE SWABS DETECTED AT THE CATERING PREMISES BY PHASE OF THE EDUCATION PROGRAMME

PHASE 1

Set No.	DATE	PLATE COUNT	COLIFORM	ENTERO COCCI	*STAPH AUREUS*
1	89/01/11	83.0%	62.5%	50.0%	0.0%
2	89/01/24	75.0%	62.5%	37.5%	0.0%
3	89/02/07	75.0%	50.0%	12.5%	0.0%
4	89/02/22	60.0%	25.0%	25.0%	0.0%
5	89/03/15	100%	75.0%	37.5%	0.0%
	MEAN	80.0%	55.0%	32.5%	0.0%

PHASE 2

Set No.	DATE	PLATE COUNT	COLIFORM	ENTERO COCCI	*STAPH AUREUS*
6	89/03/21	100%	50.0%	25.0%	0.0%
7	89/04/05	83.0%	50.0%	25.0%	0.0%
8	89/04/19	80.0%	25.5%	12.5%	0.0%
9	89/05/17	67.0%	50.0%	25.0%	0.0%
10	89/05/24	50.0%	62.5%	12.5%	0.0%
	MEAN	75.9%	47.5%	20.0%	0.0%

PHASE 3

Set No.	DATE	PLATE COUNT	COLIFORM	ENTERO COCCI	*STAPH AUREUS*
11	89/08/16	17.0%	37.5%	0.0%	0.0%
12	89/08/23	0.0%	25.5%	0.0%	0.0%
13	89/08/30	67.0%	25.0%	25.0%	0.0%
14	89/09/20	33.0%	37.5%	12.5%	12.5%
15	89/09/27	17.0%	0.0%	0.0%	0.0%
	MEAN	26.7%	25.0%	7.5%	2.5%

PERCENTAGE OF POSITIVE SWABS DETECTED FOR EACH TYPE OF INDICATOR ORGANISM FOR ALL THREE PREMISES BY PHASE OF THE EDUCATION PROGRAMME

ORGANISM	PHASE 1	PHASE 2	PHASE 3
Plate count	87.5%	76.2%	34.1%
Coliform	60.2%	43.3%	25.0%
E. Coli	5.9%	1.7%	2.5%
Enterococci	43.2%	28.3%	20.0%
Staph. aureus	6.8%	5.0%	1.7%
Cl. perfringens	1.7%	2.5%	0.8%

BACTERIOLOGICAL REPORTS ON WATER SAMPLES

APPENDIX 5

FOR MEAT PLANT

PHASE 1

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 1 - 5				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
1	1039	89-01-11	0	0
2	1042	89-01-24	0	0
3	1045	89-02-08	0	0
4	1140	89-02-21	0	0
5	1198	89-03-14	0	0

PHASE 2

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 6 - 10				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
6	2010	89-03-29	0	0
7	34	89-04-11	0	0
8	2a.73	89-04-25	0	0
9	2a.200	89-05-17	0	0
10	2a.208	89-05-24	0	0

PHASE 3

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 11 - 15				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
11	a.216	89-08-16	0	0
12	a.224	89-08-23	0	0
13	a.232	89-08-30	0	0
14	a.240	89-09-13	0	0
15	a.248	89-08-26	0	0

BACTERIOLOGICAL REPORTS ON WATER SAMPLES

FOR BAKERY/CONFECTIONERY

PHASE 1

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 1 - 5				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
1	b.1000	89-04-25	0	0
2	b.1008	89-05-03	0	0
3	b.1016	89-05-16	0	0
4	b.1024	89-05-23	0	0
5	b.1032	89-06-06	0	0

PHASE 2

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 6 - 10				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
6	b.1040	89-06-20	0	0
7	b.1048	89-07-04	0	0
8	b.1056	89-07-18	0	0
9	b.1064	89-08-01	0	0
10	b.1072	89-08-08	0	0

PHASE 3

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 11 - 15				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
11	b.1080	89-08-15	0	0
12	b.1088	89-08-22	0	0
13	b.1096	89-08-29	0	0
14	b.1104	89-09-12	0	0
15	b.1112	89-08-19	0	0

BACTERIOLOGICAL REPORTS ON WATER SAMPLES

FOR CATERING/PREMISES

PHASE 1

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 1 - 5				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
1	c.1041	89-01-11	0	0
2	c.1044	89-01-24	0	0
3	c.1047	89-02-07	0	0
4	c.1144	89-02-22	0	0
5	c.2000	89-03-15	0	0

PHASE 2

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 6 - 10				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
6	c.2017	89-03-21	0	0
7	c.1	89-04-05	0	0
8	c.1	89-04-19	0	0
9	2c.81	89-05-17	0	0
10	2c.97	89-05-24	0	0

PHASE 3

BACTERIOLOGICAL REPORT ON WATER TAKEN Together with Sets No: 11 - 15				
Water			Probable Number of Organisms per 100ml of water	
Set no.	Sample No.	Date	Coliforms	*E. Coli*
11	c.105	89-08-16	0	0
12	c.113	89-08-23	0	0
13	c.121	89-08-30	0	0
14	c.129	89-09-20	0	0
15	c.137	89-08-27	0	0

HYGIENE PROFILES OBTAINED BEFORE THE EDUCATION PROGRAMME IN PHASE 1 COMPARED WITH HYGIENE PROFILES OBTAINED DURING THE EDUCATION PROGRAMME IN PHASE 2

INDICATOR ORGANISM	MEAT PLANT PREMISES		BAKERY/ CONFECTIONERY PREMISES		CATERING PREMISES	
	PHASE		PHASE		PHASE	
	1	2	1	2	1	2
Plate Count	100%	96.6%	83.3%	53.8%	80.0%	75.9%
Coliforms	81.6%	75.0%	45.0%	7.5%	55.0%	47.5%
Enterococci	78.9%	60.0%	20.0%	5.0%	32.2%	20.0%
E. Coli	18.4%	5.0%	0.0%	0.0%	0.0%	0.0%
Staph. aureus	13.2%	7.5%	7.5%	7.5%	0.0%	0.0%
Cl. perfringens	2.6%	5.0%	0.0%	0.0%	0.0%	0.0%

HYGIENE PROFILES OBTAINED BEFORE THE EDUCATION PROGRAMME IN PHASE 1 COMPARED WITH HYGIENE PROFILES OBTAINED AFTER THE EDUCATION PROGRAMME IN PHASE 3

INDICATOR ORGANISM	MEAT PLANT PREMISES		BAKERY/ CONFECTIONERY PREMISES		CATERING PREMISES	
	PHASE		PHASE		PHASE	
	1	3	1	3	1	3
Plate Count	100%	46.7%	83.3%	28.6%	80.0%	26.7%
Coliforms	81.6%	30.0%	45.0%	20.0%	55.0%	25.0%
Enterococci	78.9%	42.5%	20.0%	10.0%	32.2%	7.5%
E. Coli	18.4%	7.5%	0.0%	0.0%	0.0%	0.0%
Staph. aureus	13.2%	0.0%	7.5%	2.5%	0.0%	0.0%
Cl. perfringens	2.6%	2.5%	0.0%	0.0%	0.0%	0.0%