Alternative methods to control and prevent escherichia coli o157:h7 growth on fre...

Abstract: Postharvest washing has been and remains the most common method of prevention and control of Pathogenic organism found on and within fresh-cut produce. With pressing concern for both the environment and consumption of products undergoing disinfectants such as chlorine, many countries are searching for more effective and cost efficient methods to prevent the colonization of pathogenic organisms such as *Escherichia coli* O157: H7 [1]. In this review, I will be analyzing the current methodology of controlling and preventing *E. coli* O157: H7 growth on fresh-cut produce, and how alternative decontaminating research like oxidizing water, ozone microbubble water, and pulsed UV-light have potential to better prevent both economical loss and cross-contamination.

Keywords: *Escherichia coli* O157: H7; decontamination; Postharvest washing; Fresh-cut produce

1. Introduction

Escherichia coli is a Gram-negative, facultative anaerobic bacterium that has been a persistent concern in the fresh-cut produce industry [2]. While most strains of *Escherichia coli* (*E. coli)* are harmless to humans, strains such as *E. coli O157: H7* contain pathogenic functions that cause foodborne illnesses [2]. These functions are known as virulence factors, which are anything an organism uses to cause disease, invade hosts, and resist host defense [3]. *E. coli* O157: H7's invasive nature allows the bacterium to survive in a multitude of environments including soil, water, food, and animal reservoirs [2]. Cattles, for example, naturally contain *E. coli* O157: H7 within their gastrointestinal tracts [2]. Furthermore, *E. coli* O157: H7 can adapt to extreme changes in temperature and pH making it increasingly difficult to control with the current methods of prevention [2].

1. 1 Postharvest washing

The most popular method of preventing the colonization of *E. coli* O157: H7 in fresh produce is known as postharvest washing. The outcome of this process is to provide an efficient way to obtain high value produce without contamination [4]. The process serves two primary functions. The first of which is to remove any soil or debris obtained from harvest, and the second is to remove/reduce any field-acquired contamination that may be present [5, 6].

When postharvest washing was first developed, producers believed the methods and sterilizers completely removed field-acquired contamination [4, 5]. When produce was inoculated with high levels of pathogenic microbes in a controlledenvironment, the results showed a 5 log CFU/mL reduction of microorganisms [1, 4]. However, when eventually observed in commercial conditions—the actual log reduction was shown to only be 1-2 log CFU/mL regardless of the sanitizers applied [1, 4]. Furthermore, research indicated that postharvest washing focused on only eliminating contamination on the surface of produce and had difficulty eliminating the colonization of *E. coli* O157: H7 and other microorganisms that may be found *inside* the product [4]. For example, when *E. coli* O157: H7 is colonized within plants such as the stoma and internal crevices, the effectiveness of sanitizers is eliminated, because vegetables contain extremely hydrophobic surfaces making it difficult for decontamination to penetrate the skin of plants [1, 4]. This has resulted in many facilities limiting the use of commercial sanitizers and looking for alternative methods of control.

As research continues to be conducted on the efficacy of postharvest washing, many trusted sterilizers such as hypochlorite (chlorine) are imposing both environmental and health concerns [1, 5]. For example, hypochlorite forms what is known as disinfection byproducts (DBP) due to its rapid reactions when in contact with organic matter [1, 4]. These byproducts have been shown to be carcinogenic to human health and lower the antimicrobial activity of hypochlorite by exhausting free chlorine concentrations [1, 4]. Because of this, many European countries such as Germany, Switzerland, and Belgium prohibit the use of chlorine in food processing facilities [1].

1. 2 Seeking an alternative

According to The Center for Disease Control and Prevention (CDC), fresh produce remains the leading cause of foodborne illness in the United States [6]. More specifically, the current prevention methods to inhibit the colonization of *E. coli* O157: H7 continue to cause great economic loss due to hospital visitation averaging around 400 million dollars a year [7]. While *E. coli* O157: H7 cases in the United States may be lower than other foodborne pathogens, statistics show the pathogenic bacteria has much higher hospitalization and death rates than other organisms such as *Salmonella* [2, 6]. Furthermore, the purpose of this review is to analyze current research involving promising alternative decontamination methods to prevent the colonization of *E. coli* O1157: H7 and provide further insight in the potential future of freshly-cut produce sterilization.

2. Alternative decontamination methods

One of the biggest imposing problems with the current methods of preventing *E. coli* O157: H7 colonization is the plethora of variables to consider when sanitizing freshly-cut produce. Although hypochloriteis cost efficient, easy to apply, and greatly resistant to microbial growth—its spontaneous tendencies to produce DBP, and its inability to efficiently keep wash water sterile has undermined its ability to rapidly inactivate microorganisms such as *E. coli* O157: H7 [1]. For example, hypochlorite must have certain levels of free-chlorine concentration to be effective in keeping wash tanks sterile which imposes great challenge and costs beyond the initial use of the product [4].

2. 1 Neutral electrolyzed oxidizing water

With fresh-cut produce being the leading cause of foodborne illness, there has been a push to develop new sanitation methods to not only eliminate pathogenic organisms on the surface of foods but also on the surfaces of which they are washed to prevent cross-contamination [4, 5]. Neutral electrolyzed oxidizing water (EO water) shows promise with its ability to sanitize a diversity of pathogenic organisms while also being environmentally efficient [8]. EO water is created by passing a ϟ1% NaCl solution through an electrochemical cell [8]. By passing an electric current through the cell, the negative chloride ions are met with an abundance of oxygen ions helping facilitate the conversion of water molecules into chlorine oxidants [8]. The use of near-neutral pH solutions is being researched because high acidic levels limit the long-term use of EO water because of the rapid loss of Cl_2 gas at pH levels of 3 or below [8]. Cl_2 gas is vital component in helping facilitate the decontamination of wash tanks and prevent corrosion of washing areas [4].

In a controlled experiment, researchers observed the effectiveness of both the inactivation and reduction of *E. coli* O157: H7 and other pathogenic foodborne bacteria using near-neutral EO water [8]. *In vitro* Guentzel *et al.* concluded that in E. coli O517: H7 concentrations of 20, 50, and 100—bacterial reduction coupled with 120 ppm of total residual chlorine (TRC) showed a 100% reduction of E. coli O157: H7 [8]. As far as environmental conditions, the pure cultures were held at a temperature of 25°C and a near-neutral pH of 6. 3-6. 5 [8]. To further examine the effectiveness of electrolyzed oxidizing water, Guentzel *et al.* tested its efficacy on lettuce and spinach leaves as well as food processing surfaces [8]. Both results show reduction in the presence of E. coli O157: H7, however due to the limited experimentation done on near-neutral EO water, inactivation efficacy cannot be fully determined [8].

2. 2 Stable ozone microbubble water

Another potential method in preventing the growth of E. coli O157: H7 on the surface of freshly cut produce and food processing equipment is the use of stable ozone microbubble water (OMBW) [9]. Over the past decade, research has been conducted on the use of Ozone (O_3), a highly effective antimicrobial compound, as an alternative sanitizer to chlorine [9]. it can damage both gram-positive and gram-negative cell walls allowing it to destroy exposed bacteria of interest [9]. However, due to its high oxidative activity, it decomposes into a non-toxic product in an exponential rate giving the compound a short half-life of 1-10 minutes when in water [9]. With this said, research shows that when ozone water (OW) is used to control the growth of E. coli O157: H7, it yields more than a 5. 0 Log CFU/mL Bacterial reduction [9]. In recent developments to help stabilize ozone in the form of 10μm in diameter microbubbles, researchers developed a solution that can extend the shelf-life of aqueous ozone from 10 minutes to several months [9]. In the past, ozone was too spontaneous in the decomposition of free-chlorine concentration [9]. The development of OMBW, allows ozone to stay effective longer and inactivate E. coli O157: H7 and other pathogenic bacteria that may be found on fresh produce [9].

In an experiment conducted by Inatsu *et al.,* they observed the effectiveness of ozone microbubble water sanitizer on reducing and eliminating the growth of 13 pathogenic organisms, including *E. coli* O157: H7 *in vitro* [9]. After 3 minutes of exposure, E. coli O157: H7 had a 7. 4 log CFU/mL reduction of viable cells at a temperature of 25°C in a 5. 44 mg/L O_3 concentration [9]. While *in vitro* performance of OMBW seems promising, to further observe the efficacy of the ozone solution, research has beenconducted on vegetables and fruits showing a reduction of E. coli O157: H7 [9]. However, the inactivation efficacy of OBMW cannot be determined officially until further experimentation is conducted [9]. Ozone remains one of the most efficient/effective sanitizers known of today and has a significantly lower chance of producing DBP compared to hypochlorite.

2. 3 Pulsed UV-Light

Pulsed UV-light has been observed recently with its effectiveness to inactivate foodborne microorganisms of which include E. coli O157: H7 [10]. Pulsed light can deliver a wide range of electromagnetic radiation ranging from 200 nm up to 1100 nm flashes that can inactivate 1—3 log CFU/g reduction [4]. However, working with light has shown to reduce the inactivation by 1 log CFU/g on objects that are uneven such as blueberries and cantaloupe due to its inability to penetrate shaded areas on produce surface [4]. The use of pulsed UV-light has promising applications by eliminating the use of water, which could in turn prevent cross-contamination [4]. At around 270 nm, pulsed UV-light showed high efficiency in inactivating *E. coli* [10]. In an experiment conducted on the inactivation of pulsed UV-light on blueberries, the results show that with an 8 cm distance from the fruit there was no observable damage to its wall structure and reduced E. coli O1157: H7 by 1. 1—2. 9 log CFU/g [10]. With this said, there is still plenty of research to be conducted on the use and health implications of using pulsed UV-light. However, its ability to not only destroy surface level bacteria but sub-surface level as well imposes great potential in its future usage.

3. Conclusion

E. coli O157: H7 continues to impose threat in the processing and decontamination of fresh produce. Further experimentation on the use of more multipurpose disinfectants could eliminate costs and potential for cross-contamination. Research is beginning to be conducted on the combination of both UV-light as well as surface level disinfectants to in turn potentially provide evidence towards complete sanitation of field-acquired microorganisms. While postharvest washing remains the most commonly used method of fresh produce decontamination, the need for more versatile and less harmful disinfectants imposes a great push for an eco-friendly yet healthy alternative to DBP producing agents.

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