

## Comparison of commercially available food decontaminants with established methods of decontamination for household practices which are used to keep foods safe

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### Abstract

The microbiological safety of food has been a major concern in Bangladesh following several reports of food borne outbreaks associated with contaminated food and vegetables. To minimize the outbreak, several studies suggested that decontamination is necessary before cooking. Washing with water is the most common technique for decontamination in Bangladesh. In order to ensure food safety, the use of different food washing agents is also becoming popular day by day. For this reason, this study was conducted to evaluate the efficacy of various sanitizers and treatment method for decontamination. In this study, several decontamination methods including washing with hot water, cold water, salt water, vinegar and commercially available food sanitizer to evaluate for their efficacy against different microorganisms. Here, salad vegetables were washed with various sanitizers and then microbiological analysis was done to reveal the bacterial and fungal load. This study revealed that most of the sanitizing methods were able to reduce microbial load minimum by 2 log CFU/g. Vinegar and hot water wash were the most effective method of decontamination compare to others with the former showing a 3 log CFU/g reduction. This can be concluded that common items like the use of vinegar and hot water were more effective than the commercial decontaminating agents available.

## 1. Introduction

Vegetables are an excellent source of nutrition and it serves as a favorite among many consumers (Nastou *et al.*, 2012; Alam *et al.*, 2015; Rahman *et al.*, 2016). Additionally, many vegetables are available in the ready to eat format, such as salad or on its own as a snack. Leafy green vegetables and other ready to eat vegetables are a potential source of pathogens with the ability to cause food-borne illnesses, especially when consumed raw (Soriano *et al.*, 2001; Ahmed *et al.*, 2014; Alam *et al.*, 2015; Rahman *et al.*, 2016; Uhlig *et al.*, 2017). Some vegetables are consumed after minimal processing in which the products are physically altered but they are still in their original state (Soriano *et al.*, 2001; Gomez-Lopez *et al.*, 2008). This includes cutting, peeling, trimming and washing (Gomez-Lopez *et al.*, 2008). Contamination may result from soil, water, manure, equipment, people and the quality of water used for cleaning (Gil *et al.*, 2009; Alam *et al.*, 2015; Rahman *et al.*, 2016). Effective decontamination is of utmost importance in order to stop the spread of pathogens in the food cycle (Gil *et al.*, 2009; Phua *et al.*, 2014).

Decontamination methods such as irradiation, ultrasound and chemical sanitizers have recently received some negative reviews from its consumers, as recent revelations have highlighted the adverse effects of its use on both human health and the environment (Dionisio *et al.*, 2009; Phua *et al.*, 2014). Chemicals such as chlorine are already banned in many countries in Europe. Bacterial regrowth also serves as a problem, since many sanitizers lose its effect over time. According to The National Advisory Committee on Microbiological Criteria for Foods (NACMCF) foods should be subjected to a decontamination treatment, prior to consumption, which can effectively reduce the microbial presence by 5 log (Phua *et al.*, 2014). Decontamination methods which can eliminate and reduce pathogens are required to maintain food safety, particularly if it is easy, cheap and reproducible (Olaimat *et al.*, 2018).

Raw foods pose more of a threat as they are only subjected to washing and sanitizing methods used by individuals at home (Soriano *et al.*, 2001; Nastou *et al.*, 2014). Washing, with the use of water and other substances, is a form of decontamination which aims to

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remove dirt, residue, pesticide and microorganisms (Gil et al., 2009; Phua et al., 2014). Vinegar acid is a reduced form of acetic acid is known to be used in different households, against wounds and infections (Aspelund et al., 2016).

For this reason, the current study compared commercially available fruit and vegetable cleaners along with household products, which are commonly used for cleaning, such as hot water, cold water, salt water and vinegar wash in an attempt to identify which household remedies are as effective as or more effective than the cleaners.

## 2. Materials and methods

### 2.1 Sample collection

All samples were collected from local markets and brought to the laboratory as soon as possible. Fruit and vegetables cleaners and vinegar was purchased from supermarkets. A total of three salad vegetables including lettuce, cucumber and carrot (*Lactuca sativa*, *Cucumis sativus* and *Daucus carota* respectively) were used, collected from local markets of Dhaka city, Bangladesh within the time frame from September 2019 to October 2019. (APHA 1998; Noor et al., 2013; Hassan et al., 2013; Senjuti et al., 2014).

### 2.2 Washing and sample processing

Samples were treated with different washing agents and soaked for 30 mins. The washing agents included three different store-bought cleaners, hot water, cold water, 2% NaCl water and vinegar water (25% vinegar solution). All water used was boiled prior to use and allowed to cool at room temperature until the desired water temperature was achieved (Das et al., 2018).

### 2.3 Enumeration of total viable bacteria (TVB), Total Fungi (TF), coliform and *Staphylococcus* spp.

Raw and treated samples (10 g) were homogenized with 90 mL buffered peptone water (BPW). The homogenized samples were serially diluted up to  $10^{-7}$  for microbiological analysis (Senjuti et al., 2014; Feroz et al., 2014; Mamun et al., 2016). In order to isolate total viable bacteria, total fungi, coliform and *Staphylococcus* spp., 0.1 ml suspension of all 3 categories samples from  $10^{-3}$  dilution was spread onto Nutrient Agar (NA), Sabouraud Dextrose Agar (SDA), MacConkey Agar and Mannitol salt agar (MSA) plates, respectively. All media Except Sabouroud Dextrose Agar (SDA) were incubated at 37°C for 24 hrs. and SDA was incubated at 25°C for 24 hrs. (Cappuccino and Sherman, 2001; Hassan et al., 2013; Feroz et al., 2014; Mamun et al., 2016).

## 2.4 Observation of physical changes

Along with the microbial analysis, physical changes were observed by soaking the whole vegetables in different washing agents for 30 mins.

## 3. Results

Lettuce (Figure 1) was highly contaminated with total viable bacterial growth of log 6.74 CFU/g. Most of the decontaminating method able to reduce 2 to 3 log reductions, while washing with vinegar showed a 4-log reduction in TVB (total viable bacteria). Here, vinegar also exhibited the highest reduction in the case of coliform and *Staphylococcus* spp. growth. All methods of washing were effective against fungal growth.

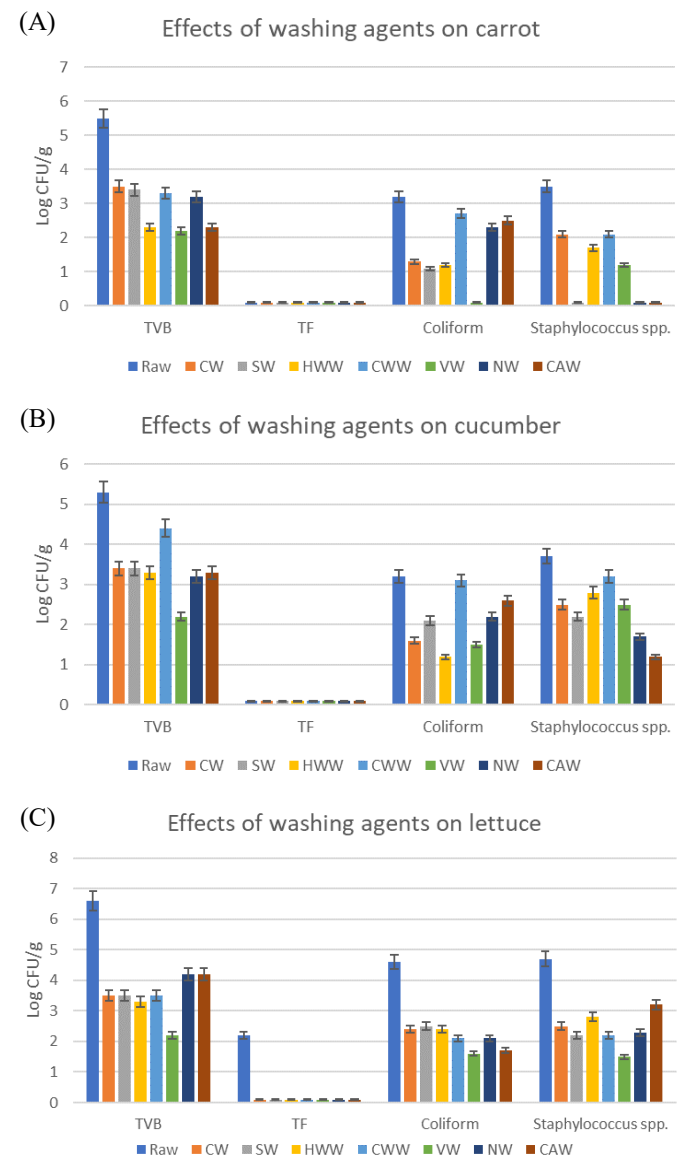


Figure 1. Log reduction of microbial population by commercially available sanitizers along with some common household methods of decontamination on (A) carrot, (B) cucumber and (C) lettuce. CW- Cleaning Agent 1, SW- Cleaning Agent 2, HWW- Hot Water Washed, CWW- Cold Water Washed, VW- Vinegar Washed, NW- NaCl washed, CAW- Cleaning Agent 3

As seen in Figure 1, raw cucumber was contaminated with total viable bacterial growth of log 5.43 CFU/g. Hot water and NaCl washing demonstrated a 2-log reduction while washing with vinegar showed a 3-log reduction in TVB (total viable bacteria). Hot water washed showed the highest reduction in the case of coliform, while in case of *Staphylococcus* spp. cleaning agent 3 was most effective (2-log reduction). No fungal growth was observed.

According to Figure 1, carrot was highly contaminated with total viable bacterial growth of log 5.65 CFU/g. Hot water was found to be most effective to reduced TVB (total viable bacteria) on carrots. Vinegar was able to completely eliminate coliform growth, then at the same time NaCl wash and cleaning agent 3 was most effective against *Staphylococcus* spp. growth. No fungal growth was observed.

#### 4. Discussion

Salad vegetables, such as lettuce, cucumber and carrot are an important part of the human diet as well as a convenient source of nutrition (Uhlig et al., 2017). That said, they are also the carriers of different pathogens which can contribute to food-borne illnesses, especially when they are consumed raw (Gómez-López et al., 2008; Feroz et al., 2016). Therefore, in order to continue to enjoy the benefits of these ready to eat foods, proper cleaning and washing need to be ensured (Nastou et al., 2012). Methods that have been proven to be highly effective often use chemicals or radiation, both of which have become unfavourable due to changes observed in the food appearance and taste as well as due to the linkage of these methods with harmful side effects (Feroz, Mori and Sakagami, 2016). The current study analysed household cleaning methods and commercially available cleaners to assess their efficacy against pathogens that can cause illness in humans.

Studies carried out by Uhlig et al. (2017) on washing lettuce have shown that it was effective in reducing bacteria, similarly current study also revealed a decrease in bacterial growth on lettuce after washing. 3-log reductions were observed for both washing with cold and hot water. Uhlig also concluded that repeated washing

with high water flow rate would produce even a greater reduction in growth. Studies conducted by Phua et al. (2014) compared chemical sanitizers with water-based methods. Their findings were partly in agreement with the current study, as the natural methods are more effective than chemical sanitizers and cleaning agents purchased from the store. Conversely, they identified hot water as the most effective, whereas our study found the vinegar and water mixture to be more effective among the natural methods (Table 1). It is to be noted that Phua et al. (2014) did not test vinegar-based solutions. Further analysis is required to properly identify one method as the most reliable.

Several studies on the effect of water washing at different temperatures were carried out, while some have found it effective others such as Nastou et al. (2012) have stated the decrease in growth is insignificant. To the best of knowledge, no study had carried out a comparison of cleaning agents with water and vinegar-based treatments. The current study found vinegar to be more effective among the household methods, in reducing bacterial growth than the other tested methods. The mixture of vinegar and water, as well as the salt and water, was able to produce the highest reduction of bacterial growth. Additionally, they both showed no physical change after use, whereas a texture change was observed after the use of hot water (Table 2). One important point to consider in sanitizing of foods is the quality of water used for washing (Gil et al., 2009). For this reason, the current study used boiled water which was cooled. To ensure the quality of water is always acceptable, use of boiled or filtered water is suggested. The cleaning agents showed similar results to that of vinegar wash, if not a higher reduction rate. The current study does not promote the use of this product as it is not a natural remedy and repeated use may become expensive.

A major difference between the current study and that of the two mentioned before was that this study attempted to use conditions that are observed in only one household. The vegetables were not inoculated prior to treatment and the raw counts were that of untreated vegetables, while the counts observed after treatment would be relatable to vegetables found in everyday

Table 1. Average reduction of microorganisms after using different cleanser on three categories of vegetables (log CFU/g)

Microorganisms	CW	SW	HWW	CWW	VW	NW	CAW
Total Viable Bacteria (TVB)	2.3	2.3	2.9	2	3.6	2.2	2.5
Total Fungi (TF)	2.2	2.2	2.2	2.2	2.2	2.2	2
Coliforms	1.9	1.7	2	1	2.6	1.3	1.4
<i>Staphylococcus</i> spp.	1.6	2.5	1.5	1.3	2.2	2.6	2.5

CW- Cleaning Agent 1, SW- Cleaning Agent 2, HWW- Hot Water Washed, CWW- Cold Water Washed, VW- Vinegar Washed, NW- NaCl washed, CAW- Cleaning Agent 3

household in Dhaka city. Therefore, the methods are not only easy to reproduce but they are applicable to natural conditions of foods in stores and in the houses. Additionally, the availability of sanitizers in Dhaka is limited, available only in select supermarkets. Also, the price of the sanitizer makes it too expensive for the majority of the country. Comparatively use of vinegar or water (hot/salt water) based methods are cheaper and easily can be conducted at home by anyone.

Table 2. Physical changes observed after exposure to washing agent

Washing agents	Physical changes observed
CW	No Changes
SW	No Changes
HWW	Slight Change in texture
CWW	No Changes
VW	No Changes
NW	No Changes
CAW	No Changes

CW- Cleaning Agent 1, SW- Cleaning Agent 2, HWW- Hot Water Washed, CWW- Cold Water Washed, VW- Vinegar Washed, NW- NaCl washed, CAW- Cleaning Agent 3

## 5. Conclusion

Along with store-bought vegetable and fruit cleaners, hot water, cold water, salt water, and vinegar solution were tested, among them salt water and vinegar solution were the most effective in reducing bacterial and fungal load. Therefore, it is a viable alternative to the chemical sanitizers and other store-bought sanitizers available. These natural methods will not only remove dirt, pesticide and microorganisms it will also ensure no harmful side effects to the consumer. Vinegar and salt are also readily available in all stores with the prices range being affordable for most.

## Conflict of interest

The authors declare no conflict of interest.

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