International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-8, Issue-7, July 2022
ISSN: 2395-3470
www.ijseas.com

Surface Sterilization System Using UV-C Light: A Review

D. Kosale[1], Shivashish Shukla[2], Anand Krishna Shukla[3]

ABSTRACT

The purpose of this research is to examine the efficiency of portable chambers for UV disinfection and the safe reuse of personal protective equipment (PPE). Single-use PPE supplies can quickly decrease during unexpected periods of increased demand for PPE, such as during the corona virus disease 2019 (COVID-19) pandemic caused by the severe acute respiratory syndrome corona virus 2 (SARS-CoV-2).Viruses and other Pathogenic microbes are spread through contacting surfaces to the environment, which is need to be sanitized for the prevention of viruses and germs and sanitization is to be done timely. UV light has been demonstrated to have high effectiveness in disinfecting materials. The design and construction of two 280 nm ultraviolet-C (UV-C) disinfection chambers in the form of portable chambers with internal dimensions of 46 cm x 46cm x 46cm one utilizing light-emitting diodes and the other using mercury vapor lamps are described in this study. The use of a UV-reflective, porous poly tetra fluoro ethylene (PTFE) material to boost the homogeneity and overall intensity of UV-C radiation within the chambers is also discussed in this work. The prototype code for a calculator prototype that calculates the decrease of SARS-CoV-2 as a result of UV-C disinfection is also supplied. The report discusses the UV-C radiation sources that were chosen for the chambers and the mechanical and electrical design of the chambers, PTFE installation, testing, and safety issues. Also, the review paper discusses the merits and demerits of UV-C light and its effect on human bodies.

Key words: disinfection; LEDs; light-emitting diodes; mercury vapor lamps; prototype; PTFE; ultraviolet; ultraviolet-C; UV-C

1 INTRODUCTION

Viruses and germs are spread in the Environment that caused harm to the ecosystem. Fruits and vegetables are essential components of a well-balanced diet. Their sufficient daily consumption may be able to help you avoid common illnesses such as cardiovascular disease and some malignancies [1]. According to a report published in 2004 by the World Health Organization/Food and Agriculture Organization (WHO/FAO), at least 400 g of fruits and vegetables per day, excluding potatoes and other starchy tubers, are recommended for the prevention of chronic illnesses such as coronary heart disease, most cancers, diabetes, and weight problems, as well as the prevention and treatment of numerous micronutrient deficiencies [1]. Whether eaten raw or cooked, culmination and greens should be firm, smooth, and free of pesticides and microorganisms as possible. However, Salmonella, Shigella spp., Campylobacter, Escherichia coli O157:H7, Listeria monocytogenes, Yersinia enterocolitica, Staphylococcus aureus, Clostridium spp., and Bacillus cereus have been linked to common food borne pathogens. The risk of infection from fresh culmination and greens can be reduced or eliminated by decreasing or eliminating exterior surface infection [3, 5]. Because just washing fresh fruit and vegetables with water may not be sufficient to remove

pathogens and other spoilage bacteria [6], various options were investigated. The simple washing of fresh fruit and vegetables with hot water or disinfectant-infused water removes a portion of pathogenic and spoilage bacteria; nevertheless, reductions of 10-fold to 100-fold should be conducted regularly. Traditional disinfectants (chlorine, chlorine dioxide, bromine, iodine, trisodium phosphate, sodium chloride, sodium hypochlorite, acids, hydrogen peroxide, ozone, permanganate salts, and so on.) are effective in warding off pathogens to some extent; however, each disinfectant has a different performance and maximum concentration allowable. Changing environment packaging [12-17], low-temperature storage [17-19], and the use of edible films [20-24] were all attempts to reduce the number of microorganisms on the surface of fresh fruits and vegetables while extending shelf life. These treatments target a specific group of pathogens on the surface of sparkling fruits and greens. As a result, nonselective treatments for pathogen eradication on the surface of sparkling end products and vegetables may be a preferable option. Irradiation of food and the use of germicidal ultraviolet light are two examples of alternate techniques (UV-C).

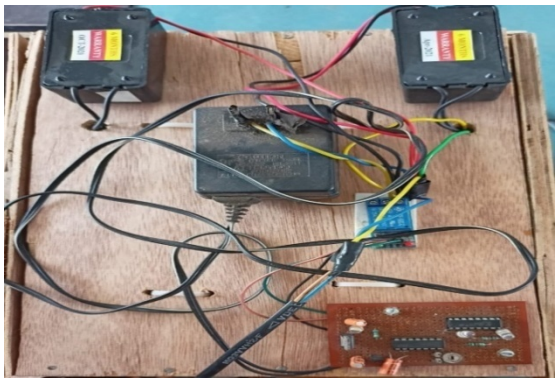

Fig 1. Picture of Model

The purpose of this research is to evaluate the available literature and provide a broad overview of the use of UV light therapy to decontaminate the surface of fresh fruits and vegetables. UV lights are of 3 types: UV-A, UV-B, and UV-C. UV-A has a longer wavelength (varies from 315 nm-400 nm) and this causes retinal diseases. UV-B has a medium wavelength (varies from 280nm-315nm) and causes skin cancer, UV-C has a shorter wavelength (varies from 100nm-280nm) and is useful to kill germs and viruses.

Fig 2. Picture of UV-C Chamber

2. LITERATURE REVIEW:

The utilization of UV-C radiation for food preservation became decided in 1977 when resveratrol and vinifera were generated insource and microorganism types. Self-contained chambers with fluorescent germicidal lamps are common constructions for exposing fruit and vegetables to UV-C radiation, and they have been extensively documented in the literature. However, modifications to classic self-contained chambers have been made to prevent further microbial reductions and preserve a pleasant environment property even at low UV-C radiation doses. Low doses of 0.1-03 kJ/m2 from water-assisted UV-C radiation equipment with pressurized water sprinklers were enough to reduce respiratorily, preserve great, and provoke 0.9–2.0 log CFU/g (log colony-forming unit/g) reductions of Listeria monocytogenes (L. Monocytogenes) and Salmonella enterica (S. enterica) in lettuce and spinach

Current status:- The study revealed that improved efficiency was due to dual irradiation by immersion and simultaneous**[1]** activities of method water from the replacement of standard treatment chambers with pressured water sprinklers.**[2]**confirmed that reducing big versions and increasing UV-C radiation exposure on fruit surfaces in disinfection structures is feasible. This addition to the typical UV-C lamp self-contained chambers ensured dosage homogeneity, resulting in a median dose of 1 kJ/m2 for the fruits, as opposed to 0.2 kJ/m2 for culminating without rotation. In Escherichia coli O157:H7 (E. Coli O157:H7) and E. Coli ATCC 25922, the altered rotation device resulted in 1.3–1.8 and 1.0–1.2 log CFU/fruit reductions, respectively, compared to 0.5–0.7 log CFU/fruit reductions obtained with the original rotation device revealing the significance of dose uniformity for the optimum impact of UV-C radiation in disinfection systems. For cocktail combinations of S. enterica and E. Coli O157:H7 at the surfaces of tomatoes, **[3]** verified that increasing UV-C radiation doses from 0.6 to 6.0 kJ/m2 resulted in 2.2–3.1 and 2.8–3.5 log CFU/fruit discounts, respectively. Under the same conditions, lower reductions of 1.9%–2.8% and 1.7–3.2% log CFU/fruit were reported at the stem scar, demonstrating that the particular location of microorganisms on produce might also impact treatment performance and should be addressed when designing UV-C radiation disinfection systems. Further testing revealed that the increased doses did not affect tomato color or texture. According to **[4],** raising the intensity for a given dosage should enhance the benefits of UV-C radiation. After nine days of storage, only 5 percent of tomatoes irradiated with a greater depth of 33 W/m2 showed instances of postharvest rot caused by Botrytis, compared to 8 percent of tomatoes irradiated with a reduced intensity of 3 W/m2. In contrast, after 5 days, only 12% of strawberries were irradiated with a higher depth verified degradation indications, compared to 46% of strawberries irradiated with a lower depth. The treatment also delayed ripening and kept fruit quality higher, but titratable acidity, soluble solids, and antioxidant qualities were intact.**[5]** used a similar tool to discover that trichomes on peach surfaces and wounds on pears shielded microorganisms from irradiation, even though pear surfaces had a more uniform distribution of microbial cells due to their smaller surface roughness and spreading coefficient than peach surfaces. After four minutes at 7.56 kJ/m2, E. Coli reductions of 3.70 log CFU/g were achieved on intact pear surfaces, with decreasing discounts of 3.10 and 2.91 log CFU/g achieved on damaged pear and peach surfaces,

respectively.**[6]** discovered that a low dose of 0.3 kJ/m2 had no effect on total bacteria quantity and browning-related enzymes of fresh-cut lotus throughout storage and resulted in a high degree of browning, but that a low dose of 1.5–3 kJ/m2 significantly retarded microbial growth and suppressed the sports of browning-related enzymes. Low dosages of zero, according to **[7].**Although 97 kJ/m2 was no longer sufficient to postpone metabolic breakdown in tomatoes, it did result in a 2.1 log CFU/g reduction in mesophilic load, a delay in crimson shade development, and increased firmness and phenolic content material. Variations in findings might be related to the factors mentioned above and the type of disinfection methods used. When the dosage of L. Monocytogenes, Salmonella spp., and Staphylococcus aureus (S. Aureus) on Roma tomatoes and jalapeno peppers was increased from 5 to 40 kJ/m2, **[8]** observed a novel increase from 2.59 to 3.79 log CFU/g in the inactivation of L. Monocytogenes, Salmonella spp., and Staphylococcus Similarly, increasing UV-C radiation dosages resulted in larger reductions of E. Coli, S. Aureus, S. Enteritidis, and Listeria innocua (L. Innocua) on tomato, lettuce, and strawberry without causing texture or appearance alterations [19,43]. The decrease of human adenoviruses from 0.92 to 2.22 and 1.26 to 3 was also doubled when the UV-C radiation exposure was increased from 32 to 72 kJ/m2. For tomato and strawberry, there are 98 logs in all. **[9]** Found a 2.56 log CFU/cm2 decrease in E. coli O157:H7 on lettuce leaves when using pulse mode software with 10 s on and 6 s off from a 14 mm probe, 26 kHz, 90 m, and 200 W US device in both non-stop and pulsed mode configurations. For up to 25 minutes of use, results revealed no significant differences between non-stop and pulsed mode programs, suggesting that decontamination performance became dependent on remedy duration rather than probing device type. **[10]** used a 20 kHz probe device with a 1.9 cm diameter. The pH, color, soluble solids, and sugar content material of strawberries treated with 10.6–21.2 W/cm2 were also shown to be affected. when in comparison with the ones dealt with 31.8 W/cm2, indicating that better US depth turned into negative to the first-class of strawberry. **[11]** confirmed that the population of general microbes, yeast, and mold on tomatoes had fallen to zero. 42–1.04 Increasing US intensity from 66.64 to 145.74 W/L resulted in 41–0.93 log CFU/g, respectively. Similarly, lower intensity levels inhibited ethylene production and respiration rates while maintaining the firmness and antioxidant properties, whereas higher intensity levels had poor results on tomato satisfaction, demonstrating that the right US intensity can prevent decay while preserving the nutritional properties and taste of tomatoes during storage.**[12]** built a closed-tank non-stop-glide device that allowed for frequency and nominal energy variations and discovered that transducers operating at 25, 40, and 75 kHz dissipated 95%, 85%, and 45% of rated electricity, respectively, corresponding to intensities of 79.41, 68.95, and 42.36 W/L. The use of agitation guaranteed spatial consistency of US treatment, and E. Coli O157:H7 populations on spinach leaves were reduced fourfold. From 25, 40, and 75 kHz transducers, 45, 4.21, and 2.42 log CFU/g were obtained, suggesting that non-uniform cavitation from ultrasonic area versions can also contribute to variations in microbial inactivation and go-contamination inside the US bathtub device. **[13]** demonstrated that using a dual-mode frequency of 20/40 kHz during US treatment of tomatoes resulted in microbial reductions of 1.3–2.6 log CFU/g for mesophilic microorganisms, molds, and yeasts, compared to 1 log CFU/g when using a mono-mode frequency of 20 or 40 kHz. At some point during storage, there were no

negative effects on the bioactive components and physicochemical properties of the tomato, substantiating the improved cavitation defined by twin-mode frequency packages.**[14]** confirmed that immersion treatment from a 40 kHz, a 100 and 80 W bathtub machine provided apples with a decreased mass loss of 0.5–1.2%, dry depend on0.115 kg dm/kg, better bioactive compound contents, and less color change when in comparison with touch treatment from a 24 kHz, a hundred% amplitude ring sonotrode probe device. The surrounding water all through immersion remedy performed a tremendous position in water gain and cooling of apples, consequently decreasing weight reduction, while localized oxygen on apple tissue pores and enhanced enzymatic sports at some stage in contact treatment should degrade bioactive compounds. **[15]** Reported 2.0 and 1.2 log discounts in bacterial counts and yeast and mold, respectively, further to retention in the shade, firmness, vitamin C, and antioxidant hobby. Prolonged exposure time after 40 min, 33 kHz, and 60 W did no longer similarly make bigger shelf lifestyles however can also have precipitated accidents to strawberry samples. In every other look, the action of US at 25 kHz and 26 W/L became pronounced as just like the moves of abiotic stress such as wounding in triggering and eliciting protection structures.**[16]** suggested antagonistic effects against Cronobactersakazakii while US at 37 kHz and 380 W changed into blended with a hundred and fifty ppm of NaOCl. Although the doable cause for adverse effect turned into not clean, synergistic aggregate eliminated microorganism cells from the floor of lettuce and in the stomata, as discovered within the scanning emission spectroscopy, yielding 4.44 log CFU/g reduction in comparison with 0.01–2.71 log CFU/g reduction for person packages of US and NaOCl. These studies confirmed that US alone become now not substantially powerful, even with lengthy remedy time, whilst the cavitations effect of the US detached microorganisms from sparkling produce, especially in inaccessible regions, growing their susceptibility to sanitizers. Thus, the chemical composition of the liquid within the US machine can impact decontamination movements. The presence of microorganisms in treatment answers had been also very low and, in some cases, nonexistent, indicating that US and adequate sanitizer concentrations may want to save you and/or lessen move-infection .

3. METHODOLOGY:

A. Methods UV-C device.

To allow accurate and controlled UV-C treatment of test samples, a test apparatus was devised, optimized, manufactured, and calibrated (Fig. 1). Based on a twin-chamber design, a collimated beam arrangement was created. The UV-C light source, electrical driver, and shutter mechanism for controlling sample exposure durations while keeping the lamp output steady are all housed in the tabletop chamber. In the bottom compartment, samples were exposed to deep UV-C light provided by a traditional Mercury type TUV PLL 35 W light source with a peak wavelength of 254 nm. Multiple sensor-based safety precautions were included to safeguard the user from UV-C radiation exposure. A calibrated meter was used to measure the irradiance level of three different lights within the treatment chamber UV-C sensor system (Spectro radio meter GL Optic Spectis 5.0 Touch

with detector GL Opti Probe 5.1.50), which provided irradiance patterns and levels shown in Fig. 3 from which optimal treatment locations could be deduced.

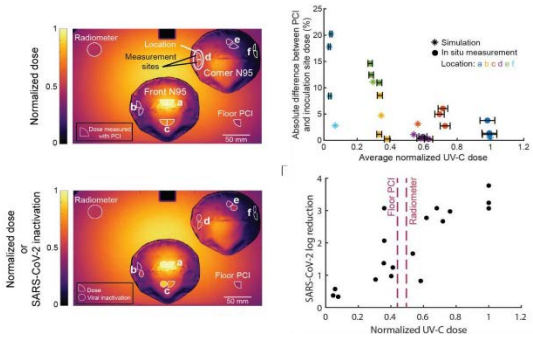

Fig 3: UV C imposed in Object which infected with Virus

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B. Virus inactivation procedures.

All of the studies were carried out in Boston University's National Emerging Infectious Diseases Laboratories' bio safety level 4 facility. SARS-CoV-2 (7.33103 PFU/ml) (USA/WA1-2020)15 was plated in 5 l aliquots onto the surface of 60 mm plastic tissue culture plates (TPP). On a subset of the plates, the virus was allowed to dry for around 2 hours before being treated in the prototype UV-C apparatus. Briefly, a pair of dishes (one to be treated and one control wrapped firmly in aluminum foil) were put in the center of the UV-C device and towards the side of the UV-C device, respectively, at an irradiation level of 0.849 m W/cm2. Te dishes were UV-C-treated for 0.8, 2, 3,4, 5, 6, 9, 15, 30, or 120 s, with each treatment time tested in triplicate. Dishes containing dried viruses were treated in the same manner. Following treatment, the wet and dried virus was re-suspended in 1.9 ml or 2 ml, respectively, of high glucose Dulbecco's Modified Eagle Medium (DMEM) (Gibco) containing 0.04 mM phenol red, 1×antibiotic–antimycotic (Gibco), 1×non-essential amino acids (Gibco), 1×GlutaMAX-I (Gibco), 1 mM sodium pyruvate (Gibco) and 2% fetal bovine serum (FBS)(Gibco). The resuspended virus was then serially diluted from 1×100 to 1×10–2.5 using half-logarithmic dilutions. A back-titration of the virus was included for each experiment.

C. Confirmation of virus inactivation by plaque assay.

Vero E6 cells were seeded onto 6-well CellBIND plates (Corning) at a density of 8.0105 cells per well in high glucose DMEM (Gibco) supplemented with 1GlutaMAX-I, 1 mM sodium pyruvate, 10% FBS (Gibco), and 1non-essential amino acids (Gibco). The cells were treated overnight at 37°C with 5% CO2. 200 l of each dilution made from the re-suspended virus was applied to the appropriate wells of a 6-well plate after the medium was removed from each well. On each plate, a control well was provided that contained just DMEM with 2% FBS. By inoculating each well of a 6-well plate with 110–2 to 110–6 dilutions of the virus used to generate the 60 mm dishes in triplicate, a back-titer of the virus was used to prepare the 60 mm dishes was done respectively .Plates were incubated for 1 hour at 37°C with 5% CO2 and occasional shaking. After that, the cells were in oculated with 2 ml of a 1:1 solution of 2.5 percent Avicel RC-591 (DuPont Nutrition and Health) and 2Temin's Modified Eagle Medium (Gibco) without phenol red, supplemented with 10 percent FBS (Gibco), 2antibiotic–antimycotic (Gibco), and 2GlutaMAX-I (Gibco) (Gibco).

The cells were cultured for two days at 37°C with 5% CO2. Plates were fixed in 10% neutral buffered formalin (Termo Fisher Scientific), then stained in 10% neutral buffered formalin with 0.2 percent Gentian Violet (Ricca Chemical). The number of plaques per viral dilution was calculated by counting them by sight. The titer of the virus using the following formula:

Virus titer in PFU/ml = Number of plaques / (virus dilution in well × volume plated in ml)

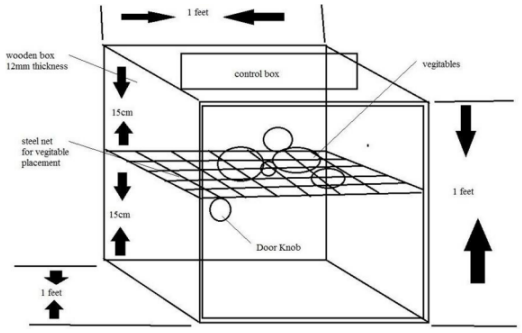

Fig 4: Proposed design

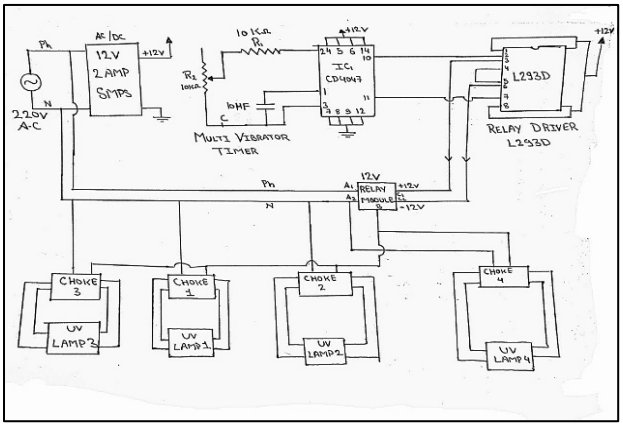

Fig 5: Block Diagram Of proposed system

4. CONCLUSION:

Because of rising customer demand for minimally processed foods with fresh-like properties, research on postharvest decontamination of fruits and vegetables is fast expanding. In postharvest disinfection of fresh fruit, UV-C radiation and US technology have shown promising results with little effect on quality parameters. However, a study in these regions has been hampered by extended exposure times, high US energy consumption, and UV-C radiation's low penetrating capabilities . When UV-C radiation or US technology is used in conjunction with other antimicrobial treatments, the potential for synergistic or complementary effects for greater efficiency has also been proven. In comparison to individual applications, the hurdle technology incorporating UV-C radiation and US technology provides replacement benefits for maintaining the overall safety and wholesomeness of fruits and vegetables.

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