Evaluating the effectiveness of cleaning with detergent soap alone verses detergent soap followed by sanitizer on reducing aerobic microorganism numbers that are present on food contact surfaces

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Abstract

Background: Cross-contamination is one of the leading causes of foodborne illness which poses a massive burden to an individual's health and to the healthcare system. One way to prevent cross-contamination is through the elimination of pathogens from surfaces by properly washing with a detergent soap followed by sanitizing with a sanitizer. However, as found from a previous research study, not all restaurants in British Columbia wash and sanitize their food contact surfaces. Thus, this study aims to compare the cleaning effectiveness between using detergent soap alone verses using detergent soap followed by sanitizer.

Methods: Aerobic organisms were introduced to a cutting board by cutting alfalfa sprouts and then the surface was cleaned with Dawn Detergent soap and sanitized with 200ppm of chlorine bleach sanitizing solution. 3M™ Quick Swabs were used to sample the aerobic organisms (colony forming units) prior to and after each method of cleaning. The swabs were then transferred to 3M™ Petrifilm Plates, incubated at room temperature for 4 days, and then enumerated.

Results: The results show that there is a statistically significant greater microbial reduction through cleaning with detergent soap followed by sanitizer (mean log microbial reduction of 4.10) as compared to cleaning with detergent soap alone (mean log microbial reduction of 3.53). The p-value obtained is 0.003843 when α=0.05. The power was determined to be 92%.

Conclusions: This study was able to conclude that cleaning with detergent soap followed by sanitizer is 0.57 log (mean log microbial reduction of 4.10 - mean log microbial reduction of 3.53) more effective at cleaning than using detergent soap alone. However, the specific log microbial reduction value for the detergent soap followed by sanitizer achieved in this study is lower than what is found in the previous studies (Gilbert, 1970; Sores *et al.*, 2012; Rossvoll *et al.*, 2015). A possible reason for this discrepancy may be due to the presence of soil and food debris on the surface which may have had interfered with the sanitizing ability of the chlorine bleach (Lee et al., 2007).

Keywords: Aerobic organism, colony forming unit, chlorine bleach, sanitizer, sanitizing, detergent soap, cleaning, cutting board, food contact surface, cross-contamination, foodborne illness, cleaning methods, log reduction

Introduction

Every year, approximately 4 million (1 in 8) Canadians contract a foodborne illness and among these, there are approximately 11,600 hospitalizations and 238 deaths (Government of Canada, 2016). Cross-contamination is identified as one of the top ten contributing factors to foodborne illness in Canada (Burton, 2014). Improper washing and sanitization of dishware can lead to cross-contamination which is the unintentional transfer of pathogens from one area to another. It can also result from raw products transferring harmful organisms to cooked and prepared food. One study showed that after the preparation of batter or the mixing of eggs, pathogens can be discovered on surfaces over 40cm away from the mixing bowl even after 24 hours of the food preparation (Humphrey, Martin, & Whitehead, 1994). Thus, proper washing and sanitizing is pivotal in preventing foodborne illness. Washing requires the use of detergent soap to remove surface dirt and grease; sanitizing is the use of sanitizer to eliminate or greatly reduce the amount of pathogens on an already washed surface (Burton, 2014). These two processes performed together result in a food contact surface that is free from contamination.

Although as suggested by Burton (2014) proper cleaning and sanitation requires both soap detergent and sanitizer, the researcher of this study has observed that in some commercial kitchens this is not always true. From conversing with multiple kitchen leaders, it was suggested that some utensils are only washed with detergent soap at the end of the day (without the use of sanitizer). According to Matthewson & Heacock (2017), it was determined that out of the kitchen workers who participated in their study, 56.5% use only sanitizer solution, 13% use only soap, and 30.4% use soap followed by sanitizer to clean food contact surfaces (however, it is worth mentioning that this study did have a low survey response rate so the results may not be representative). Therefore this begs the question, how clean are these surfaces after they have been cleaned? Is it possible that substantial quantities of pathogens still remain on food contact surfaces even after they have just been cleaned? This research experiment intended to answer these questions. Therefore, the purpose of this study is to evaluate the role of detergent soap and sanitizer in the removal of bacterial colonies and to compare the effectiveness between washing with soap verses washing with soap followed by sanitizing with sanitizer based on the number of colony forming units before and after cleaning. It is worth noting that environmental health officers from the Surrey branch of Fraser Health Authority (British Columbia) also have expressed interest in knowing the results from this study.

Literature Review

a. Foodborne Illness in Canada

According to the Government of Canada (2016), at least 30 bacteria, parasites, and viruses are capable of causing a foodborne illness. The most common pathogens that cause foodborne illnesses in Canada are norovirus, *Listeria monocytogenes, Salmonella, Escherichia coli O157:H7, and Campylobacter* (Government of Canada, 2016). The risk of contracting these pathogens is even greater if food contact surfaces, such as utensils and cutting boards, are not washed and sanitized properly. Although Canada is considered to have a very safe food supply, many Canadians still obtain a foodborne illness every year. Thus, more work must be performed to identify, prevent, and control foodborne illnesses with extra effort being placed on pathogens that have been shown to cause the most illnesses.

Foodborne illness poses a considerable burden to an individual's health and to a society's economic development. Firstly, the symptoms range from mild (vomiting, diarrhea, and nausea) to severe (such as kidney and liver failures and neural disorders) and can cause permanent consequences or even death. To malnourished infants and children, these pathogens present an even larger risk as they develop a more severe infection which will increase the likelihood of death and even if individuals do survive, they are likely to develop

physical and mental disorders (World Health Organization, 2015). Secondly, foodborne diseases negatively affect the economy in numerous ways. For example, foods that are affected by foodborne pathogens will cause agricultural and food exporting industries to lose significant economic capital due to unsafe exports (World Health Organization, 2015). In addition, medical care is often required for individuals who become sick with foodborne illnesses, especially if one has severe symptoms. Therefore, the medical treatment costs related to foodborne illnesses causes a significant burden to the healthcare system (Hoffmann, 2015). Also, since many people contract foodborne diseases every year, the value of lost wages, time spent taking care of sick family, and lost leisure or education time are other economic burdens associated with these illnesses (Hoffmann, 2015). According to the United States Department of Agriculture, foodborne illnesses costs the economy $10-83 billion United States dollars every year (McLinden et al., 2014).

b. Laws and Regulation

Laws and regulations outline that food operators are responsible for creating an environment that is free from contamination. According to section 17 (1) of the BC Food Premises Regulation, food operators must ensure that all equipment, utensils, and food contact surfaces be safe and sanitary for food handling (B.C. Government, 2017). Although it is not specified in the regulations how "safe and sanitary" conditions must be met, prescriptive information can be found in the Food Retail and Food Services Code, Canada's food service code guideline. In this guideline, it states that cleaning for food contact surfaces can only be achieved through five steps: (i) scraping debris from surfaces; (ii) washing with detergent soap to loosen soil; (iii) rinsing with hot water to remove soil and detergent; (iv) sanitizing by heat or chemical solution; and (v) then air drying the items (Federal/Provincial/Territorial Food Safety Committee, 2016). Washing with detergent soap removes organic and inorganic matter from the surface which allows for sanitization to effectively occur; this eliminates pathogens of public health importance which may be present on the surface (Burton, 2014). Effective sanitization means that the food contact surface must reach a minimum of 5 log reduction of microorganisms within a 30 second contact period time in order for the surface to be considered as safe for the general public to use: free from pathogens which may be present on the surface (Federal/Provincial/Territorial Food Safety Committee, 2016).

c. Detergent Soap

Washing with soap is one of the oldest and most well-known cleaning methods in the world (Marriot and Gravani, 2006). Detergent soap is responsible for physically or chemically loosening and removing soil, dust, fats, oil, greases, or microorganisms from food contact surfaces (Gaulin, Lê, Shum, & Fong, 2011; Marriot and Gravani, 2006). Detergent soap quality is mostly based on cleaning performance, but foaming (gas produced on top of the surface liquid), biodegradability (metabolic degradation by microorganisms), and irritability to skin are other properties that are considered as well (Blagojević, Blagojević, & Pejić, 2016). Cleaning performance is affected by numerous factors including (i) contact time, (ii) physical force exerted onto surface, (iii) concentration of detergent, (iv) temperature of cleaning solution, (v) rinsing water, (vi) person performing the cleaning, and (vii) dirtiness of the surface (Marriot and Gravani, 2006). In the Food Retail and Food Services Code, there are no specific detergent soap products that are required for dishwashing; the guideline only states that when using detergent soap, to follow the manufacturer's product label instructions (Federal/Provincial/Territorial Food Safety Committee, 2016).

d. Sanitizers

There are many methods of sanitizing including thermal, steam, hot water (above 80 degrees Celsius), radiation, high hydrostatic pressure, vacuum, and chemical sanitizing (Marriot and Gravani, 2006). Chemical sanitizers are most often used in food processing, food handling, food preparation, and service industries (Gaulin,

Lê, Shum, & Fong, 2011). The purpose of sanitizers is to reduce the number of organisms present on a surface and this does not necessarily have to be through means of elimination. In order for a chemical to be classified as a food contact sanitizer, it must be capable of reaching a 5 log or 99.999% microbial reduction (non-food contact sanitizers must reach a 3 log or 99.9% reduction) (Marriot and Gravani, 2006). This can only be reached through "precleaning" which involves washing with soap and rinsing with water to remove food particles and other debris that may inactivate or decrease the effectiveness of the sanitizer (Gaulin et al., 2011). This is because as organic matter, such as food residue, is known to protect bacteria during mechanical washing causing ineffective sanitation (Lee, Cartwright, Grueser, & Pascall, 2007).

Chemical sanitizers that are approved for businesses in British Columbia to use are chlorine bleach, iodine, and quaternary ammonium solution (Burton, 2014; Federal/Provincial/Territorial Food Safety Committee, 2016). The role of chlorine as an antimicrobial agent has not been fully studied but it is believed that it is able to kill a cell through inhibiting glucose oxidation of enzymes which are important in carbohydrate metabolism (Marriot and Gravani, 2006). Unlike chlorine, the roles of iodine and quaternary ammonium compounds as microbial agents have been determined: iodine is able to disrupt the bonding between proteins and thus inhibit protein synthesis and quaternary ammonium forms an antimicrobial film over surfaces which prevents the growth of bacterial spores (Marriot and Gravani, 2006). Depending on whether mechanical or manual dishwashing procedures are used, different minimum concentrations and temperatures of the solutions are required (Federal/Provincial/Territorial Food Safety Committee, 2016). Hot water sanitizing methods may also be used only for mechanical dishwashing where the water used to rinse the dishes must reach at least 74 degrees Celsius for at least 10 seconds (Federal/Provincial/Territorial Food Safety Committee, 2016). Alternative sanitizing methods may be utilized only if they can be scientifically tested and proven that they are able to achieve the minimum of 5 log reduction of harmful organisms (Federal/Provincial/Territorial Food Safety Committee, 2016).

e. Comparison Between the 2 Types of Cleaning Methods

In British Columbia, it is required that detergent soap should not be used to clean surfaces by itself in food processing and food-service establishments. As stated by Marriot and Gravani (2006), detergent soap does not clean well and reacts with hard water to form insoluble compounds (Marriot and Gravani, 2006). This is because detergent soap is not formulated to remove microorganisms but rather to remove specific types of soils, such as proteins, fat, carbohydrates, or minerals (Gibson, Taylor, Hall, & Holah, 1999). In fact, it was found by Tebbutt (1984) and Gibson, Taylor, Hall, & Holah (1999) through sampling catering equipment and work surfaces that were cleaned with detergent soap that they only found a 2-3 log microbial reduction on these surfaces. This aligns with another study's finding where cutting boards and knives that were vigorously mechanically scrubbed to remove particles and debris before washing with soap, were reported to have only approximately a 4 log reduction in pathogens (Ravishankar, Zhu, & Jaroni, 2010). Thus, washing with only detergent soap will not reach the Food Retail and Food Services Code requirement of 5 log reduction. However, in Gkana, Lianou, and Nychas' (2016) experiment they found that washing with water and detergent can reach a 5 log reduction of bacteria, depending on the type of surface: 5 log reduction on polyethylene and stainless steel surfaces but only a 2 log reduction on wooden surfaces. It is worth noting that likewise to washing with detergent soap alone, it is written in the Food Retail and Food Services Code that washing with only sanitizer is inadequate to effectively reduce pathogens. This is reasoned as that the presence of debris (such as soil, fat and oil) will affect the efficacy of the chemical sanitizers because, as mentioned earlier, these particles will shield and protect the microorganisms from the sanitizers

(Federal/Provincial/Territorial Food Safety Committee, 2016; Gaulin, Lê, Shum, & Fong, 2011; Lee, Cartwright, Grueser, & Pascall, 2007).

In the studies that compared the effectiveness between the two methods of cleaning (using only detergent soap verses detergent followed by sanitizer), detergent soap followed sanitizer was usually found to be the best cleaning method (Gilbert, 1970; NSF International, 1992; Rossvoll et al., 2015; Soares et al., 2012). For example in Soares et al.'s (2012) experiment, they measured the number of *Salmonella enteritidis* across various types of cutting boards after rinsing with running water, washing with soap, or washing with soap followed by sanitizing with a chlorine sanitizer. They discovered that cleaning with soap and sanitizer was able to reduce the largest amount of the pathogen on wood, polyethylene, glass, and stainless steel surfaces (Soares et al., 2012). Another study which compared the difference in bacterial numbers on the surface polyethylene cutting boards also found that washing and sanitizing reached a 7.5-7.9 log reduction whereas washing with soap alone only reached a 1.6-2.3 log reduction (Rossvoll et al., 2015). A related experiment which looked at a meat slicing machine came to a similar conclusion in that washing with a detergent followed by a sanitizer was the most effective: resulting in greater than a 6 log microbial reduction (cleaning with detergent alone or a sanitizer alone was only able to reach a 2 or 1 log reduction respectively) (Gilbert, 1970). Interestingly, a different experimental result was found by Hall, Saltmarsh, Fielding, & Peters (2007). In their study, they evaluated the reduction in bacterial numbers after cleaning with using detergent alone, sanitizer alone, and dishwasher-based methods (washing with both detergent and sanitizer) in mixing bowls of hot drink vending machines. It was seen from their experiment that there was no significant difference in microbial reduction numbers between using the three cleaning methods as there was only a less than 0.5 log CFU/cm^2 difference (Hall et al., 2007). Although it is worth noting that the dishwasher-based method did have a slightly greater microbial reduction compared to the other two methods (Hall et al., 2007).

Hence from this literature review, it appears that washing with detergent soap followed by sanitizing with sanitizer is more effective than cleaning with detergent soap alone. However, the studies that were reviewed in this paper either did not directly compare all these cleaning methods in a same study or did not use manual wash, rinse, and sanitizing techniques. For example, many of the studies did not compare both of the cleaning methods or utilized a mechanical dishwasher. In addition, for the studies that did compare the effectiveness of the cleaning methods, some are outdated and thus, newer research is required.

f. Frequent and Regular Cleaning

Tebbutt (1984) determined that frequent and efficient cleaning with soap and water can be more effective in reducing pathogens than cleaning with a detergent soap followed by a food sanitizer as contamination can often occur in a kitchen setting. Tebbutt (1984) found although washing and sanitizing is the most effective cleaning method, their uncontrolled use can lead to food handlers having a false sense of security. Staff may believe that the use of the cleaning solutions can replace the need to clean as frequently or they may have used the improper concentration and/or contact time (Tebbutt, 1984); these issues all contribute to the ineffective use of detergent soap and sanitizers causing pathogens to remain on food contact surfaces and contaminate food products. NCCEH suggest similarly that regular and effective cleaning may be more effective in decreasing microbial load as the use of detergent soap alone or sanitizer alone can already reach a 2 to 3 microbial reduction (Gaulin, Lê, Shum, & Fong, 2011).

Materials and Methods

A plastic cutting board (60cm x 45cm) was obtained from the BCIT Environmental Health Lab Technological Assistant, Fred Shaw, and fresh alfalfa sprouts from the brand EATMORE

SPROUTS were bought from Save-On-Foods supermarket. The alfalfa sprouts were bought on the morning of the experiment. To introduce aerobic organisms onto the food contact surface, the cutting board was first divided to equal and separate 10cm x 10cm regions where each region represented one sampling area for swabbing. Next, a handful of alfalfa sprouts was cut at the middle of each region for two minutes. This simulated a real-life situation where pathogens were introduced to a cutting board surface when a food is being cut. All the cut alfalfa sprouts were then brushed off from the cutting board and disposed of into the garbage.

Environmental surface swabs, specifically 3M™ Quick Swabs, were then used to sample the microorganisms that were introduced onto the cutting board at three steps after the alfalfa sprouts were cut: prior to cleaning, after cleaning with detergent soap, and after cleaning with sanitizer. Firstly, swabs were used to sample the cutting board prior to cleaning. Next, the cutting board was placed into a sink and scraped clean. Afterwards, Dawn detergent soap was applied to the sponge and then used to wash the cutting board with warm running water that was no less than 43 degrees Celsius. Subsequently, the cutting board was rinsed with water that was less than 45 degrees Celsius to remove the detergent soap. Using the pre-labelled 3M™ Quick Swabs, each of the regions of the cutting board was sampled; these swabs reflected the number of aerobic organisms after washing with detergent soap. Next, 200pm of chlorine bleach solution was used to sanitize the cutting board with a contact time for at least 7 seconds. Lastly, the swabs were used to sample the cutting board; this showed the number of microorganisms that are present after washing and sanitizing. All of the cleaning techniques that were used in this experiment are in accordance with the Food Retail and Food Services Code (Federal/Provincial/Territorial Food Safety Committee, 2016). The collected swabs were then transferred to 3M™ Petrifilm Plates for incubation. Some of the swab samples (before cleaning and after cleaning with detergent soap) collected were diluted with distilled water prior to transferring onto the plates in order to introduce an optimal number of aerobic colonies to the plates (3M, 2018).

The 3M™ Petrifilm Plates were incubated at room temperature in the fume hood for 4 days and the total number of bacteria was enumerated using a cell counter. The microbial numbers before cleaning, after washing with detergent soap, and after sanitizing with sanitizer were thus achieved. These numbers were then used to calculate the log reduction values for cleaning with detergent soap alone and cleaning with detergent soap and sanitizer (Microchem Laboratory, 2015). The following was the equation used to calculate the log reduction:

$$\text{Log Reduction} = \log_{10}\left(\frac{A}{B}\right)$$

or,

$$\text{Log Reduction} = \log_{10}(A) - \log_{10}(B)$$

A - the number of aerobic microorganisms prior to cleaning.
B - the number of aerobic microorganisms after the cleaning method (either after detergent soap or after sanitizer).

Statistical Analyses and Results

Type of Data and Descriptive Statistics

In this study, numeric discrete data were collected. This scale of measurement only gathered whole numbers – this study measured the number of colony forming units (CFUs).

Hypotheses

The null and alternate hypothesis for this study are:
Ho: The log microbial reduction in the number of CFUs after cleaning with detergent soap and sanitizing with sanitizer is ≤ the log microbial reduction in the number of CFUs after cleaning with only detergent soap.
HA: The log microbial reduction in the number of CFUs after cleaning with detergent soap and sanitizing with sanitizer is > the log microbial

reduction in the number of CFUs after cleaning with only detergent soap.

Descriptive Statistics

The descriptive statistics results were obtained through utilizing Microsoft Excel 2016. The results are presented in Table 1.

As seen from Table 1, the means for "Log Microbial Reduction – Detergent" and "Log Microbial Reduction – Detergent + Sanitizer" are 3.5332 and 4.1037 respectively. This indicates that using detergent soap followed by sanitizer has a greater average log reduction when compared to using detergent soap alone to clean.

Inferential Statistics

The statistical package used to analyze the inferential statistics was Number Cruncher Statistical System 11 (NCSS 11). Since this experiment has two groups of dependent numeric data which compares the before and after of using sanitizer, this study would either perform the Paired T-test (parametric) or the Wilcoxon Signed-Rank test (non-parametric) (Heacock and Ma, 2017). The researcher conducted a one-tailed test as it was expected that cleaning with detergent soap and sanitizer would have a greater microbial reduction than cleaning with detergent soap alone.

The NCSS11 print out statistic results can be found in Appendix 1. To determine whether the parametric or non-parametric statistical test should be used, one must first analyze the "Tests of Assumptions". From looking at all the "Assumption" results, it is seen that 2 out of the 3 tests reject normality. Thus, this means that the data sets are not normally distributed and this suggests that a non-parametric test should be used, Wilcoxon Signed-Rank Test. The researcher has previously established that this test will utilize the one-tailed t-test, therefore, the "Median < 0" row was analyzed. From this, it is found that the p-value is equal to 0.0038. Hence, since the p-value is less than the cut-off of 0.05, the null hypothesis is rejected and this suggests that there is a statistically significant greater microbial reduction after using sanitizer to clean; cleaning with detergent soap followed by sanitizer is more effective than cleaning with detergent soap alone.

It is unlikely that the statistically significant difference found in the test result is caused by alpha error as the p-value is relatively low, 0.0038. Looking at the "Power for the Paired-Sample T-Test" results, it is seen that when alpha is 0.05, the power is 0.92 which is greater than the cut-off of 0.80. Since the beta error is equal to 1-power, when the power is equal to 0.92, the beta error is 0.08.

Log Microbial Reduction - Detergent		***Log Microbial Reduction - Detergent + Sanitizer***	
Mean	3.5332	Mean	4.1037
Median	3.6576	Median	4.0458
Standard Deviation	0.3799	Standard Deviation	0.1914
Range	1.2590	Range	0.5601
Minimum	2.6271	Minimum	3.8601
Maximum	3.8861	Maximum	4.4202
Count	9.0000	Count	9.0000

Table 1 – Descriptive statistics obtained from Microsoft Excel 2016 on the microbial reduction numbers after each of the two cleaning methods

Discussion

The purpose of this research study was to determine the efficacy of washing with detergent soap alone compared to washing with detergent soap followed by sanitizing with sanitizer based on the number of colony forming units present before and after cleaning. Based on the 9 replicate results for each of the two cleaning methods, it was observed that cleaning with detergent soap alone reached a mean log microbial reduction of 3.53 while cleaning with detergent soap followed by sanitizer reached a mean log microbial reduction of 4.10. Based on these mean log microbial reduction values and the inferential statistic results, it is determined that cleaning with detergent soap followed by sanitizer to be more effective in reducing the number of CFUs than cleaning with detergent soap alone; hence, the rejection of the null hypothesis. This finding is aligned with previous studies which compared the cleaning effectiveness between the two cleaning methods (Gilbert, 1970; NSF International, 1992; Rossvoll et al., 2015; Soares et al., 2012).

Comparing each of the two methods' mean log microbial reductions to previous experiments, it can be seen that this study's result of cleaning with only detergent soap reaches a similar log reduction, 3.53. For example, Tebbutt (1984) and Gibson *et al.* (1999) both found a 2-3 log microbial reduction and Ravishankar *et al* (2010) obtained a 4 log reduction when using detergent soap alone to clean. However, the log microbial reduction achieved for cleaning with detergent soap followed by sanitizer, 4.10, is lower than what is achieved in prior studies. For instance, Soares *et al.* (2012) achieved a 5.11 log reduction, Rossvoll *et al.* (2015) found a 7.5-7.9 log reduction, and Gilbert (1970) attained greater than a 6 log reduction. Furthermore, this experiment did not reach the clean and sanitation requirement established by the Food Retail and Food Services Code of 5 log microbial reduction (Federal/Provincial/Territorial Food Safety Committee, 2016). In addition, comparing the two experimentally obtained log microbial reductions, the difference between cleaning with detergent soap followed by sanitizer verses cleaning with detergent soap is only log 0.57 (4.10 – 3.53). This suggests that cleaning with detergent soap followed by sanitizer did not eliminate a significantly greater number of aerobic organisms as expected compared to cleaning with detergent soap alone. Hence, it is seen that although the inferential statistic results state that there is a statistically significant difference between the two cleaning methods, this difference between the two cleaning methods is not that great.

A possible explanation for the low log microbial reduction in the detergent soap followed by sanitizer cleaning method may be due to the cutting board surface not being clean enough. As stated by Gaulin *et al.* (2011), soil and food debris that is present on surfaces will decrease the efficacy of sanitizers. This is because the presence of organic and inorganic particles will form biofilms which shield and protect microorganisms from antibacterial compounds in chemical sanitizers (Lee et al., 2007). It is found that high protein loads on surfaces will require a greater sanitizer concentration and increase contact time to reach the same degree of microorganism elimination as compared to low protein loads surfaces (Kusumaningrum *et al.*, 2002) Relating back to this study, it is possible that as a result of a high number of aerobic colonies being introduced onto the cutting board by the alfalfa sprouts, washing with detergent soap was not capable of fully eliminating all the debris that was present on the surface. Therefore, the chlorine bleach sanitizer was not able to directly contact all the aerobic colonies and was not allowed to achieve its maximum effect.

Negative control results were taken to determine the number of aerobic microorganisms present in the distilled water and the cutting board before cutting alfalfa sprouts: 0 CFUs and 22 CFUs were found respectively for each sample. Thus, the distilled water and cutting board, prior to the experiment, had very low to no aerobic organisms present. This indicates that nearly all the aerobic colonies found from before and after the cleaning steps were contributed by the cutting of the alfalfa sprouts on the cutting board.

Knowledge Translation

The findings from this study can be translated many ways which will benefit food handlers and the general public. Firstly, the results can be incorporated into the Food Retail and Food Services Code (2016) because as of now, this guideline does not provide information about the microbial reduction after using only detergent soap to wash. In addition, as found from Matthewson and Heacock's (2017) research study, the majority of restaurant staff who participated in their study do not clean and sanitize food contact surfaces (countertops) properly. However, it is worth noting that Matthewson and Heacock's study did have a small number of survey participants. Nonetheless, the results from this study can be integrated into various workshops, such as FOODSAFE, to educate and inform food handlers the quantities of aerobic microorganisms that can be eliminated from each method of cleaning. Another point to note is that if someone searches on the internet about how to wash their dishes at home, the majority of websites will only suggest to wash their dishware with detergent soap (without any sanitizer). It would be interesting if the health authorities created a website or a pamphlet to educate the public that in some cases, it is beneficial to clean *and* sanitize at home, especially after handling foods which are likely to contain pathogens, such as raw meat and produce. Since it is determined that more than 50% of all foodborne illnesses are due to improper food handling practices at home, it is likely that promoting cleaning and sanitizing to the public will decrease the number of food-related illnesses. Thus, the results from this study can be used to better design cleaning protocols that ensures the proper microbial reduction for food contact surfaces at restaurants and at home kitchens.

Limitations

The most significant limitation in this study was the small sample size for each cleaning method. This is mainly because of the budget available as each student experiment had a limited funding. For example, purchasing the 36x 3M™ Quick Swabs already utilized nearly all the financial resources for this study. In addition, the researcher only had a limited amount of time to perform this study. Because of these two factors, only 9 replicates were obtained for each cleaning method. With more money and time, more replicates for each cleaning method could have been taken and tested. With a higher replicate number, this would have allowed the research experiment to be more representative and accurate to the true number of aerobic colonies that are reduced from cleaning with detergent soap or detergent soap followed by sanitizer. Also, foodborne illnesses are not caused by all aerobic microorganisms but rather pathogens. Thus, another limitation to this study is that since this experiment occurred in an Environmental Health Laboratory setting, no specific pathogen could be inoculated and directly introduced to the cutting board surface such as *Listeria monocytogenes, Salmonella,* and *Escherichia coli* O157:H7. By using 3M™ Quick Swabs, which measures all types of aerobic microorganisms, it is impossible to determine the exact number of pathogens that are eliminated from the two cleaning methods.

Future Research

Some interesting future student projects that can be conducted based on this research study includes:

- Repeating this study in order to have a higher number of replicates for each cleaning treatment to confirm the results that were obtained, especially for the detergent soap followed by sanitizer cleaning method.
- Conducting a similar study to determine the microbial reduction of cleaning with only a chemical sanitizer (without the use of any detergent soap) as the Food Retail and Food Services Code (2016) does not provide this information.

Conclusion

Washing and sanitizing food contact surfaces is one of the most important methods to prevent cross-contamination which causes various foodborne illnesses. Foodborne illness is not only a significant burden to a person's health, but it also adversely affects the whole society. Although there are specific laws, regulations and guidelines in place, it has been found from the researcher's previous experience and Matthewson and Heacock's (2017) study that some food handlers do not always wash and sanitize food contact surfaces properly. In this study, the results suggest that cleaning with detergent soap followed by sanitizer is the most effective method to reduce aerobic microorganisms. However, the specific log microbial reduction value for the detergent soap followed by sanitizer cleaning treatment found in this study is lower than what is found in previous studies (Gilbert, 1970; Sores *et al.*, 2012; Rossvoll *et al.*, 2015). This may have been due to the presence of inorganic and organic particles that remained after cleaning with detergent soap which decreases the effectiveness of the chlorine bleach sanitizer used. The information obtained in this study can be utilized (1) to continue educating the public, especially food handlers, about the importance of proper cleaning and sanitizing and (2) to further develop studies which investigate the efficacy of different cleaning methods.

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Competing Interest

The authors declare that they have no competing interests.

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