Effectiveness of cleaning and sanitation of food contact surfaces in the PNG fish canning industry

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Abstract

This article reports on an experimental study to examine the cleanliness and sanitation of food contact surfaces in a PNG fish canning factory. The sample for the study consisted of five food contact surfaces from the skinning section of a tuna fish processing line. The data were gathered by using the Compact Dry Nissui swab method to test for three microorganisms of concern to fish products that include the *Staphylococcus aureus*, *Total plate count* and *Escherichia coli.* The tests were carried out before cleaning, after cleaning and after sanitation of selected stainless steel, plastic and human surfaces. The findings confirmed that the cleaning and sanitation methods and procedures used in the fish canning factory involved in this study were effective and complied with seafood safety standards. Further, the study confirmed that the Compact Dry Nissui swab method was efficient and effective to test for the presence of microorganisms.

Key words: cleaning, sanitation, swab test, experimental study, food borne illnesses

Introduction

A major goal for the food processing industry is to provide safe, wholesome and acceptable food to the consumer and the control of microorganisms is essential to meet this goal. The control is exerted through processing and preservation techniques which eliminate microorganisms or prevent their growth. It is also required that the basic hygiene level during processing is high and that cleaning and sanitation procedures to eliminate spoilage and pathogenic bacteria are efficient. Many food spoilage bacteria are able to attach to food contact surfaces and remain viable even after cleaning and sanitation (Good Manufacturing Practice, 2000) and therefore the hygiene of the processing environment is a significant factor in the production of microbiologically safe and good-quality products in the fish industry. As such both the quantity and the specific type of microbial flora are important factors for evaluating the hygiene of the processing plant (WHO, 2007).

Various components of the processing plant and in particular the food contact surfaces may easily become contaminated by microbial flora and pathogenic microorganism thereby compromising product safety and quality. Food contact

surfaces are surfaces that come into contact with food for humans which ordinarily occur during the normal course of operations and which contaminate the food with pathogenic microorganisms. Food contact surfaces include knives, tables, cutting boards and food handlers. In order to reduce the number of pathogenic and food spoilage microorganisms to acceptable levels, there are two separate procedures involved in an operation which include cleaning and sanitation.

According to Mc Evoy, Sheridan, Blair, & McDowell (2004), cleaning consists of removing the products residue from surfaces. It involves washing and rinsing using detergents and is a prerequisite for sanitation process. Unlike cleaning, sanitizing eliminates or substantially reduces the number of pathogenic microorganisms by controlling the source of contaminants in the environment as well as preventing contamination of food products and reducing the possibility of cross contamination (Good Manufacturing Practice, 2000).

Review of related literature

Several studies have discussed the main causes of microbial contamination typically occurring in food service establishments which include dirty food contact surfaces, poor personal hygiene practices and inappropriate storage temperatures (Griffith & Clayton, 2005). Findings from these studies showed the main sources of cross contamination during processing come from food contact surfaces (Gill & Jacxsens, 2001; Mc Evoy *et al.,* 2004). Equipment and surfaces can be the source of direct contamination when they have not been effectively cleaned or sanitized or remained wet between cleaning and use (Evans, Overton, Alshingiti, & Levenson, 2004).

The cleaning and sanitation procedure is important because inadequate cleaning and sanitation of food contact surfaces represents a risk factor for cross contamination because of the possible presence of pathogens that have low minimum infective dose such as *Escherichia coli* (Davidson & Ginny, 1999) or *Listeria spp* (Gibbons, Adesiyun & Rahaman*,* 2006). Cleaning and sanitation procedures are an effective means to reduce cross contamination and the occurrence of foodborne outbreaks (Cogan & Watchel 2002).

The microbial quality of surfaces has been identified as a useful indicator for control of the critical points related to the procedures of cleaning and sanitation (Legnani & Chinchilla, 2004). Furthermore, the microbial analysis of food contact surfaces may indicate the actual status of the hygienic design of equipment and facilities and actual specificity of the sanitation program.

In June 2002, the Mildura Rural City Council of Australia carried out a survey concerning the cleanliness of food contact surfaces in a food industry. The *Adenosine Triphosphate* swabbing method was used to determine the levels of cleanliness of food contact surfaces. Results revealed that food contact surfaces were not being effectively cleaned to test standards and that cleaning processes needed to be addressed through devising cleaning schedules, replacing food

contact surface materials if not in good condition and modify cleaning and sanitation methods.

A similar study was conducted by Cosby, Costello, Morris, Haughton, Devereaux, Harte, and Davidson (2008. The standard microbiological swabbing method was used to determine aerobic plate counts and *Escherichia coli/coliform* counts of 50 cm^2 area. The results of the study detected both of these pathogenic microorganisms and demonstrated that the extent of bacterial contamination was dependant on the time of the day and the area sampled.

A study was done in November 2004 by the American Dietetic Association on microbiological quality of food contact surfaces. The study showed positive results on the presence of *Enterobactreae* and *Staphylococcus aureus* contaminating food contact surfaces even though cleaning and sanitizing of food contact surfaces had been done before food preparation.

A preliminary study was carried out in Sri Lanka by the National Aquatic Research Centre in 2006 on the presence of biofilms on food contact surfaces in a fish processing industry. Swabs were taken from selected food contact surfaces 6-8 hours after the day's major cleaning operation. The samples were then quantified by *aerobic plate count* (APC) and *Escherichia Coli* counts. This study showed that food contact surfaces in the fish processing industry supply an excellent environment for biofilm formation irrespective of the different cleaning and sanitation methods used. The tests results proved that gloves, cutting boards, table tops and knives have high chances of contaminating food products with detached biofilm bacteria.

Duong (2006) conducted a study on the hygiene of food contact surfaces in a fish processing factory with different hygiene-monitoring methods to determine the level and presence of biofilms on food contact surfaces. Both *Adenosine Triphosphate* measurements and contact agar methods were used to detect pathogens. Surface samples were taken after cleaning operations and just before processing begin. The results of this study revealed that, out of 28 fish factories studied, the number of adequately washed and disinfected fish processing factories was low (2 out of 28).The recommendations were to evaluate the hygiene of these factories on a regular basis with effective and appropriate hygiene and monitoring methods.

The efficacy of cleaning and sanitation of food contact surfaces may vary in different food processing plants. A few of the factors would include the cleaning and sanitizing agents such as the chemicals, soaps or detergents used, the type of materials used as contact surfaces such as plastics, stainless steel, the condition and status of the materials such as cracks/crevices wear and tear and the methods or procedures used to clean and sanitize the contact surfaces. Some bacteria have the tendency to adhere to hard surfaces, multiply and produce extracellular polymeric substances, forming a so-called biofilm. Other bacteria may become entrapped in such a biofilm and even be protected from active compounds used during sanitation.

In fact, attachment of microorganisms to food contact surfaces is a concern in the food industry because previous studies have shown that these cells appeared to be more resistant to sanitizers (Frank & Koffi, 1990; Schwach & Zottola, 1984). Pathogenic bacteria are of concern as biofilm formation may become a nest for them, facilitating their proliferation on contact surfaces and consequently their transfer to the food being processed.

Jeyasekaran and Mattila (2000) conducted a study on the effectiveness of sanitizers on food contact surfaces. Samples used were stainless steel and plastic contact surfaces and a chlorine sanitizer was used to test for its effectiveness. The results of the study showed that there were more biofilm formation on the surface of stainless steel than on plastic. Upon exposure to 100 ppm chlorine for five minutes, there was a decrease in microbial count on the stainless steel surfaces, while on plastic surface, the count remained the same. Chlorine was more effective in inactivating biofilm cells grown on stainless steel.

Snyder (1997) found that cleaning was practical in reducing the initial bacterial load on stainless steel, plastic and wooden surfaces prior to sanitation and that a vinegar solution used to wipe the surfaces was an efficient sanitizer, especially on plastic. Nevertheless, used plastic boards were more difficult to clean manually with hot water and detergent than wooden ones, especially when coated with fat. Kampelmacher and Snider (1971) recommended cleaning cutting boards with an abrasive alkaline detergent and a sanitizer. Gilbert and Watson (1971) reported that physical cleaning was the most effective on meat-contaminated wooden and plastic boards both new and used and that disinfecting with hypochlorite reduced the bacterial load only slightly. These findings exemplify the fact that the efficiency of cleaning and disinfecting agents is greater when initial cleaning is done before using chemical agents.

In search of similar studies in food processing plants in Papua New Guinea, no literature was found. However, it can be reasonably assumed that in-house tests are carried out to satisfy requirements of regulatory authorities. Given the lack of published literature, this study was considered important to make an initial contribution to literature in this field.

Study design

The purpose of the study was to ascertain the effectiveness in the methods used for cleaning and sanitizing food contact surfaces in a PNG fish canning factory and to detect the presence of food spoilage microorganisms that might compromise the quality of fish products.

The questions that guided the study were: (1) what is the relationship between cleaning and sanitation on food contact surfaces? (2) What are the methods used for cleaning and sanitation of food contact surfaces and (3) how effective are the methods?

This study applied the rapid 'Nissui' microbial Compact Dry swab test method to test for microbial contamination. The Compact Dry 'Nissui' swab testing method was used to test for the presence of microorganisms on samples of five specific food contact surfaces: a stainless steel table top, stainless steel knife, plastic tray, plastic cutting board and the hand of a fish skinner.

The test kit is composed of a swabbing stick, container for a solution, and pre-prepared agar in agar plates. The method requires simple and easy manipulation, needs only small physical space for storing, testing and incubating, is ready to use and the samples diffuse automatically and evenly onto the plates.

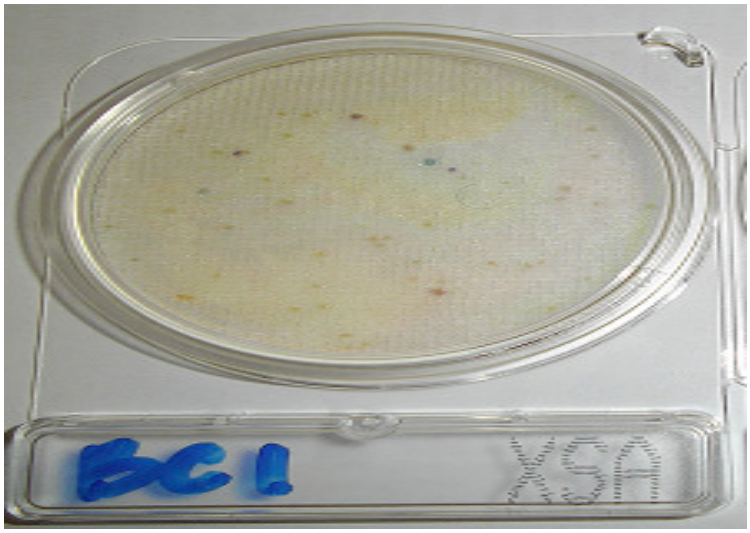

Figure 1: Showing two blue dots of *Staphylococcus aureus* on the agar plate

Data analysis

Results gathered were analyzed and interpreted graphically using line graphs for each food contact surface tested. The lines on the graphs represent the number of each microorganism appearing on the agar plate for each food contact surfaces tested. The microorganisms are counted in coliforming units per square centimetre or 50cm^2.

Results

The findings of this study are presented in five parts according to samples of each food contact surface tested, that is, the stainless steel table top (figure 2), plastic tray (figure 3), stainless steel knife (figure 4), a worker's hand (figure 5) and a plastic cutting board (figure 6).

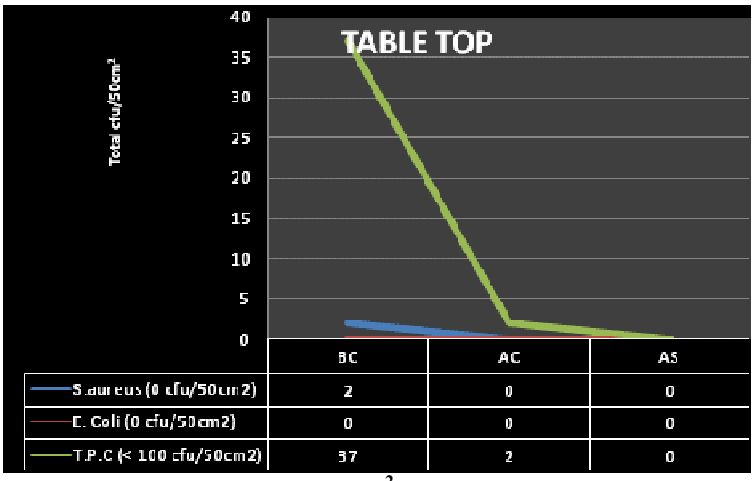

Figure 2: Total count of cfu/cm^2 for S. aureus, E.Coli & TPC on the stainless steel table top

Figure 2 shows that there were 2 counts of *Staphylococcus aureus* present on the stainless steel table top before cleaning, and 0 counts after cleaning and after sanitation. *Escherichia Coli* have negative or zero count all throughout the test before cleaning, after cleaning with biowash and after sanitation with chlorine. The *Total Plate Count*, showed 37cfu/50cm^2 on the table top before cleaning, 2cfu/50cm^2 after cleaning with biowash and 0cfu/50cm^2 after sanitizing with chlorine.

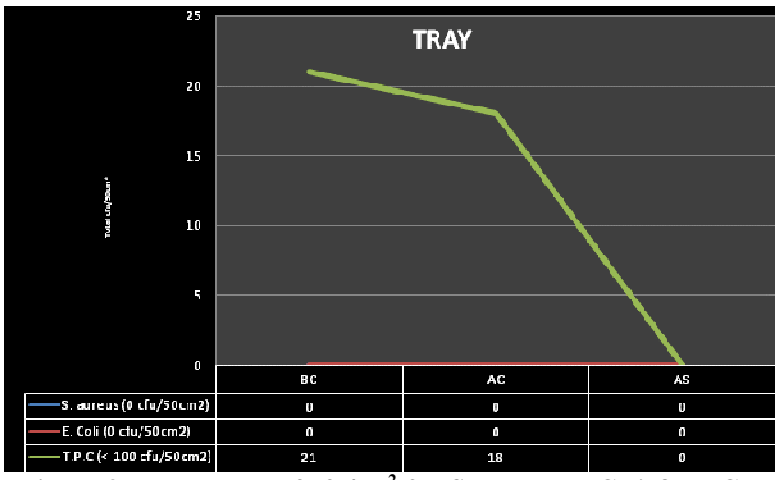

Figure 3: Total count of cfu/cm^2 for S. aureus, E.Coli & TPC on the plastic tray

Figure 3 shows the results for the plastic tray. As indicated, there were zero counts of *Staphylococcus aureus* and *Escherichia coli* before cleaning, after cleaning with biowash and after sanitation with chlorine. The *Total Plate Count*, contained 21cfu/50cm^2 appearing on the agar plate after 48 hours of

incubation. The swab test was taken before cleaning the plastic tray with biowash as the cleaning detergent, 18cfu/50cm^2 appeared after cleaning and 0cfu/50cm^2 appeared after sanitizing the tray with chlorine solution.

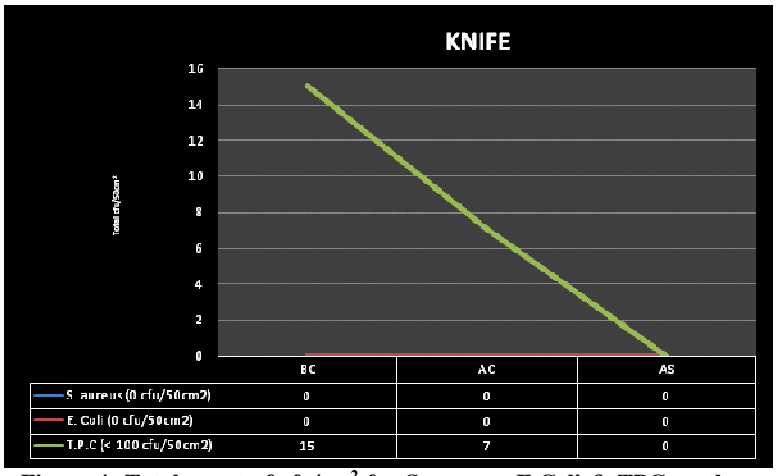

Figure 4: Total count of cfu/cm^2 for S. aureus, E.Coli & TPC on the stainless steel knife

Figure four presents the results for stainless steel knife where it showed that there were no counts of *Staphylococcus aureus* and *Escherichia Coli* before cleaning, after cleaning with biowash and after sanitizing with chlorine. As for the *Total Plate Count*, 15cfu/50cm^2 were present before cleaning, 7cfu/50cm^2 after cleaning and negative counts of TPC after sanitizing the stainless steel knife.

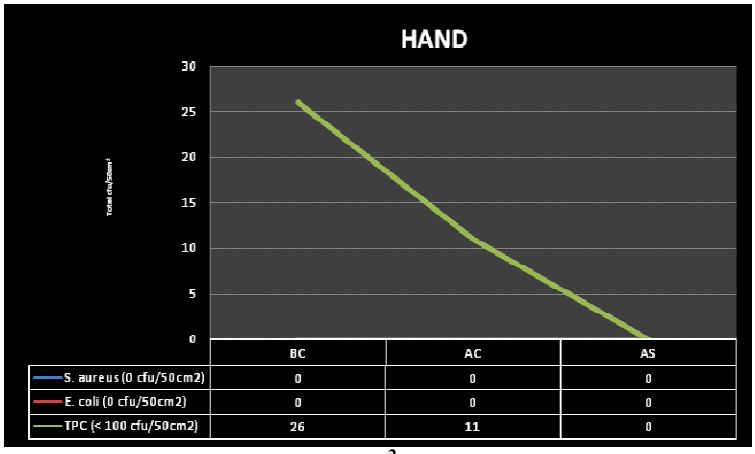

Figure 5: Total count of cfu/cm^2 for S. aureus, E.Coli & TPC for a fish skinner's hand

Figure 5 shows the results of the swab test done on the fish skinner's hand in which there was no detection of *Staphylococcus aureus* and *Escherichia Coli*

before cleaning, after cleaning and after sanitation but the *Total Plate Count* had 26cfu/50cm^2 that appeared before cleaning, 11cfu/50cm^2 after cleaning with biowash and 0cfu/50cm^2 after dipping the skinner's hand in 200 ppm of chlorine solution as the sanitizer.

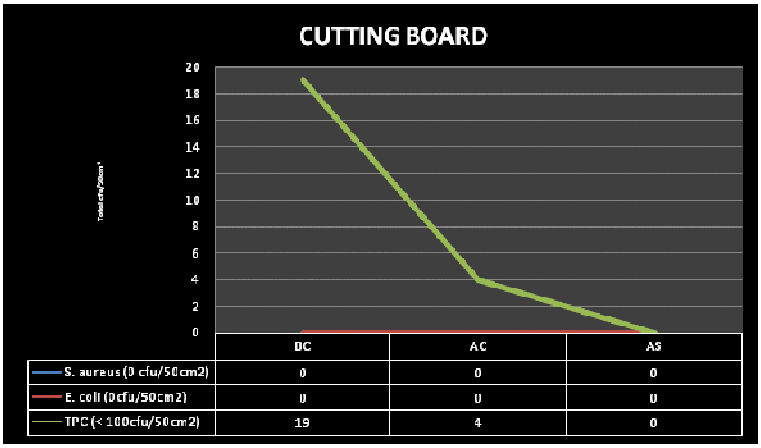

Figure 6: Total count of cfu/cm^2 for S. aureus, E.Coli & TPC on the plastic cutting board

Figure 6 shows the swab results for the cutting board in which there were zero counts for *Staphylococcus aureus* and *Escherichia coli* throughout the test. The *Total Plate count* however indicated 19cfu/50cm^2 before cleaning, 4cfu/50cm^2 after cleaning with biowash and 0cfu/50cm^2 after sanitizing with chlorine.

Discussion

This study explored the effectiveness of cleaning and sanitation on five food contact surfaces in a PNG fish canning factory using the Compact Dry swab test. The microorganisms tested were of seafood safety concern that included *Staphylococcus aureus (S. Aureus), Escherichia coli* (*E. coli*) and *Total Plate Count (TPC).*

Microbiological test on the stainless steel table top

The first swab test on the stainless steel table top was to test for *S. aureus* before cleaning, after cleaning with biowash and after sanitizing with chlorine with a 15 minute interval between each test. After the swab, the swabbing sticks were diluted and the solution poured onto the agar plates. Then the plates were incubated at a temperature of 36º Celsius for 24 hours. After 24 hours the agar plates were removed from the incubator and were observed for any positive signs of *S. aureus*. It was found that 2cfu/50cm^2 of *S. aureus* was present on the table top before cleaning. This contamination was possibly due to human contact through air particles breathed, coughed or sneezed out during the course of work or from food handlers or from other sources in the air within

the processing area. However, after cleaning with biowash and after sanitation with 300ppm of chlorine, the stainless steel table top had no counts of *S. aureus*. This showed that the cleaning and sanitation procedures were effective.

The second test on the stainless steel table top was to test for *E. coli* following the same process as before. After the 24 hour incubation period and through close observation, no signs of *E. coli* were found on the plates for the table top.

The third test on the stainless steel table top was to test for *TPC* following the same process as before except that the incubation period was longer and lasted for 48 hours. After incubation and through close observation, red dots indicating TPC were observed on the plates. They showed 37cfu/50cm^2 before cleaning, 2cfu/50cm^2 after cleaning with biowash, and no sign (0cfu/50cm$^{2)}$ of TPC after sanitizing with chlorine. All the results for *TPC* fall below the international food safety standard for *TPC* of < 100 cfu/50cm^2. This shows that the cleaning and sanitation procedures were effective in totally eliminating microorganisms to zero counts.

Microbiological test on the plastic tray

The first swab test on the plastic tray was to test for *S. aureus* before cleaning, after cleaning and after sanitizing following the same process as used for the stainless steel table top. After incubation and through close observation, no blue/blue purple dots appeared indicating no presence of *S. aureus*. This has showed that the cleaning and sanitation procedures and the methods used are effective.

The second test on the plastic tray was to test for *E. coli* following the same process as before. After the 24 hour incubation period, no blue dots for *E. coli* were found on the agar plates for the plastic tray.

The third test on the plastic tray was to test for *TPC* following the same process and an incubation period of 48 hours. After incubation and through close observation, red dots indicating TPC were observed on the agar plates. They showed 21cfu/50cm^2 before cleaning, 18cfu/50 cm^2 after cleaning and no sign (0cfu/50cm$^{2)}$ of TPC after sanitizing with chlorine. All the results for TPC fall below the international food safety standard showing that the cleaning and sanitation procedures were effective in eliminating the microorganisms.

Microbiological test on the stainless steel knife

The first swab test on the stainless steel knife was to test for *S. aureus* before cleaning, after cleaning and after sanitizing following the same process as before. After the 24 hour incubation period, no blue/blue purple dots had appeared indicating no presence of *S. aureus* on the agar plates for the knife.

The second test on the stainless steel knife was to test for *E. coli* following the same process as before. After the 24 hour incubation period, no blue dots for *E. coli* were found on the agar plates for the stainless steel knife.

The third test on the stainless steel knife was to test for *TPC* following the same process as before. After the 48 hour incubation period, red dots indicating TPC were observed on the agar plates. They showed 15cfu/50cm^2 before cleaning, decreasing to 7cfu/50cm^2 after cleaning, and none (0cfu/50cm$^{2)}$ after sanitation. This shows that the cleaning and sanitation procedures done are effective in eliminating the microorganisms.

Microbiological test on the fish skinners hand

The first swab test on the hand of a fish skinner employee was to test for *S. aureus* before cleaning, after cleaning and after sanitizing following the same process as before. After the 24 hour incubation period, no blue/blue purple dots had appeared indicating no presence of *S. aureus* on the agar plates for the hand of the fish skinning employee.

The second test on the hand of a fish skinner employee was to test for *E. coli* following the same process as before. After the 24 hour incubation period, no blue dots for *E. coli* were found on the agar plates for the hand of the fish skinning employee.

The third test on the hand of a fish skinner employee was to test for *TPC* following the same process as before. After the 48 hour incubation period, red dots indicating TPC were observed on the agar plates. They showed 26cfu/50cm^2 before cleaning, reduced to 11cfu/50cm^2 after cleaning, and none (0cfu/50cm$^{2)}$ after sanitation. This shows that washing the hand with biowash does not eliminate all the microorganisms but when the hand is dipped into the chlorine solution, all the microorganisms on the hand were eliminated.

Microbiological test on the plastic cutting board

The first swab test on the plastic cutting board was to test for *S. aureus* before cleaning, after cleaning and after sanitizing following the same process as before. After the 24 hour incubation period, no blue/blue purple dots had appeared indicating no presence of *S. aureus* on the agar plates for the plastic cutting board.

The second test on the plastic cutting board was to test for *E. coli* following the same process as before. After the 24 hour incubation period, no blue dots for *E. coli* were found on the agar plates for the plastic cutting board.

The third test on the plastic cutting board was to test for *TPC* following the same process as before. After the 48 hour incubation period, red dots indicating TPC were observed on the agar plates. They showed 26cfu/50cm^2 before cleaning, reduced to 11cfu/50cm^2 after cleaning, and none (0cfu/50cm$^{2)}$ after sanitation. This shows that washing the cutting board with biowash does not eliminate all the microorganisms but when the board is dipped into the chlorine solution, all the microorganisms were eliminated. The finding is that chlorine is an effective sanitizer against microorganisms.

Comparative findings

The findings of this study are that cleaning of plastic and stainless steel food contact surfaces with biowash reduces the number of microorganisms but does not completely eliminate them. This finding compares favourably with the research of Parallely and Snyder (1997) who found that biowash was effective in reducing the initial bacterial load on plastic and stainless steel food contact surfaces.

The results of research by Gilbert & Watson have shown that cleaning with biowash reduces bacterial load slightly, and that the efficiency sanitizing is more effective when cleaning is done before sanitizing. This will ensure that chemical agents applied to the remaining bacterial load have quicker and effect if initial cleaning is done first.

Controversially, Jeyasekaran and Mattila (2000) argued that sanitisation with chorine was not as effective on plastic surfaces as it was on stainless steel surfaces. However later research contradicts this, and they now claim that chlorine provides complete inactivation of biofilm cells and is effective in total reduction of microorganisms from both type of surfaces, as was found in this study.

Limitations of the study

Although this study has thrown some light with regard to the effectiveness of cleaning and sanitation of five food contact surfaces in the fish processing line of a PNG fish canning factory, it has its limitations. First and foremost it was an experimental study with a limited sample size. Therefore, the generalization of the findings of this study should be done with caution. The cleaning detergent used during the time of study was biowash for cleaning and chlorine for sanitation. No other detergents were used in order to compare their effectiveness. Due to limited time of the study, only the Compact Dry swab test was done to test for the effectiveness of cleaning and sanitation on food contact surfaces rather than other testing methods.

Directions for future research

In light of the findings and the limitations faced in this study, the following recommendations should be taken heed of:

- For future studies, more effective research design, data analysis plans, effective organization by researchers could be taken into consideration.
- Each section should be tested to identify the possible cross-contamination sources between the fish processing line.
- Future studies could involve different tests rather than Dry Compact Dry swab test alone to identify microorganisms on food contact surfaces and also to identify which testing method is more effective.

Conclusion

This study primarily looked at the effectiveness of cleaning and sanitation on food contact surfaces used in a PNG fish canning factory. Using the Compact Dry swabbing method, five plastic, stainless steel or human food contact surfaces from the skinning section of the tuna fish processing line were tested. The main findings of this study are as follows.

Before cleaning was done on the stainless steel table top, the swab results on the agar plate showed two blue/blue purple dots of *Staphylococcus aureus*. This finding indicates that there might have been a cross contamination between the food handler and the table top or between the surrounding contaminated air and the table top.

Out of the three microorganisms that were tested for, *Total Plate Count* appeared on all the five food contact surfaces tested however, the total coliforming units for each count are well below the International Standard Guideline Value for microorganisms on food contact surfaces which is less than one hundred coliforming units per square fifty centimeters (< 100 cfu/50cm^2).

The cleaning procedure using the biowash as the cleaning detergent proved to be effective in removing the specified microorganisms under study as well as for Chlorine as the sanitizing detergent in which microorganisms in all the food contact surfaces tested was eliminated to 0cfu/50cm^2 after sanitation regardless of the type of materials tested whether it be a plastic or stainless steel food contact surface.

All the five food contact surfaces tested for *Escherichia coli* and *Staphylococcus aureus* have shown 0cfu/50cm^2 in the entire swab test taken except for the table top before cleaning.

Cleaning is a prerequisite for sanitation process as after cleaning was done with biowash, there were still some counts of microorganisms on food contact surfaces and when the food contact surfaces were sanitize with chlorine, it completely eliminate all the microorganisms present on the food contact surfaces.

This study confirmed that the cleaning and sanitation procedures used in the fish canning factory visited for this study were effective. The study has enabled us to distinguish and discuss some of the microorganisms important to international food safety. This was possible by carrying out the Compact Dry swab test on plastic, stainless steel food and human contact surfaces and identifying the effective cleaning and sanitation detergents used to eliminate these microorganisms. Microbial swab tests were carried out before cleaning, after cleaning and after sanitation.

This study has also indentified the effective detergents that are useful to the fish industries in substantially reducing or eliminating the number of food spoilage microorganisms by controlling the source of contaminants in the environment, preventing contamination of food products and reducing the possibility of cross contamination that may hinder the quality of fish products before reaching consumers and thus, preventing the occurrence of food borne illnesses.

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