The attachment of bacteria on food processing surfaces biology essay

Science, Biology

Abstract

The attachment of bacteria on food processing surfaces and in the environment can cause potential cross-contamination, which can lead to food spoilage, possible food safety concerns, and surface destruction. Food contact surfaces used for food handling, storage or processing are areas where microbial contamination commonly occurs. Even with proper cleaning and sanitation regimes or practices in place, bacteria can remain attached to the surfaces and this attachment can lead to biofilm formation. The purpose of this study was to identify the presence of pathogenic microorganisms in a food processing area and to evaluate the effect of the cleaning procedure on the microbial load in the food processing area. Ten replicate food contact surfaces were tested: stainless steel, marble and wood, with adjacent areas being sampled before and after cleaning. The test surfaces were analyzed with a swab method before and after the cleaning stage. The results of these studies indicate that three of ten stainless steel surface were contaminated before cleaning and no surface was contaminated after cleaning. Furthermore, three out of ten marble surfaces were contaminated before cleaning and one surface was contaminated after cleaning. Six of ten wood surfaces were heavily contaminated before cleaning and three surfaces were contaminated after cleaning. The difficulty in cleaning was related to the amount of surface damage and it is best to avoid this type of surface. Hypochlorite solution that was used for cleaning the surfaces in this study was considered to be effective against the foodborne pathogens tested. This study has highlighted that the pathogens remain viable on dry stainless steel surfaces for long periods of time, dependent on the levels of contamination

and type of pathogen. Keywords: Microorganisms; Survival; Cross-contamination; Food contact surface

Introduction

Food contact surfaces are the chief denizen of biofilm that can host potentially harmful microorganisms. This, therefore, is a prominent phenomenon in food processing plants owing to dregs and residues of all sorts - chemical, biological, organic, and/or inorganic -which build up on the surfaces of equipments that may get in contact with food (Mafu et al. 2010). The presence of these undesirable microorganisms to the material surfaces is a source of concern, as this can result in food cross-contamination, leading to food poisoning. Under favourable circumstances (temperature, pH, relative humidity), pathogenic microorganisms are able to survive and/or replicate on a large scale within the biofilm. In domestic kitchens and food processing industries, foodborne illness can result from incorrect storage of foods, particularly with respect to temperature, contamination of raw or cooked foods before consumption, by contact with other foods or utensils (food contact surfaces) carrying pathogens, and inadequate cleaning procedures that may not see complete removal of microorganisms (Teixeira et al. 2007). In food processing industries, food contact surfaces, such as stainless steel, marble and wood may create an enabling environment for the survival of the microorganism, leading to serious hygienic problems. Furthermore, dead ends, corners, joints, valves and any other hard-to-reach places are the most appropriate areas for the presence of bacteria. (Peng et al. 2001). The value of maintenance and disinfection processes in food

processing industries depends, to a large extent, on the design and maintenance programmes adopted by the company. Lack of efficacy in cleaning procedures may allow persistence and survival of pathogens in foods owing to their consistent adherence to food contact surfaces. This may lead to transfer of microorganisms from people, objects or contaminated food to other food or material, hence leading to cross-contamination. People can, in many ways, be a source of cross-contamination to foods (Holah and Thorpe, 1990). Food can be contaminated when it is handled, so it is very important that people who may be carrying or suffering from certain diseases do not handle food. Contamination can also be passed from equipment when contacting food. It specifically happens when utensils or equipment are not efficiently cleaned and sanitized between each use and may lead to development of biofilm, creating favourable conditions for the survival of the pathogens. Contamination from food to food occurs mainly when raw foods come into contact with cooked or prepared foods (Montville et al. 2001). The persistent presence of microorganisms in food processing factories, specifically on food contact surfaces despite deliberate efforts to combat the phenomenon, poses great challenges to the company. It reduces the profit margins of the industries due to the increased cost incurred in the attempts to adopt advanced cleaning services and programmes. A potential effect of the presence of microorganisms on food surfaces is food poisoning. Occurrence of food poisoning will mean great damage to the image of the company and persistent stress on the part of the management, thus derailing the progress of the company. Cross contamination is also becoming a common problem both in the kitchen setting and in industry. Transfer of

resistant pathogens and microorganisms across and around these food producers through various agents and factors that propagate and carry the pathogens is a health hazard. Studies show that the level of contamination varies depending on the duplication and the rate of material handling that occurs in the factory. In this context, therefore, workers' hands, utensils and the broad extension of all food contact surfaces contribute to in cross contamination (Zhao et al. 1998). A thorough examination of the whole concept of microbial survival and persistence on food contact surfaces despite typical cleaning procedures and revised designs of the food contact surfaces (such as textural properties, maintained solid surface hydrophobicity) will reveal that more detailed analysis and studies should be focused on the factors that create an enabling environment for the persistent replication and presence of the foodborne pathogens in the food processing industries and kitchen setting (Scott and Bloomfield, 1990). The study of various relevant properties for the microbial adhesion process has been another imperative goal of this study and the purpose behind it is to obtain a broader knowledge base of the mechanisms of bacterial adhesion to food contact surfaces so as to formulate strategies for its control. The objective of this study is to identify the microorganisms that can survive in the food contact surface, such as stainless steel, marble and wood, even after cleaning procedures, thus increasing the risk of food cross-contamination. The study will focus on microorganisms that survive in the food processing areas even after the cleaning procedure. Foodborne pathogenic bacteria adhere to inert surfaces; they may exhibit a greater scale of resistance to chemical or ordinary cleaning and fumigating agents (Barnes et al. 1999).

The concept of cross contamination is of major concern in the food processing industries that constitute a threat to human health because they cause most food borne illness outbreaks. Food poisoning is one of the consequences of adherence of microorganisms to food contact surfaces (Sattar et al. 2001).

Materials and Methods

Premises

In order to assess the microbiological safety of a food processing area in Oman, three types of food contact surfaces were studied: Stainless steel, marble and wood. Ten surfaces of each of the three types were tested, with the adjacent areas of each one being sampled before and after cleaning. This study was performed randomly in nineteen selected Army camps kitchen.

Data analysis

Swabs were taken from the food processing area within the Royal Army camps kitchen and sent to the food microbiology laboratory of the environmental of health unit for analysis. The swabs were each tested for pathogenic bacteria linked with food and coliforms that can survive on the surface of food preparation areas before and after cleaning. The plates were read for the number of colonies of pathogenic bacteria and coliforms. A Phoenix machine was used to identify the bacteria and readings were taken directly from the Phoenix machine. A Phoenix is automated microbiology machine is intended to provide rapid identification results for most aerobic and facultative anaerobic Gram positive bacteria as well as most aerobic and facultative anaerobic Gram negative bacteria. The identification of the

Phoenix panal uses a range of conventional test, chromogenic and fluorogenic biochemical tests to identify the organism. The growth and enzymatic substrates are employed to cover a broad range of reactivity among the range of taxa. The tests are based on the use of bacteria and deterioration of specific substrates detected by different indicator systems. The production of acid is indicated by a change in phenol red indicator when an isolate is able to utilize a carbohydrate substrate. A yellow colour is produce by Chromogenic substrates upon enzymatic hydrolysis and the enzymatic hydrolysis of fluorogenic substrates results in the release of a fluorescent coumarin derivation (BD Phoenix, 2007). These results were recorded and the log reduction was calculated for each plate at each dilution rate after and before cleaning of the surface.

Sampling methods and microbiological examination (Before Cleaning)

Tests using the swab method were carried out on surfaces contaminated with food borne pathogens in a food processing area. Tubes containing 10 ml of sterile buffered peptone saline solution were used to wet the swabs prior to sampling. Cotton swabs were removed from their sterile packaging and were held by the stick while they were moistened with buffered peptone saline solution, the excess broth was returned into the bottle. All surfaces were prepared in sizes of 20 x 20 cm2 for survival experiments. The swabs were rotated while in contact with the food preparation surface. After the defined area was swabbed, the swab was returned to the test tube containing the buffered peptone saline solution to dislodge the bacteria. Serial dilutions of the swab solutions were prepared and duplicate pour

plates were prepared for each dilution using nutrient agar, MacConkey agar and Blood agar. The plates were incubated for 24 hours at 37oC.

Sampling methods and microbiological examination (After Cleaning)

The surfaces were washed with hot water and chemical detergent and then rinsed with hot water. Then the surfaces (stainless steel, marble, and wood) were disinfected with 5. 25% of hypochlorite solution for 10 minutes. The surfaces were allowed to dry before sampling. The swabbing method used was as above. Duplicate pour plates were prepared for each dilution using nutrient agar, MacConkey agar and Blood agar. The plates were incubated for 24 hours at 37oC.

Sampling methods and microbiological examination (Control)

Some of the food borne pathogen strains used as a control for these experiments on the surfaces (stainless steel, marble, and wood), such as Staphylococcus aureus and Escherichia coli were obtained from the Armed Forces Hospital Laboratory. For their control strains a clean stainless steel table without tiny groove was prepared as the food contact surface because it can be fabricated with a smooth cleanable finish. The surface was washed with hot water, with chemical detergent and rinsed with hot water. The table then was disinfected with 5. 25 % of hypochlorite solution for 10 minutes. The surface was allowed to dry before sampling. The test suspensions were prepared by making serial dilutions of the microorganisms in peptone saline solution. Two different levels of contamination were prepared: high

contamination (approximately 106 colony forming units (CFU)/100 cm2) and low contamination (approximately 103 CFU/100 cm2), obtained by spreading 1 ml of an appropriate solution on a surface of 20 x 20 cm2 over the grid reference table. The table was allowed to dry for 15 minutes to represent the environment of food preparation area. Selective agar media were used for the enumeration of pathogens: Blood agar for Staphylococcus aureus, incubated for 24 hours at 37oC and MacConkey agar for Escherichia coli incubated for 18 – 24 hours at 37oC. Furthermore, the effects of two different contamination levels on the survival of pathogens on dry stainless steel surfaces for 24 hours at room temperature were investigated.

Discussion

Sampling food contact surfaces is a complex problem, and the results depend on many factors, including the type of surface, the sources of contamination, the cleaning solution, and the temperature. The accuracy and reproducibility of all sampling methods are reduced when the numbers of bacteria on the surface are low. Some differences between methods are probably due to an uneven distribution of bacteria on the surface. The type of surface markedly influenced the cleaning results. For this study, nineteen selected premises were tested/studied (Ten replicate surfaces were tested; stainless steel, marble and wood, with adjacent areas being sampled before and after cleaning). The results of these studies indicate that three of ten stainless steel surfaces were contaminated before cleaning the surfaces and no surface was contaminated after cleaning, which means that stainless steel surfaces were more easily cleaned. Furthermore, three out of ten

marble surfaces were contaminated before cleaning and one surface was contaminated after cleaning the surfaces, which means marble surfaces were easily cleaned but using the wrong cleaning products and the wrong cleaning techniques can damage the marble because marble is a calcium-based natural stone which is highly sensitive to acidic materials (Marble Institute of America, 2012). Stainless steel resists impact damage but is vulnerable to corrosion, while marble surfaces are exposed to deterioration and may develop surface scratches and cracks where bacteria can accumulate (Leclercq and Lalande, 1994). Wood surfaces were particularly difficult to clean. As has been found in other studies, the difficulty in cleaning wooden surfaces in comparison to stainless steel and marble surfaces is due to the physical structure of wood which can absorb moisture and retain bacteria (Carpentier, 1997). Six out of ten wood surfaces were heavily contaminated before cleaning and three surfaces remained contaminated after the cleaning methods. The difficulty in cleaning was related to the amount of surface damage and it is best to avoid this type of surface. Nowadays, there is a need to change the use of wood as a medium for food contact because it allows a high level of bacteria attachment. The cut on the edge of wood surface that occur by the knife allow food residues to accumulate, thus creating a suitable medium for biofilm adherence and making cleaning difficult. A proper surface is essential for avoiding scratched and cracks where organic material could accumulate which leads to forming biofilms. Food contact surfaces sometimes harbour foodborne pathogens (Bloomfield and Scott 1997). As a result, these surfaces may pose a constant risk of transferring contaminants. Therefore, all such surfaces should have

antimicrobial treatment prior to use (Bloomfield and Scott 1997). The results of this study further confirm the necessity for using the appropriate food processing area sanitizing product for the specified food contact surface because contact surfaces may attain high levels of bacteria instead, which can contaminate food if it is not properly cleaned with a certain frequency, becoming a potential risk to cause cross contamination. Using products in a manner for which they are intended will help ensure microbial populations will be reduced to levels considered safe, and thus minimize the likelihood of foodborne illness. On the other hand, using agents with unproven antibacterial actions may lead to a false sense of safety. Hypochlorite solution, used for cleaning the surfaces in this study, was considered to be effective against the tested foodborne pathogens. With reductions reported for all organisms, it can be concluded that bleach (hypochlorite solution) is an appropriate sanitizer (Cozad and Jones 2003). Similarly, the contact surfaces that were disinfected with hypochlorite solution showed better microbiological performance. It has been found that rinsing with water and domestic chemical cleaners does not ensure total elimination of bacteria from food contact surfaces (Cogan et al. 2002). The use of hypochlorite solution to clean the surfaces has been found in other studies to be effective to reduce bacteria and pathogens that require a short to moderate contact time to acceptable limits (Williams et al. 2005). Although cleaning was carried out under observation and at times when it may not normally have been done, there was no evidence that attitudes towards cleaning methods markedly changed during the study. Bacterial contamination of food processing areas is common. Studies of the domestic environment by

Josephson et al. (1997) and Rusin et al. (1998) indicate that micro-organisms, including some pathogenic species, are commonly found in all areas of the home environment. As a result, in the domestic environment, foodborne illness caused by cross contamination is a major issue. According to a survey done by Scott et al. (2000), of 200 homes studied/tested it was found that 90% of the food processing areas were contaminated with Pseudomonas and 69% of domestic kitchens were contaminated with Enterobacteriaceae (Kagan, et al. 2002). The Enterobacteriaceae spp. isolated in this study from the three types of contact surfaces included Klebsiella, Enterobacter and Proteus. Although these species are not normally pathogenic, they must be regarded as indicators of poor hygiene. Other species which were isolated included Staphylococcus aureus and Pseudomonas aeruginosa. Staphylococcus aureus can cause food poisoning when a food handler contaminates surfaces or equipment on which food is prepared and when food not kept at the correct temperature. These bacteria multiply rapidly at room temperature to produce a toxin which is called an enterotoxin that causes inflammation or gastroenteritis of the lining of the intestinal tract. On other hand, Pseudomonas aeruginosa is widely distributed in nature and is common in moist environments in food processing areas. In many foods, Pseudomonas aeruginosa are regarded as potential spoilage microorganisms (Riemann and Cliver, 2006). To prevent the growth of this type of bacteria, proper hand washing techniques and proper sanitation of food contact surfaces must be ensured (Food Safety. gov, 2012). Yersinia enterocolitica was also isolated from the marble surface before the cleaning stage. Although less frequently, Yersinia enterocolitica is

transmitted through the fecal–oral route, resulting from improper hand washing and poor hygiene (Sreedharan et al, 2012). Failure to remove bacteria from a food contact surface can greatly increase the risk of foodborne illness by cross contamination. When bacterial colonies dry, a significant reduction of recoverable organisms results (Scott and Bloomfield, 1990). Surface roughness and hydrophobicity can significantly affect the attachment of an organism. The roughness of a surface increases the surface area available for colonization. Organisms adhere to hydrophobic surfaces, such as plastics, better than hydrophilic surfaces, such as stainless steel (Lee, et al. 2007). This is due to the hydrophobic surface features present on the cell (Doyle, 2000). The survival of Staphylococcus aureus and Escherichia coli on stainless steel surfaces is indicated in Table No. 13. Two different contamination levels were used for the experiments with Staphylococcus aureus and Escherichia coli. The results indicated that the survival of bacteria decreased rapidly, especially when the initial numbers on the surfaces were low. Staphylococcus aureus could be detected on dry surfaces for at least 12 hours at a high level of contamination, while at low levels, the cells decreased below the detection limit (3. 8 x 103 CFU/100 cm2) within 6 hours after contamination. For Escherichia coli, the viable cells could still be detected after 6 hours when a high initial level was present, but at low contamination levels, the count of Escherichia coli within 2 hours was below the detection limit. Microorganisms can attach to the food contact surface within hours or they may take days depending on surface characteristics (Cliver and Riemann 2002). Depending on the organism, nutrient availability may play an important role in the adhesion rate of the bacteria. When

surfaces are dry, minimal bacterial growth and survival can be attributed to reduced bacterial attachment and lack of available nutrients (Kusumaningrum, et al. 2003). Surface soiling then may preserve viability (Scott and Bloomfield 1990). Scott et al. (1990) found that on soiled surfaces, Gram positive and some Gram negative bacteria were recoverable in significant numbers for 4 hours and up to 24 to 48 hours in some cases. High numbers of bacteria can be transferred to hands, dish cloths and food from contact with the contaminated surface (Scott and Bloomfield 1990). This study has highlighted that the pathogens may remain viable on dry stainless steel surfaces and presents a (re)-contamination risk for long periods of time. Moreover, cross-contamination from food contact surfaces could lead to contamination of food; therefore, attention needs to be given to supervision and training to ensure appropriate hand washing and proper cleaning procedures to reduce or eliminate cross-contamination.