Journal of Multidisciplinary Sciences
www.multidisciplines.com

Pre- and post-harvest antimicrobial treatments of fresh produce

Chadni Akter[1], Alfi Shahrin[2], Purnima Das[3], Mahmuda Akter Mele[4], Ho-Min Kang[5], Young-Tack Lee[6], and Mohammad Zahirul Islam[6*]

[1]*Department of Botany, Government Titumir College, Dhaka 1213, Bangladesh*
[2]*Department of Pharmacy, East West University, Dhaka 1212, Bangladesh*
[3]*Department of Water Resources Engineering, Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh*
[4]*College of Science and Engineering, James Cook University, Townsville, Queensland 4811, Australia*
[5]*Interdisciplinary Program in Smart Agriculture, Kangwon National University, Chuncheon 24341, Republic of Korea*
[6]*Department of Food Science and Biotechnology, Gachon University, Seongnam 13120, Republic of Korea*
**Corresponding author email address: zahirul@gachon.ac.kr (M.Z.I.)*

Received: 12 October 2023; Accepted: 01 December 2023; Published online: 07 December 2023

Abstract. There has been a significant rise in attention and worry surrounding fresh produce. This is due to the response of consumers and marketers to widespread media coverage on the health impacts of microbial contaminants in food. Multiple studies have consistently found that high-quality and non-contaminated products have a higher demand compared to those that are contaminated with microbes. Given the growing demand for fresh food, it is necessary to examine the current research that focuses on the microbiological quality. So far, only a limited number of carefully conducted studies have been completed to develop viable therapies for managing microbial activity. Nevertheless, a slight elevation in the inclination of several therapies, including physical, chemical, biological, gaseous, and radiation methods, is noted. A proper treatment may elevate market value and consumer satisfaction. Prominent areas for future research can be identified and given special attention.

Keywords: *Acidic electrolyzed water, hydrogen peroxide, sodium hypochlorite, ozone water, and MAP*

Cite this as: Akter, C., Shahrin, A., Das, P., Mele, M.A., Kang, H.-M., Lee, Y.-T. & Islam, M.Z. (2023). Pre- and post-harvest antimicrobial treatments of fresh produce. J. Multidiscip. Sci. 5(2), 32-38.

1. Introduction

Different treatments are used to control microbial activity, such as physical, chemical, biological, gaseous, and radiation. Microbial quality is an indicator of the microbial safety of fresh produce. This quality is affected by the processing and handling of leafy vegetables such as lettuce, spinach, romaine lettuce, and green sesame leaves (Oliveira et al., 2010; Tango et al., 2014).

There are many methods or techniques used to detect the pathogens, for example, polymerase chain reaction (PCR), culture colony technique, and immunology-based procedures. Velusamy et al. (2010) reported that biosensors and bio- receptors are used to detect the pathogen. Quantitative polymerase chain reaction (qPCR) has been used more recently. The culture colony technique is used for *Campylobacter jejuni* (Sanders et al., 2007), *Yersinia enterocolitica* (Weagant, 2008), and Salmonella, *S. aureus*, *E. coli*, and Coliforms (Delbeke et al., 2015) detection.

There are many chemicals, physical, biological, and modified atmosphere packaging (MAP) treatments usually used to protect fruits, vegetables, and cereals, as described by researchers (Table 1). These are acidic electrolyzed water (Rahman et al., 2012; Rahman et al., 2016; Islam et al., 2018c), cold atmospheric conditions and hydrogen peroxide (Islam et al., 2017; Islam et al., 2018c), sodium hypochlorite and ozone water (Islam et al., 2018c), sonication (Forghani et al., 2013), chlorine dioxide gas (Islam et al., 2017), organic acids (Martin & Maris, 2012; Islam et al., 2018c), MAP (Islam et al., 2014; Mele et al., 2017; Islam et al., 2017), neem oil, and Trichoderma (Islam et al., 2018e). Therefore, this review was conducted to get an overview of proper pre- and post-harvest antimicrobial treatment of fresh produce.

Table 1. Effects of different treatments on microbial quality of fresh produce

Sl	Fresh produces	Treatments	Microbial performances	References
1	Carrot	(1) inoculated control (o min), (2) ozone water washed (0.5, 1, 2, 5, 10 min) and (3) water washed (0.5, 1, 2, 5, 10 min)	All treatments showed lower *P. carotovorum* than inoculated control. Ozone water washed with 2 min showed the lowest *P. carotovorum.*	Hassenberg et al., 2008
2	Lettuce	(1) low concentration electrolyzed water (LcEW), (2) sonication, (3) LcEW + sonication, (4) LcEW - sonication, (5) sonication – LcEW with 1, 3 and 5 min	Sonication performed lower log reduction than other treatments. Moreover, 1 min showed the lowest log reduction.	Forghani et al., 2013
3	Cherry tomato	(1) Control, (2) 150 ppm NaOCl 10 minutes, (3) 1 ppm ClO_2 gas 6 hours, (4) 1 ppm ClO_2 gas 12 hours, (5) 1 ppm ClO_2 gas 24 hours, (6) 5 ppm ClO_2 gas 6 hours and (7) 5 ppm ClO_2 gas 12 hours with MAP	All treatments exhibited lower fungal incidence than control. The 5 ppm ClO_2 gas 12 hours effectively suppressed the *Botrytis cineria*.	Islam et al., 2017
4	Blueberry	**chitosan (a):**(1) Uncoated control (C), (2) chitosan (CH), (3) CH plus inulin (CH-IN), (4) CH plus oligo fructose (CH-OL), (5) CH plus apple fiber (CH-AF), (6) CH plus orange fiber (CH-OF).	**chitosan (a):** CH coatings (regardless of fiber addition) greatly controlled mesophilic bacteria and yeasts/molds growth	Alvarez et al., 2018
		sodium alginate-based coatings (b): Alginate (AL), AL plus IN (AL-IN), AL plus OL (AL-OL), AL plus AF (AL-AF), AL plus OF (AL-OF)	**sodium alginate-based coatings (b):** OL and OF added to CH had a positive effect on the nutritional and microbiological quality of treated fruits.	
5	Cherry tomato	(1) water (distilled water as a control, pH 7.0); (2) acidic electrolyzed water (AcEW 32 mg L^{-1}, pH 2.6); (3) hydrogen peroxide (5 mg L^{-1} H_2O_2, pH 6.3); (4) ozone water (5 mg L^{-1} O_3, pH 6.4); and (5) sodium hypochlorite (150 mg L^{-1} NaClO, pH 9.3).	All treated tomato fruits showed lower bacteria, coliform, fungi and yeast spores compared with control. Fungal incidence and microbial activity were the lowest in O_3-treated tomato fruits.	Islam et al., 2018c

2. Different techniques and treatments

2.1. Acidic electrolyzed oxidizing water

Acidic electrolyzed oxidizing water (pH 2.06) and chlorine (37.50 ± 2.5 ppm) for sanitizing for 3 min reduced the numbers of *E. coli* O157:H7, *L. monocytogenes*, and *S. typhimurium* in fresh-cut onions (Park et al., 2008). Moreover, combined alkaline electrolyzed water and 1% citric acid at 50 °C reduced *L. monocytogenes* and *E. coli* O157:H7 in carrots (Rahman et al., 2011). According to Islam et al. (2018c), adding 32 mg L^{-1} of acidic electrolyzed water to cherry tomatoes before harvesting cut down on the growth of fungus, bacteria, coliforms, and yeast.

2.2. Chitosan

Chitosan (CH), found in shrimp and crustacean shells, is a linear polysaccharide formed with β-(1→4)-linked D glucosamine (deacetylated unit) and N-acetyl-D glucosamine (acetylated unit). CH is an important coating material for fresh produce due to its antimicrobial activity and functional ingredients (Alvarez et al., 2018). They mentioned that chitosan coating (with and without fibers) inhibited mesophilic bacterial and yeast/mold growth, increased antioxidants, retained firmness, reduced decay, decreased off-odor development, and improved overall visual quality as well as the shelf life of blueberries. The CH coating maintained freshness by improving the internal and external quality of fruits, which is needed to extend their shelf life and satisfy consumers. Moreira et al. (2011) mentioned that CH coating reduced total mesophilic and psychrotrophic bacteria during storage in broccoli. They also mentioned that CH coating has a bactericidal effect on *E. coli* and inhibits the growth of total coliform during storage. In strawberries, CH coating reduced the decay and maintained the anthocyanin, antioxidant, ascorbic acid, enzyme activity, flavonoids, phenolic, oxygen radical absorbance capacity, and hydroxyl radicals (Wang & Gao, 2013). In addition, the CH coating extended the shelf life of strawberries by maintaining quality and controlling decay.

2.3. Chlorine (ClO_2) gas

Chlorine (ClO_2) gas is an oxidizing agent with strong antimicrobial properties that is effective against a wide range of pHs and is a strong biocidal compound that eliminates bacteria, fungi, yeasts, and molds. Pao et al. (2007) reported that ClO_2 (20 ppm for 1 min) is needed for a 5-log reduction in Salmonella enterica inoculated on tomatoes. Gómez-López et al. (2007) mentioned that for a 2-log reduction in the mesophilic counts of carrots, 1.3 ppm ClO_2 gas for 30 s is needed. The ClO_2 gas (5 ppm for 12 hours) is effective against *Botrytis cinerea* of cherry tomatoes (Islam et al., 2017).

2.4. Hydrogen peroxide (H_2O_2)

Hydrogen peroxide (H_2O_2) is effective against *Staphylococcus aureus* and *Pseudomonas aeruginosa* (Tote et al., 2010). Islam et al. (2018c) found that H_2O_2 (5 mg L-1, pH 6.3) effectively suppressed the bacteria, viruses, molds, and yeasts of cherry tomatoes in pre-harvest treatment. The effectiveness of H_2O_2 is shown by damaging bacterial cell membranes, DNA, and proteins (Martin & Maris, 2012). There is no residue in H_2O_2, but phytotoxicity happens in lettuce and berries (Olmez & Kretzschmar, 2009). They also mentioned that H_2O_2 increased browning in lettuce and mushrooms.

2.5. Proper modified atmosphere packaging (MAP)

The MAP prolongs the shelf life by maintaining the O_2 and CO_2 composition surrounding the products (Kurubas et al., 2018). Proper MAP is conditioned to balance the atmosphere to maintain the quality of fruits and vegetables (Islam et al., 2014; Mele et al., 2017; Islam et al., 2017). Gomes et al. (2011) mentioned that the irradiation sensitivities of organisms (*Salmonella* spp. and *Listeria* spp.) increased with increased oxygen in packages. Oxygen permeability film 20,000 cc showed the highest quality for cherry tomatoes for long-term storage (Islam et al., 2014; Islam et al., 2017).

2.6. Sodium hypochlorite (NaOCl)

Sodium hypochlorite (NaOCl, 100 ppm for 10 min) reduced *L. monocytogenes* in cherry tomatoes, cucumbers, and carrots (Kwon et al., 2011). They also mentioned that NaOCl (100 ppm for 10 min) effectively reduced *S. typhimurium* but had no effect on cucumber or carrot. The pre-harvest application of NaOCl (150 ppm for 10 min) reduced bacterial and fungal contamination in a cherry tomato (Islam et al., 2018c). The byproducts of NaOCl, such as chloroform and haloacetic acid, have mutagenic and carcinogenic effects on human health (Hrudey, 2009).

2.7. Organic acids

A different type of organic acid (1% acetic acid, ascorbic acid, citric acid, and lactic acid) had antimicrobial activity against *E. coli* and *L. monocytogenes* of iceberg lettuce (Akbas & Ölmez, 2007). The *E. coli* O157: H7, *S. typhimurium*, and *L. monocytogenes* in apple, pear, and melon juices are inactivated by malic acid (Raybaudi-Massilia et al., 2009). Fresh-cut apples were washed with 20 ppm peroxyacetic acid for 1 minute to reduce *E. coli* O157:H7 and *L. innocua* (Abadias et al., 2011).

2.8. Gaseous ozone

Najafi & Khodaparast (2009) reported that gaseous ozone (5 ppm for 60 min) reduced *E. coli* and *Staphylococcus aureus* on date fruits. Low concentration (1–5 ppm) for a short duration (1–5 min) is effective against bacteria, molds, and yeast (Olmez & Kretzschmar, 2009). Islam et al. (2018c) reported that ozone water (5 mg L-1, pH 6.4) as a pre-harvest treatment suppressed the maximum fungal incidence of bacteria, coliforms, fungus, and yeast in cherry tomatoes and during inactivation for the ozone attack on the cell wall components to oxidize the pathogens. Ozone water (20 °C for 10 days) effectively inactivated *Pectobacterium carotovorum* (soft rot) on the carrot (Hassenberg et al., 2008). In the near future, most of the industry will start using a chemical-free technique for microbial quality to produce safe fruits, vegetables, and cereals.

2.9. Neem oil (*Azadirachta indica*) and Trichoderma

Neem oil (*Azadirachta indica*) and Trichoderma are used to control the fungal incidence of different fruits and vegetables. For example, *Aspergillus niger*, *Botrytis cinerea*, *Cladosporium* sp., *Fusarium* sp., and *Penicillium* sp. were less common when there was more neem oil (Islam et al., 2018e). Neem oil attacked the fungal pathogen's cell wall (Mahmoud et al., 2011) as it contained desactylimbin, quercetin, and sitosterol (Singh et al., 1980). Moreover, they also mentioned the *in vitro* antagonistic activity of *Trichoderma* sp. against fungal species. The highest sensitivity against the tested bacterial strains (*Rahnella aquatilis*, *Microbacterium oxydans*, *Pseudomonas panacis*, *Gordonia sputi*, and *Escherichia coli*) was achieved by cefatazidime (30 µg), ciprofloxacin (5 µg), and octafloxacin (5 µg) (Islam et al., 2018e). The lytic enzymes in Trichoderma break down the phytopathogenic fungal cell wall (Harman et al., 2008). *Trichoderma harzianum*, *Fusarium oxysporum,* and *A. pullulans* have also produced volatile antifungal substances (Mari et al., 2012) that are used as a bio-fumigant (Spadaro & Droby, 2016). The percentage and zone of inhibition were highest against *Aspergillus niger* in Trichoderma treatment (Islam et al., 2018e).

2.10. Hot water treatment

During cold storage, apple fruit develops green mold (*Penicillium expansum*), grey mold (*Botrytis cinerea*), bitter rot (*Colletotrichum* spp.), and bull's eye rot (*Neofabraea* spp.) (Grantina-Ievina, 2015). Hot water treatment (45 ^{o}C for 10 min) of apple fruit against *Botrytis cinerea*, *Colletotrichum acutatum*, and *Neofabraea vagabunda* is more effective than control (crude protein extracts from untreated apple fruits) or distilled water (Francesco et al., 2018). Hot water reduces decay and protects the pathogens of peach and citrus by increasing their defense mechanisms against pathogens (Ballester et al., 2010; Liu et al., 2012).

2.11. Ultraviolet (UVc) irradiation

Ultraviolet (UVc) irradiation is well-known to reduce microbial activity and is widely used for air disinfection as well as the control of microorganisms during the packing and storage of fruits, vegetables, and cereals (Begum et al., 2009). According to wavelength, within the UV light lies UVA (320–400 nm), UVB (280–320 nm), UVC (200–280 nm), and UVV (100–200 nm) (Guerrero-Beltrán & Barbosa-Cánovas, 2004). UVC (250–260 nm) is lethal to algae, bacteria, fungi, protozoa, yeast, and viruses and good for disinfecting water (Begum et al., 2009). The UVC (254 nm) light attacks microorganisms by the physical shifting of electrons and breaking of bonds in deoxyribonucleic acid (DNA), causing microorganisms to lose their activity (Lopez-Malo & Palou, 2005). Some researchers mentioned that they inactivate the microorganisms in different fruits, vegetables, and cereals. For instance, *Botrytis cinerea* (1.00 Jcm^{-2}) and *Monilinia fructigena* (0.50 Jcm^{-2}) are inactivated in strawberries and cherries (Marquenie et al., 2002). Based on dose and exposure time, the UV irradiation (254 nm, UVC) was more effective to inactivate *Aspergillus flavus*, *Aspergillus niger*, *Penicillium corylophilum*, and *Eurotium rubrum* (Begum et al., 2009).

2.12. Plasma treatment

Plasma treatment is used to inactivate microbial contamination at low temperatures, mainly in the surface areas of fruits, vegetables, and cereals. Electrical, thermal, optical (UV light), radioactive (gamma radiation), and X-ray electromagnetic radiation can generate energy that can ionize the gases (Schluter et al., 2013; Pankaj et al., 2018). This type of treatment is used as an alternative to chemical (chlorine treatment) or physical methods (high pressure, pulsed electric fields, and ionizing irradiation) (Schluter et al., 2013). They also mentioned that plasma is a gas containing free electrons, ions, and neutral particles and consists of two types: thermal and non-thermal plasma. The non-thermal or cold plasma treatment is used to inactivate the microorganisms in fruits, vegetables, and cereals. The non-thermal plasma effectively reduces the *Salmonella stanley* and *E. coli* O157:H7 in apples and almonds (Deng et al., 2007; Niemira & Sites, 2008).

3. Conclusion and future perspective

Over the past 20 years, there has been an increasing public discussion on the quality and safety of fresh produce. The consumer's awareness of fresh produce contamination heightened as a result of the foodborne illness outbreak. Consumers desire to guarantee the health advantages, food safety, and utmost quality of fresh goods. Hence, people want a fresh product that is devoid of pests. The quality of fresh produce relies on appropriate handling and processing. Consequently, uncontaminated products are more favored than contaminated ones due to their superior quality. Furthermore, additional research is required to establish uniform standards for the safety of fresh produce.

Conflicts of interest. The authors mentioned that none of them have a conflict of interest when it comes to this article.

ORCID

Chadni Akter: https://orcid.org/0000-0001-8971-8905
Alfi Shahrin: https://orcid.org/0000-0003-2116-8171
Purnima Das: https://orcid.org/0000-0002-3305-5708
Mahmuda Akter Mele: https://orcid.org/0000-0002-7886-1228
Ho-Min Kang: https://orcid.org/0000-0003-1703-4699
Young-Tack Lee: https://orcid.org/0000-0001-7233-6126
Mohammad Zahirul Islam: https://orcid.org/0000-0001-7688-463X

References

Abadias, M., Alegre, I., Usall, J., Torres, R. & Viñas, I. (2011). Evaluation of alternative sanitizers to chlorine disinfection for reducing foodborne pathogens in fresh-cut apple. Postharvest Biology and Technology, 59, 289-297.

Akbas, M.Y. & Ölmez, H. (2007). Effectiveness of organic acid, ozonated water and chlorine dippingson microbial reduction and storage quality of fresh-cut iceberg lettuce. Journal of the Science of Food and Agriculture, 87, 2609-2616.

Alvarez, M.V., Poncea, A.G. & Moreira, M.R. (2018). Influence of polysaccharide-based edible coatings as carriers of prebiotic fibers on quality attributes of ready-to-eat fresh blueberries. Journal of the Science of Food and Agriculture, 98, 2587-2597.

Ballester, A.R., Izquierdo, A., Lafuente, M.T. & Gonzale-Candelas, L. (2010). Biochemical and molecular characterization of induced resistance against *Penicillium digitatum* in citrus fruit. Postharvest Biology and Technology, 56, 31-38.

Begum, M., Hocking, A.D. & Miskelly, D. (2009). Inactivation of food spoilage fungi by ultra violet (UVC) irradiation. International Journal of Food Microbiology, 129, 74-77.

Delbeke, S., Ceuppens, S., Jacxsens, L. & Uyttendaele, M. (2015). Survival of *Salmonella* and *Escherichia coli* O157: H7 on strawberries, basil, and other leafy greens during storage. Journal of Food Protection, 78(4), 652-660.

Deng, S., Ruan, R., Mok, C.K., Huang, G., Lin X. & Chen P. (2007). Inactivation of *Escherichia coli*on almonds using nonthermal plasma. Journal of Food Science, 72(2), M62-M66.

Forghani, F., Rahman, S., Park, M.-S., Park, J.-H., Park, J., Song, K.-B., et al. (2013). Ultrasonication enhanced low concentration electrolyzed water efficacy on bacteria inactivation and shelf life extension on lettuce. Food Science and Biotechnology, 22(1), 131-136.

Francesco, A.D., Mari, M. & Roberti, R. (2018). Defense response against postharvest pathogens in hot water treated apples. Scientia Horticulturae, 227, 181-186.

Gomes, C., Moreira, R.G. & Castell-Perez, E. (2011). Radiosensitization of *Salmonella* spp. and *Listeria* spp. in ready-to-eat baby spinach leaves. Journal of Food Science, 76, E141-E148.

Gómez-López, V.M., Devlieghere, F., Ragaert, P. & Debevere, J. (2007). Shelf-life extension of minimally processed carrots by gaseous chlorine dioxide. International Journal of Food Microbiology, 116, 221-227.

Grantina-Ievina, L. (2015). Fungi causing storage rot of apple fruit in integrated pest management system and their sensitivity to fungicides. Rural Sustainability Research, 34(329), 1-11.

Guerrero-Beltrán, J.A. & Barbosa-Cánovas, G.V. (2004). Advantages and limitations on processing foods by UV light. Food Science and Technology International, 10, 137-147.

Harman, G.E., Björkman, T., Ondik, K. & Shoresh, M. (2008). Changing paradigms on the mode of action and uses of *Trichoderma* spp. for biocontrol. Outlooks on Pest Management, 19, 24-29.

Hassenberg, K., Fröhling, A., Geyer, M., Schlüter, O. & Herppich, W. (2008). Ozonated wash water for inhibition of *Pectobacterium carotovorum* on carrots and the effect on the physiological behaviour of produce. European Journal of Horticultural Science, 73(1), S.37-42.

Hrudey, S.E. (2009). Chlorination disinfection by-products, public health risk tradeoffs and me. Water Research, 43(8), 2057-2092.

Islam, M.Z., Mele, M.A., Lee, H.J., Lee, K.S., Hong, S.M., Jeong, M.J., et al. (2014). Selection of non-perforated breathable film to enhance storability of cherry tomato for modified atmosphere storage at different temperatures. Protected Horticulture and Plant Factory, 23,116-122.

Islam, M.Z., Mele, M.A., Park, J.M., Kim, I.S. & Kang, H.M. (2017). Chlorine dioxide gas retain postharvest quality and shelf life of tomato during modified atmosphere packaging storage. AGRIVITA- Journal of Agricultural Science, 39(3), 233-238.

Islam, M.Z., Mele, M.A., Hussein, K.A. & Kang, H.M. (2018c). Acidic electrolyzed water, hydrogen peroxide, ozone water and sodium hypochlorite influenced quality, shelf life and antimicrobial efficacy of cherry tomatoes. Research Journal of Biotechnology, 13(4), 51-55.

Islam, M.Z., Mele, M.A., Hussein, K.A., Joo, J.H. & Kang, H.M. (2018e). The effects of antibiotics, neem oil and *Trichoderma* on spoilage bacteria and fungi of cherry tomatoes. Journal of Hygienic Engineering Design, 23, 15-20.

Kurubas, M.S., Maltas, A.S., Dogan, A., Kaplan, M. & Mustafa, E. (2018). Comparison of organically and conventionally produced Batavia type lettuce stored in modified atmosphere packaging for postharvest quality and nutritional parameters. Journal of the Science of Food and Agriculture, 99(1), 226-234.

Kwon, K.Y., Kang, K.A. & Yoon, K.S. (2011). Effects of sodium hypochlorite and acidified sodiumchlorite on the morphological, microbiological, and sensory qualities of selected vegetables. Food Science and Biotechnology, 20(3), 759-766.

Liu, J., Sui, Y., Wisniewski, M., Droby, S., Tian, S., Norelli, J., et al. (2012). Effect of heat treatment on inhibition of *Monilinia fructicola* and induction of disease resistance in peach fruit. Postharvest Biology and Technology, 65, 61-68.

Lopez-Malo, A. & Palou, E. (2005). Ultraviolet light and food preservation. In: Barbosá-Cánovas, G. V., Tapia, M.S. & Cano, M.P. (Eds.). Novel Food Processing Technologies. CRC Press, Boca Raton, F.L., pp. 405-421.

Mahmoud, D.A., Hassanein, N.M., Youssef, K.A. & Zeid M.A.A. (2011). Antifungal activity of different neem leaf extracts and the nimonol against some important human pathogens. Brazilian Journal of Microbiology, 42, 1007-1016.

Mari, M., Martini, C., Spadoni, A., Rouissi, W. & Bertolini, P. (2012). Biocontrol of apple postharvest decay of *Aureobsidium pullulans*. Postharvest Biology and Technology, 73, 56-62.

Marquenie, D., Lammertyn, J., Geeraerd, A.H., Soontjens, C., Van Impe, J.F., Nicolai, B.M., et al. (2002). Inactivation of conidia of *Botrytis cinerea* and *Monilinia fructigena* using UV-C and heat treatment. International Journal of Food Microbiology, 74, 27-35.

Martin, H. & Maris, P. (2012). Synergism between hydrogen peroxide and seventeen acids against sixbacterial strains. Journal of Applied Microbiology, 113(3), 578-590.

Mele, M.A., Islam, M.Z., Baek, J.P. & Kang, H.M. (2017). Quality, storability, and essential oil content of *Ligularia fischeri* during modified atmosphere packaging storage. Journal of Food Science and Technology, 54(3), 743-750.

Moreira, M.R., Roura, S.I. & Ponce, A. (2011). Effectiveness of chitosan edible coatings to improve microbiological and sensory quality of fresh cut broccoli. LWT- Food Science and Technology, 44, 2335-2341.

Najafi, M.B.H. & Khodaparast, M.H.H. (2009). Efficacy of ozone to reduce microbial populations in date fruits. Food Control, 20, 27-30.

Niemira, B.A. & Sites, J. (2008). Cold plasma inactivates *Salmonella stanley* and *Escherichia coli* O157:H7 inoculated on golden delicious apples. Journal of Food Protection, 71, 1357-1365.

Oliveira, M., Usall, J., Viñas, I., Anguera, M., Gatius, F. & Abadias, M. (2010). Microbiological quality of fresh lettuce from organic and conventional production. Food Microbiology, 27(5), 679-684.

Olmez, H. & Kretzschmar, U. (2009). Potential alternative disinfection methods for organic fresh-cut industry for minimizing water consumption and environmental impact. LWT- Food Science and Technology, 42, 686-693.

Pankaj, S.K., Wan, Z. & Keener, K.M. (2018). Effects of Cold Plasma on Food Quality: A Review. Foods, 7(4), 1-21.

Pao, S., Kelsey, D.F., Khalid, M.F. & Ettinger, M.R. (2007). Using aqueous chlorine dioxide to prevent contamination of tomatoes with *Salmonella enteric* and *Erwinia carotovora* during fruit washing. Journal of Food Protection, 70, 629-634.

Park, E.J., Alexander, E., Taylor, G.A., Costa, R. & Kang, D.H. (2008). Fate of food borne pathogens on green onions and tomatoes by electrolysed water. Letters in Applied Microbiology, 46, 519-525.

Rahman, S.M.E., Jin, Y.-G. & Oh, D.-H. (2011). Combination treatment of alkaline electrolyzed water and citric acid with mild heat to ensure microbial safety, shelf-life and sensory quality of shredded carrots. Food Microbiology, 28, 484-491.

Rahman, S.M.E., Park, J.H., Wang, J. & Oh, D.-H. (2012). Stability of low concentration electrolyzed water and its sanitization potential against food borne pathogens. Journal of Food Engineering, 113, 548-553.

Rahman, S.M.E., Khan, I. & Oh, D.H. (2016). Electrolyzed water as a novel sanitizer in the food industry: current trends and future perspectives. Comprehensive Reviews *in* Food Science *and* Food Safety, 15, 471-490.

Raybaudi-Massilia, R.M., Mosqueda-Melgar, J. & Martín-Belloso, O. (2009). Antimicrobial activity of malic acid against *Listeria monocytogenes*, *Salmonella enteritidis* and *Escherichia coli* O157: H7 in apple, pear and melon juices. Food Control, 20(2), 105-112.

Sanders, S.Q., Boothe, D.H., Frank, J.F. & Arnold, J.W. (2007). Culture and detection of *Campylobacter jejuni* within mixed microbial populations of biofilms on stainless steel. Journal of Food Protection, 70(6), 1379-1385.

Schluter, O., Ehlbeck, J., Hertel, C., Habermeyer, M., Roth, A., Engel, K. -H., et al. (2013). Opinion on the use of plasma processes for treatment. Molecular Nutrition & Food Research, 57, 920-927.

Singh, U.P., Singh, H.B. & Singh, R.B. (1980). The fungicidal effect of neem (*Azadirachta indica*) extracts on some soil borne pathogens. Mycologia, 7, 1077-1093.

Spadaro, D. & Droby, S. (2016). Development of biocontrol products for postharvest diseases of fruit: The importance of elucidating the mechanisms of action of yeast antagonists. Trends in Food Science and Technology, 47, 39-49.

Tango, C.N., Choi, N.-J., Chung, M.-S. & Oh, D.H. (2014). Bacteriological quality of vegetables from organic and conventional production in different areas of Korea. Journal of Food Protection, 77(8), 1411-1417.

Tote, K., Horemans, T., Berghe, D.V., Maes, L. & Cos, P. (2010). Inhibitory effect of biocides on the viable masses and matrices of *Staphylococcus aureus* and *Pseudomonas aeruginosa* biofilms. Applied and Environmental Microbiology, 76(10), 3135-3142.

Velusamy, V., Arshak, K., Korostynska, O., Oliwa, K. & Adley, C. (2010). An overview of food borne pathogen detection: In the perspective of biosensors. Biotechnology Advances, 28(2), 232-254.

Wang, S.Y. & Gao, H. (2013). Effect of chitosan-based edible coating on antioxidants, antioxidant enzyme system, and postharvest fruit qualityof strawberries (*Fragaria*x *aranassa* Duch.). LWT- Food Science and Technology, 52, 71-79.

Weagant, S.D. (2008). A new chromogenic agar medium for detection of potentially virulent *Yersinia enterocolitica.* Journal of Microbiological Methods, 72(2), 185-190.