agronomy

MDPI

Article

Electrolyzed Oxidizing Water in Controlling *Pseudomonas syringae* pv. *tomato* in Tomato Crops

Lilia Mexicano [1,2], Tarsicio Medina [2], Adriana Mexicano [3,*] and Jesús-Carlos Carmona [3]

[1] Division of Graduate Studies and Research, Tecnológico Nacional de México, Instituto Tecnológico de Roque, Km. 8 Carretera Celaya-Juventino Rosas, Celaya 38110, Mexico; d20980176@roque.tecnm.mx
[2] Department of Agroindustrial Engineering, Universidad de Guanajuato, Privada Arteaga s/n, Col. Centro, Salvatierra 38900, Mexico; tarsicioms@ugto.mx
[3] Division of Graduate Studies and Research, Tecnológico Nacional de México, Instituto Tecnológico de Ciudad Victoria, Boulevard Emilio Portes Gil, Victoria 87010, Mexico; jesus.cf@cdvictoria.tecnm.mx
* Correspondence: adriana.ms@cdvictoria.tecnm.mx

Abstract: Bacterial speck disease in tomato crops is caused by *Pseudomonas syringae* pv. *tomato*. Chemical control is mainly used for the control of phytopathogens, which carries a risk for both human health and the environment, making it necessary to search for environmentally friendly alternatives, such as the use of electrolyzed water. In the present study, preventive treatments were applied to tomato plants of the saladette variety. The treatments employed were electrolyzed oxidizing water (EOW), electrolyzed reduced water (ERW), a commercial bactericide (Kasumin), and untreated plants as the base control. During the vegetative stage, the disease severity, stem diameter, number of leaves, and number of clusters were determined. In addition, the soluble solids (°Brix), titratable acidity (TA), pH, color, polar and equatorial diameter, weight, and weight loss of the harvested fruit were determined. According to the results, the lowest severity was obtained in the plants treated with oxidizing water, achieving results similar to those achieved with the commercial bactericide Kasumin. It can be concluded that oxidizing water can be applied to tomato crops since its effect is similar to that of Kasumin, but without affecting the growth and development of the crop. Moreover, it is environmentally friendly.

Keywords: disease control; antimicrobial; electrolyzed oxidizing water; electrolyzed reduced water

Citation: Mexicano, L.; Medina, T.; Mexicano, A.; Carmona, J.-C. Electrolyzed Oxidizing Water in Controlling *Pseudomonas syringae* pv. *tomato* in Tomato Crops. *Agronomy* **2024**, *14*, 597. https://doi.org/10.3390/agronomy14030597

Academic Editors: Maria Céu Lavado da Silva, Carmenza E. Góngora and Sang-Won Lee

Received: 29 January 2024
Revised: 28 February 2024
Accepted: 2 March 2024
Published: 16 March 2024

1. Introduction

In Mexico, the tomato is a crop of great economic importance because the production of this vegetable is primarily for export [1]. According to the Observatory of Economic Complexity, in 2021, Mexico accounted for 24.9% of the world's exports of this vegetable, with the United States being its main importer [2]. A large number of microorganisms, which include potential pathogens, constantly surround crops. The tomato crop is susceptible to various diseases, such as bacterial speck caused by *Pseudomonas syringae* pv. *tomato* [3]. *Pseudomonas* is a Gram-negative aerobic bacterium [4] and a hemibiotrophic phytopathogen that infects tomato crops and *Arabidopsis thaliana*, mainly in the aerial parts, such as the leaves and fruits [3]. It contains multiple protein secretion systems (i.e., types I, II, III, IV, V, and VI), with the most important one being the type III secretion system (T3SS) pathway [5], which suppresses the defense responses by salicylic acid of host plants [6]. It can be transmitted via seeds and infected seedlings, as well as through cultural work in the field [7]. Once it enters the plant, it multiplies endophytically and asymptomatically [4]. In the final phase of the infection, symptoms are characterized by necrosis surrounded by chlorosis appearing on the leaves [3]. On the fruit, it appears as small spots or visible lesions 3 mm in diameter [7]. This disease affects the stems, leaves, and fruits of the plants, reducing their quality [8]. In infected seedlings, up to a 75% reduction in yield has been reported [9]. Controlling this phytopathogen primarily involves adequate cultural practices, using healthy seeds, crop rotation, and balanced fertilization and designing irrigation systems [10]. Although genotypes resistant to *Pseudomonas syringae* pv. *tomato* are available on the market, this phytopathogen can still overcome the plant's resistance [11]. Therefore, the use of pesticides, such as aluminum sulfate and copper compounds, is the primary method that has been used to control these phytopathogenic agents [12], mainly comprising formulations of cupric salts both in conventional and organic agriculture [11,13]. However, there is great concern over the adverse effects they may have on both the environment and human health [14]. Due to this, new alternatives that contribute to reducing diseases in crop areas without affecting the growth and development of plantations must be generated. In this regard, electrolyzed water has been widely used in various research studies, and it has been shown to have a positive effect on reducing microorganisms such as fungi and bacteria [15–21]. It has been applied in different fields such as medicine, the livestock sector, hospitals, agriculture, and the food industry [22,23]. Electrolyzed water is synthesized in an electrolysis cell divided by a diaphragmatic membrane, to which a saline solution is added, and a voltage is induced [18,19]. At the end of the electrolysis process, two types of water are obtained: In the anode terminal, electrolyzed oxidizing water is produced with a pH of 2–3, a redox potential (E_{redox}) >1100 mV, and a free chlorine concentration of 10–90 ppm [19,24], and in the cathode terminal, electrolyzed reduced water is generated [20,21]. Reduced electrolyzed water has a pH of 10–11.5 and an E_{redox} from −800 to −900 mV [23–26].

Oxidizing electrolyzed water has been shown to have a bactericidal effect on many pathogenic bacteria under in vitro conditions [27,28], as well as an effect on fungi [17,18]. Its strong antimicrobial activity is due to its high E_{redox}, its low pH, and the chlorine species (HClO, Cl_2, and ClO^-) present in water. In addition, it has been reported that reducing electrolyzed water has a bactericidal effect due to its high E_{redox}, which allows it to reduce free bacterial radicals [29,30], cause changes in metabolic flow and the production of adenosine triphosphate (ATP), and damage bacterial membranes [30].

This research aimed to apply electrolyzed water to tomato crops and evaluate its effect on controlling *Pseudomonas syringae* pv. *tomato* while also evaluating the quality of the harvested fruits.

2. Materials and Methods

2.1. Electrolyzed Water Treatments for Tomato Plants

In a previous experiment carried out under in vitro conditions, where oxidizing (EOW) and reducing (ERW) electrolyzed water treatments were applied to cells in suspensions of *Pseudomonas syringae* pv. *tomato* DC3000 (*Pst* DC3000), 100% inhibition of the bacterial populations was achieved when applying EOW in a treatment time of one minute. A reduction of 4.45×10^7 CFU/mL was achieved when applying ERW [31]. Due to the positive effect on the growth inhibition of the *Pst* DC3000 phytopathogen, it was decided to apply the treatments under in vivo conditions. The CFU/mL values were calculated as follows: CFU/mL = (number of colonies × total dilution factor)/volume of culture plated in mL.

The in vivo experiment was carried out in a greenhouse of the Department of Agroindustrial Engineering of the University of Guanajuato in Mexico (20°12′45.5′′ N, 100°52′31.1′′ W) from August 2021 to February 2022. The seedling used during these experiments was the saladette variety of the Galilea genotype, which was transplanted into soil under greenhouse conditions. Two weeks after transplantation, treatments were applied in a foliar manner, as proposed by Abbasi and Lazarovits [32], for which, with the help of a manual sprayer, 48 h before inoculation, the plants were saturated with freshly prepared electrolyzed water. The following treatments were applied: electrolyzed reduced water (ERW) and electrolyzed oxidizing water (EOW), which were synthesized using a Leveluck SD 501 machine (acquired from Agua Kangen E, Monterrey N.L., Mexico); the commercial bactericide Kasumin, the active substance of which is kasugamycin (Arysta lifeScience); and untreated plants, which were used as the control. Each treatment was replicated three times, and each experimental unit was composed of six plants. These treatments were foliarly applied once a week, during both the vegetative and reproductive stages of the plants. Forty-eight hours after the application of the treatments, the plants were inoculated with a bacterial suspension of *Pst* DC3000 at a concentration of 10^8 CFU/mL. The bacterial suspension was obtained according to the protocol described by Ovissipour et al. [33] under certain modifications. In brief, 50 mL of King broth (KB) culture medium was inoculated with the *Pst* DC3000 strain and incubated at 28 °C for 24 h to obtain a pre-inoculum. From the pre-inoculum, 50 mL of KB medium was inoculated at OD_{600} = 0.05 and incubated at 28 °C for 24 h at 180 rpm. At the end of the incubation time, 10 mL of the culture medium was taken and centrifuged at 22 °C at 7000 rpm for 15 min. The supernatant was decanted, and the cell pellet was resuspended in 10 mL of sterile deionized water and centrifuged at 22 °C at 7000 rpm for 15 min. The supernatant was discarded, and the cell pellet was resuspended in 10 mL of sterile deionized water. From this bacterial suspension, dilutions were produced until a concentration of 10^8 CFU/mL was obtained. During the vegetative stage, the severity of the disease was determined in the plants, as well as the following variables: number of leaves (NL), stem diameter (SD), and number of clusters (NC).

In order to determine the severity of the disease, a diagrammatic scale consisting of the following values was used: 1: plant with no disease symptoms; 2: plant with 15% of leaves with symptoms; 3: plant with 15–35% of leaves with symptoms; 4: plant with 35–70% of leaves with symptoms; 5: plant with 70–100% of leaves with symptoms; and 6: death of the plant [34].

2.2. Quality Tests on the Fruit

Healthy and disease-free fruits were harvested to evaluate fruit quality. The harvested fruits were immediately transported to the laboratory and then hydrocooled. A total of 30 fruits per treatment were randomly selected (10 fruits per repetition), and the following variables were evaluated: polar diameter, equatorial diameter, weight, weight loss, °Brix (using a SPECTRONIC 334610 digital refractometer; ANTOELI Bajio, El Carmen, Queretaro, Mexico), titratable acidity (obtained according to AOAC (2000)), pH (using a HANNA HI98127 potentiometer, Industrial KEM, Leon Guanajuato, Mexico), and color (using a Minolta CR-400 colorimeter; Industrial KEM, Leon Guanajuato, Mexico). The color index was determined using Equation (1).

$$CI = \frac{2000a^*}{L^* \sqrt{a^{*2} + b^{*2}}} \tag{1}$$

where:

CI: color index;
*L**: luminosity;
*a**: red/green coordinate (+*a* indicates red, −*a* indicates green);
*b**: yellow/blue coordinate (+*b* indicates yellow, −*b* indicates blue).

2.3. Statistical Analysis

The data corresponding to weight, polar diameter, and equatorial diameter were analyzed using an ANOVA (α = 0.05), and Tukey's test was employed to compare means. For the analysis of severity, °Brix, pH, titratable acidity, firmness, color, and weight loss, a non-parametric Kruskal–Wallis test was used, followed by a Dunn's test, utilizing GraphPad Prism 7 software.

3. Results

Table 1 shows the values of stem diameter (SD), number of leaves (NL), and number of clusters (NC) of plants treated with ERW, EOW, and Kasumin. The table shows that the biggest stem thickness was found in plants treated with ERW ($p > 0.05$) and that there were no significant statistical differences between the EOW and Kasumin treatments, as well as untreated plants ($p < 0.05$). As for NL and NC, no significant statistical differences were found between treatments ($p < 0.05$). This suggests that the application of treatments in tomato plants does not affect their growth and that the application of reducing electrolyzed water could contribute to biomass production because a larger stem diameter was obtained compared to the other treatments. However, more experiments are required to evaluate the effect of EWR on the increase in biomass in plants.

Table 1. Agronomic parameters in tomato plants treated with electrolyzed water as a preventive treatment for bacterial speck caused by *Pseudomonas syringae* pv. *tomato*.

Treatment	SD (cm)	NL	NC
EOW	1.91 ± 0.12^{ab}	14.22 ± 1.08^{a}	6.78 ± 0.48^{a}
ERW	2.07 ± 0.51^{a}	14.78 ± 0.51^{a}	6.50 ± 0.17^{a}
Kasumin	1.74 ± 0.12^{b}	14.67 ± 0.88^{a}	7.39 ± 0.26^{a}
Control	1.72 ± 0.10^{b}	13.78 ± 0.25^{a}	7.22 ± 0.09^{a}

Values correspond to the mean of three repetitions + the standard deviation. Values with the same letters in the same column are statistically equal. SD—stem diameter, NL—number of leaves, NC—number of clusters.

Figure 1 shows the severity of the disease caused by *Pst* DC3000 on tomato plants, where it can be observed that the lowest severity was observed in plants treated with either EOW or Kasumin, with no statistically significant differences observed between these treatments ($p < 0.05$). However, the highest severity of the disease was observed in those plants that did not receive any treatment, followed by those that were treated with ERW. Therefore, the results show that the best treatments to reduce the severity of the disease were EOW and Kasumin.

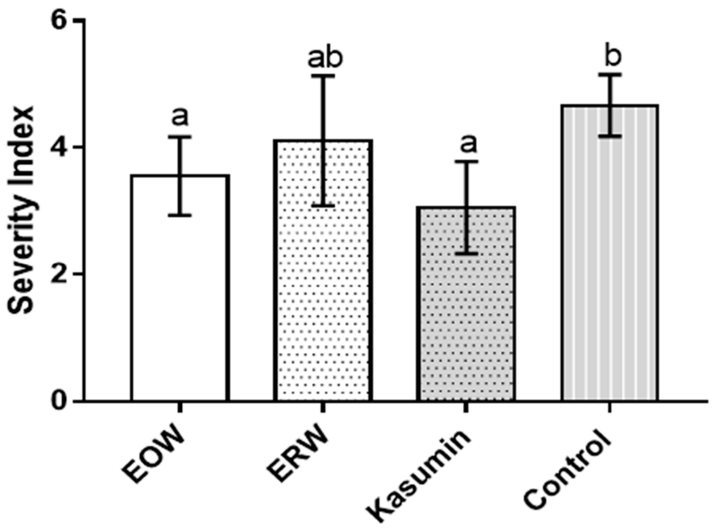

Figure 1. Severity of disease caused by Pst DC3000 in plants treated with Electrolyzed Oxidizing Water (EOW), Electrolyzed Reducing Water (ERW), and Kasumin as a preventive treatment. Different letters in the bars mean statistical differences between treatments.

In the present study, the highest severity was observed in the control plants and those treated with ERW (35–70% of the infected leaves). The lowest severity was observed in plants treated with EOW and Kasumin (15–30% of the infected leaves). These results show that EOW has a similar effect to the commercial Kasumin bactericide, which suggests it could be used during the production of tomato crops and that ERW has a lesser antibacterial effect (Figure 2). This reduction in the plants' disease severity could be due to the fact that electrolyzed oxidizing water activates the plant defense system through the priming phenomenon. This activation leads to a favorable reduction in the severity of the disease caused by *Pst* DC3000.

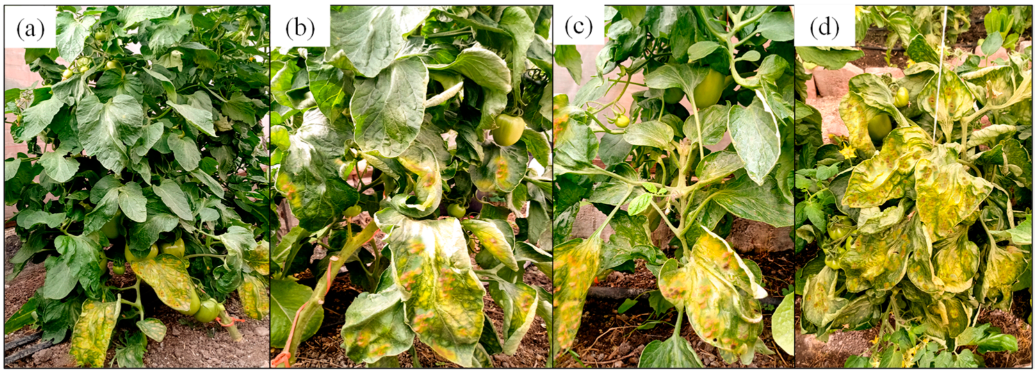

Figure 2. Severity of disease caused by *Pst* DC3000 in tomato plants with different preventive treatments: (**a**) EOW, (**b**) ERW, (**c**) Kasumin, and (**d**) control. The symptoms were presented as chlorosis and necrotic spots, similar to those reported by Peñaloza-Vazquez et al. [35].

Fruit Quality

Table 2 shows the weight of the harvested fruits, as well as their polar diameter (PD) and equatorial diameter (ED). This table shows that the highest weight was obtained in fruits harvested from plants treated with ERW ($p > 0.0001$) in comparison to the other treatments. The fruits had 14.35% and 13.15% more weight in comparison to the EOW and Kasumin treatments, respectively. With respect to the polar diameter, no statistically significant differences were observed between the ERW, EOW, and control treatments ($p < 0.0001$); however, the fruits with lower PDs were those from plants treated with Kasumin. Finally, the largest equatorial diameter was observed in the fruits of plants treated with ERW ($p > 0.0001$), and no statistically significant differences were found with respect to the equatorial diameter in fruits of plants treated with EOW, Kasumin, and the control ($p < 0.0001$). According to the obtained results, it can be concluded that infection with *Pst* DC3000 did not affect the weight of tomato fruits. According to the technical data sheet of the seed (Hazera Seeds), the average weight of the fruits is in the range of 150–220 g, and the obtained fruits are within this range. It was also observed that treatment with ERW had a positive effect, with these fruits exhibiting greater weight and equatorial diameter ($p > 0.0001$). For polar diameter, the lowest value was obtained in the fruits of plants treated with Kasumin ($p > 0.0001$).

Table 2. Weight, polar diameter (PD), and equatorial diameter (ED) of fruits with different preventive treatments.

Treatment	Weight (g)	PD (cm)	ED (cm)
EOW	202.27 ± 49.39 ^{a}	8.36 ± 0.74 ^{ab}	6.50 ± 0.58 ^{ab}
ERW	236.16 ± 42.86 ^{b}	8.16 ± 1.53 ^{ab}	6.92 ± 0.44 ^{b}
Kasumin	205.11 ± 36.85 ^{a}	8.15 ± 0.59 ^{b}	6.67 ± 0.45 ^{ab}
Control	223.27 ± 35.62 ^{ab}	8.65 ± 0.67 ^{a}	6.80 ± 0.48 ^{a}

Values correspond to the mean ± standard deviation. Values with the same letters within the same column are statistically equal.

Although no differences were observed between the aforementioned variables, differences were observed in the yield per plant, as mentioned above. The highest yield was obtained in those plants treated with EOW (7.72 ± 2.27 kg) compared to the control (5.59 ± 1.89).

Table 3 shows the values of °Brix, titratable acidity (presented as a percentage of citric acid), pH, and firmness, in which it is shown that the highest brix degrees were found in the fruit of plants treated with EOW (3.58 ± 0.49) when compared to those treated with ERW or Kasumin and the control ($p > 0.0001$).

Table 3. Physicochemical analysis of fruits under different treatments.

Treatment	°Brix	TA (% Citric Acid)	pH	Firmness (kg/cm^2)
EOW	3.58 ± 0.49 [a]	0.323 ± 0.003 [a]	4.44 ± 0.26 [a]	2.38 ± 0.53 [a]
ERW	3.44 ± 0.58 [ab]	0.358 ± 0.003 [ab]	4.53 ± 0.19 [ab]	2.39 ± 0.55 [a]
Kasumin	2.97 ± 0.49 [b]	0.352 ± 0.004 [abc]	4.51 ± 0.07 [a]	2.33 ± 0.47 [a]
Control	3.10 ± 0.53 [b]	0.308 ± 0.004 [ad]	4.60 ± 0.31 [b]	2.55 ± 0.47 [a]

Values correspond to the mean ± the standard deviation. Values with the same letters within the same column are statistically equal.

For titratable acidity values, no statistically significant differences were found among the fruits evaluated ($p < 0.0001$).

As for the pH, the highest value (4.60 ± 0.31) was observed in the control group, which was statistically different from the EOW (4.44 ± 0.26) and Kasumin (4.51 ± 0.07) treatments ($p > 0.0001$). The fruits of plants treated with ERW and Kasumin showed a slight increase in pH values compared to those treated with EOW; however, no statistically significant differences were found between these treatments ($p < 0.0001$).

Finally, the firmness value did not show statistically significant differences among the fruits evaluated ($p < 0.0001$).

In the present study, weight loss was evaluated over a 7-day storage period, with fruit stored at ambient temperature (20 °C) and a relative humidity (%RH) of 40–45%. Figure 3 shows that from days 1 to 6, no statistically significant differences were observed among fruits ($p < 0.0001$). However, on day 7, it was observed that fruits with greater physiological weight loss were those from plants treated with Kasumin and EOW ($p > 0.0001$).

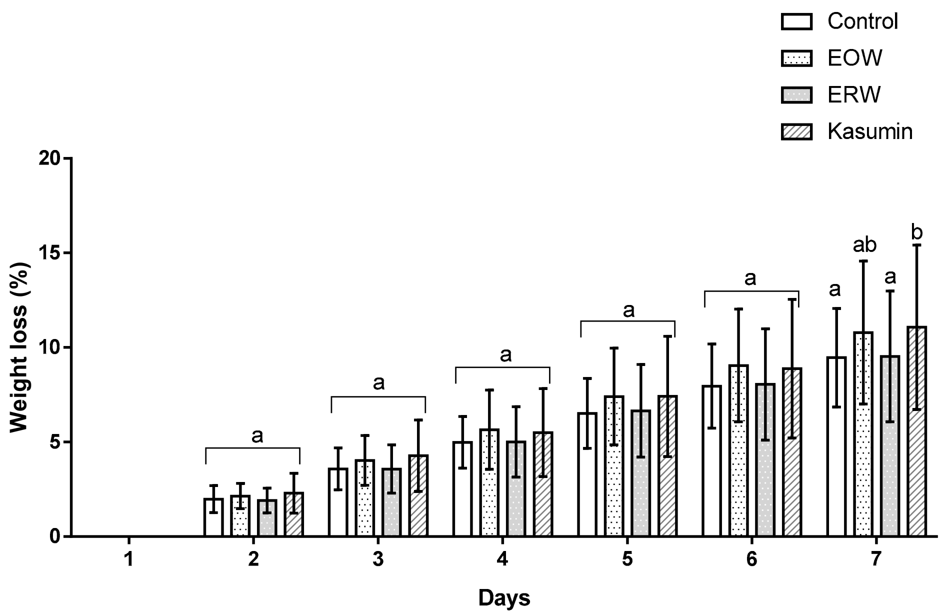

Figure 3. Weight loss over seven days in fruits under different treatments. The letter *a* in the figure means that from day 1 to 6 there were no statistical differences between treatments. On the seventh day, different letters in the bars (a and b) indicate significant differences between treatments.

Table 4 shows the color coordinates (L^*, a^*, and b^*), the ratio (a^*/b^*), and the color index (*CI*) of the fruits. The results show no statistically significant differences in fruit brightness, regardless of the treatment applied to the plants in the field ($p < 0.0001$). However, the lowest values in the a^* and b^* coordinates were present in the fruits harvested from plants treated with Kasumin ($p > 0.0001$).

Table 4. L^*, a^*, b^* coordinates, *CI*, and a^*/b^* ratio in fruits of plants under different treatments.

Treatment	L^*	a^*	b^*	a^*/b^*	*CI*
EOW	38.10 ± 1.19 ^{a}	26.09 ± 3.01 ^{a}	26.13 ± 1.72 ^{a}	1.00 ± 0.12 ^{a}	37.03 ± 3.04 ^{a}
ERW	38.36 ± 1.26 ^{a}	24.34 ± 2.47 ^{ab}	25.59 ± 1.51 ^{a}	0.95 ± 0.07 ^{a}	35.92 ± 2.13 ^{a}
Kasumin	38.34 ± 1.17 ^{a}	23.72 ± 2.68 ^{b}	24.32 ± 4.28 ^{b}	0.99 ± 0.13 ^{a}	36.49 ± 3.41 ^{a}
Control	38.57 ± 1.32 ^{a}	26.27 ± 1.91 ^{ac}	26.42 ± 1.61 ^{ac}	1.00 ± 0.06 ^{a}	36.58 ± 1.84 ^{a}

Values correspond to the mean ± the standard deviation. Values with the same letters within the same column are statistically equal. L^*: luminosity; a^*: red/green coordinate (+*a* indicates red, −*a* indicates green); b^*: yellow/blue coordinate (+*b* indicates yellow, −*b* indicates blue); a^*/b^* ratio; *CI*: color index.

The maturity of the tomato fruits can be reflected in the values of the a^* coordinate, as it has been reported that the coordinates for the green color are L^* = +50, a^* = −60, b^* = 0 and those for the red color are L^* = +50, a^* = +60, b^* = 0, according to Thole et al. [36].

As for the *CI* values and the a^*/b^* ratio, no statistically significant differences were observed between treatments ($p < 0.0001$), and positive values were observed for all fruits, indicating that they are mature fruits. These values indicate that the fruits present a red coloration known as ripening stage 5 (light red) according to the USDA maturity scale (Figure 4), which is due to the degradation of chlorophyll and the synthesis of lycopene [37]. From the obtained results, it can be concluded that the treatments did not affect the quality of tomato fruits. All fruits were visibly marketable, as shown in Figure 4. Regarding the control fruits, despite the fact that the plant showed high disease severity, the fruits did not present symptoms of the disease on their surfaces. While the results showed that the yields per plant were higher in those treated with Kasumin and EOW (6.37 ± 1.9 kg/plant and 6.32 ± 1.04 kg/plant, respectively), the yields of those treated with ERW and the control were 4.81 ± 1.89 kg/plant and 4.65 ± 2.62 kg/plant, respectively.

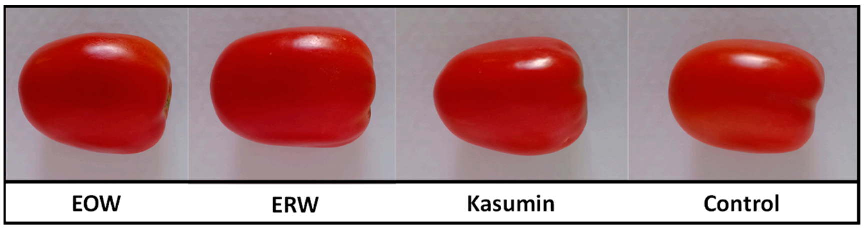

Figure 4. Fruits harvested from tomato plants infected with *Pst* DC3000 and treated with EOW, ERW, and Kasumin.

4. Discussion

According to Kim and Hung [38], electrolyzed water exerts antimicrobial activity, which is related to pH parameters, free chlorine concentration, and E_{redox}. The strong antimicrobial activity of electrolyzed oxidizing water is due to its high E_{redox}, low pH, and the chlorine species present (HClO, Cl_2, and ClO^-). McCarthy et al. [27] and Al-Qadiri et al. [28] mentioned that electrolyzed water with a pH below 3 has been shown to have a bactericidal effect on many pathogenic bacteria under in vitro conditions. However, it is known that electrolyzed reducing water has a pH greater than 11 [39]. It has been reported that it has a bactericidal effect due to its high E_{redox}, which allows it to reduce free bacterial radicals, thus causing changes in metabolic flow and the production of adenosine triphosphate (ATP). In 2020, Ramírez and Cano [30] reported that electrolyzed reducing water interrupts protein synthesis while damaging bacterial membranes. The application of electrolyzed water in crops has gained great interest due to the need to reduce the use of pesticides in agriculture. In 2003, Buck et al. reported a phytotoxic effect associated with the frequent application of electrolyzed oxidizing water (pH = 2.8–2.9; E_{redox}= 1071–1079 mV; FCC = 54–56 mg/L and 71 mg/L) on the foliage and flowers of twelve species of ornamental plants [40]. Guentzel et al. comment that the application of electrolyzed water containing chlorine concentrations of 50 and 100 ppm causes high phytotoxicity in strawberry plants, which can affect plant growth [17]. Nonetheless, in the present study, no phytotoxicity was observed in the plants after the application of the treatments, such that their development and growth remained unaffected.

Hirayama et al. [41] report a lower incidence of *Colletotrichum fructicola* in plants treated with electrolyzed water (8.3%) in comparison to plants treated with a fungicide (27%) and plants used as the control (85%). Muller et al. [42] determined the effect of oxidizing electrolyzed water in controlling powdery mildew caused by *Botrytis cinerea* in gerbera daisy, comparing it against treatments with fungicides. The work determined the effect of oxidizing electrolyzed water alone and the compatibility of oxidizing electrolyzed water with pesticides in an in vitro model. The authors observed that electrolyzed water is most effective when applied twice a week or when applied in combination with the fungicides piperalin and triadimefon. Zarattini et al. [43] reported that the application of electrochemically activated solutions can induce the defense system in tobacco plants and apple trees by inducing the expression of pathogenesis-related (PR) genes and increasing salicylic acid levels. They also observed that microorganisms present on the surface of the leaves can be eliminated with this type of treatment, without affecting the vigor of the plant or the quality of the fruit. In the present study, the highest severity was observed in the control plants and those treated with ERW (35–70% of the infected leaves). The lowest severity was observed in plants treated with EOW and Kasumin (15–30% of the infected leaves). Abbasi and Lazarovitz highlighted that foliarly spraying acid-electrolyzed water on tomato plants under greenhouse and open field conditions reduced *Xanthomonas campestris* populations and leaf speck severity [32]. In 2009, Fujiwara et al. observed a decrease in disease severity when applying acid-electrolyzed water to control downy mildew in hydroponic cucumber plants. The decrease in severity occurred after the first application of acid-electrolyzed water [18]. According to the abovementioned study, the electrolyzed oxidizing water could activate the plant's defense system through the priming phenomenon, the activation of which leads to a favorable reduction in the severity of the disease caused by *Pst* DC3000. Finally, it is suggested that electrolyzed oxidizing water may serve as an alternative to the use of pesticides in agriculture since it has been proven to have a similar effect to the commercial bactericide Kasumin.

Tomato fruit quality is influenced by several pre- and post-harvest factors. Pre-harvest factors include crop genotype, environmental conditions during production, irrigation, and harvest management. In addition, the maturity stage of the fruits at the time of harvesting influences their quality [44]. Regarding the size of the fruits, Nassiri et al. [45] commented that tomatoes are classified as small (5.50–5.79 cm), medium (5.72–6.43 cm), large (6.35–7.06 cm), and extra large (more than 7 cm). According to this classification, the fruits obtained in this study were extra large since their size was greater than 7 cm. Although extra-large fruits were obtained in all treatments, the highest yield was obtained with the EOW treatment (7.72 $\pm$ 2.27 kg), as mentioned above. There are studies, such as that of Sugiharta et al. [46], that have reported that the application of electrolyzed water using Fe electrodes influences the weight, number of leaves, and stem thickness in spinach grown under a hydroponic system. In addition, Zhou et al. [47] mention that slightly acidic electrolyzed water (pH = 5.0) can improve plant growth and photosynthetic efficiency in lettuce. According to the aforementioned study, it is suggested that water properties, such as pH and CCL, could influence biomass production and fruit size. In the present work, the EOW had a pH of 2.4 $\pm$ 0.13 and a CCL of 18 ppm, unlike ERW, which did not contain CCL and had a pH of 10.2 $\pm$ 0.26.

Regarding °Brix, Yeshiwas and Tolessa [48] reported values of 3–4.2 in tomato fruits grown under greenhouse conditions and of 4.1–4.56 under open-field conditions. Cantwell et al. [49] reported an average °Brix value of 3.4–5.5 for different cultivars, while Okolie and Sanni [50] observed °Brix values in the range of 4.17 and 4.37 in tomatoes stored for seven days at ambient temperature and mentioned that this value may increase with the ripening and storage time of the fruit due to the hydrolysis of polysaccharides to simple sugars. In this work, the highest °Brix values were found in the fruit of plants treated with EOW (3.58 ± 0.49) when compared to ERW, Kasumin, and control treatments ($p > 0.0001$).

For titratable acidity, Yeshiwas and Tolessa [51] reported a value of 0.55–0.78 for freshly harvested fruit. Sinha et al. [50] reported a value of 0.41 for Roma tomatoes and 0.46 for Sofol tomatoes. Cantwell et al. [49] stated that the average value in different varieties is in the range of 0.22 to 0.40%. In the present study, values within the range of 0.30–0.35 were obtained, which is in accordance with the range reported by Cantwell et al. in 2007 [49].

With regard to pH, Yeshiwas and Tolessa [48] obtained a pH value of 3.87 in freshly harvested fruit, which increased after seven days of storage (4.08). Sinha et al. [50] reported values of 4.33 for Roma tomatoes and 4.15 for Sofol tomatoes; additionally, the authors also mention that the pH in tomato fruits can vary, depending on the genotype, between the values of 3.78 and 5.25. In 2015, Arah et al. [44] stated that the optimum pH for tomatoes is 4.25 and that the maximum value is 4.4. According to the above, the fruits of plants treated with EOW obtained an optimal pH, as reported by Arah et al. [44]; however, the highest pH was obtained in the control (plants inoculated with *Pseudomonas*), which suggests that the applied treatment could influence the final pH of the fruit, as plants that received any treatment exhibited a lower pH compared to the control.

In this work, the firmness value did not show statistically significant differences among the fruits evaluated ($p < 0.0001$). Cardona et al. [52], when evaluating foliar fertilization with calcium, found that the obtained fruits had a firmness of 3.06 and 3.19 kg/0.505 cm^2. Urrieta-Velazquez et al. [53] mentioned that saladette tomatoes may exhibit a firmness of 1.187 kg/cm^2, up to 1.598 kg/cm^2. In 2017, Cruz-Crespo et al. [54], when evaluating the effect of substrates on tomato fruit quality, reported average values of 2.36 kg/cm^2 for fruits of plants grown in tezontle plus a nutrient solution and 2.73 kg/cm^2 for plants grown in tezontle with vermicompost and irrigated with a nutrient solution; the authors commented that the addition of vermicompost can increase fruit firmness and that this increase depends on the concentration applied, as well as on the variety of tomato used. Therefore, it is suggested that the organic fertilizer applied to the soil contributed to the firmness of the fruits.

Roberts et al. [55] observed a weight loss of 16% in tomato fruits stored at 22 °C and of 3.18% in those stored at 10 °C during a storage period of twelve days. In 2019, Sinha et al. [51] reported weight losses of 2.87% for Roma tomatoes and 3.36% for Sofol tomatoes. Casierra-Posada and Aguilar-Avendaño [34] mention that weight loss is due to the loss of water in the fruit, which reduces turgor and causes fruit softening. Yeshiwas and Tolessa [48] comment that weight loss is also influenced by the variety and the storage period. As the number of storage days increases, fruit weight loss also increases. In addition, Arah et al. [44] report that for long-term storage, tomatoes should be stored at a temperature between 10 °C and 15 °C and at a relative humidity of 85–95%, confirming that these conditions contribute to maintaining the quality of fruit. Okolie and Sanni [50] mention that weight loss is mainly due to the respiration and transpiration of the fruit. Hence, it is suggested that the weight loss in the present study was mainly due to fruit transpiration caused by low relative humidity in the storage environment after a seven-day storage period.

In terms of tomato fruit maturity, Camelo and Gómez [56] report L^* coordinate values close to 50, for a^* at 18, and for b^* at 30, indicating that these values correspond to light-red maturation during the ripening process.

The present work shows that electrolyzed water could be applied as a measure to control diseases that occur during tomato cultivation. According to the obtained results, the EOW treatment contributes to reducing disease severity in the crop, does not affect the development and growth of the plants, does not exhibit a phytotoxic effect on them, and does not affect fruit quality.

This work suggests that applying electrolyzed water to tomato crops represents an alternative for disease management, resulting in crop benefits and field sustainability. However, there is a need to evaluate the effect of electrolyzed water on the plant in relation to stimulating the activation of the plant's defense system. In future work, it would be advisable to evaluate a combination of the different treatments (ERW, EOW, and Kasumin) to verify possible synergies for better control of crop disease. This combination could contribute to greater control of the disease, as previously mentioned in a study conducted by Mueller et al. [43], in which oxidizing water was combined with fungicides. In the case of combining ERW and EOW, ERW could contribute to removing dirt from plants due to its cleaning effect. It has been reported to remove dirt and grease from surfaces [22], and it has also been reported that it can be used as a pre-wash agent for vegetables [25]. Taken together, these results suggest that ERW could be used as a pre-wash agent that promotes the interaction of EOW with microbial populations.

5. Conclusions

The application of electrolyzed oxidizing water is a viable option in tomato cultivation, as it managed to reduce disease severity in tomato plants, exhibiting an effect similar to the bactericide Kasumin. In addition, it did not affect the growth or yield of the crops, as the evaluated variables were not affected, and the fruits obtained were commercially viable and did not present disease symptoms. In addition, the application of ERW may contribute to increased biomass production in the crop. When applied to the plants, its application resulted in greater stem diameters and heavier fruits.

Author Contributions: Conceptualization, L.M. and T.M.; methodology, L.M.; software, A.M. and J.-C.C.; validation, L.M., T.M. and J.-C.C.; formal analysis, L.M. and T.M.; investigation, L.M., T.M., A.M. and J.-C.C.; resources, L.M., T.M., A.M. and J.-C.C.; data curation, L.M., A.M. and J.-C.C.; writing—original draft preparation, L.M., T.M., A.M. and J.-C.C.; writing—review and editing, L.M., T.M., A.M. and J.-C.C.; visualization, A.M. and J.-C.C.; supervision, T.M.; project administration, L.M. and T.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. SADER—Secretaria de Agricultura y Desarrollo Rural, México, Referente Mundial en el Cultivo y Exportación de Jitomate: Agricultura, March 2022. Available online: https://www.gob.mx/agricultura/prensa/mexico-referente-mundial-en-el-cultivo-y-exportacion-de-jitomate-agricultura#:~:text=M%C3%A9xico%20se%20ha%20constituido%20como,y%20Singapur,%20entre%20otros%20mercados, (accessed on 25 May 2023).
2. The Observatory of Economic Complexity: OEC. Available online: https://oec.world/es/profile/hs92/tomatoes?redirect=true (accessed on 25 May 2023).
3. Morán-Diez, M.E.; Tranque, X.F.; He, S.Y. *Pseudomonas syringae* pv. *tomato* DC3000: A Model Pathogen for Probing Disease Susceptibility and Hormone Signaling in Plants. *Annu. Rev. Phytopathol.* **2013**, *51*, 473–498. [CrossRef]
4. Preston, G.M. *Pseudomonas syringae* pv. *tomato*: The right pathogen, of the right plant, at the right time. *Mol. Plan Pathol.* **2000**, *1*, 263–275. [CrossRef] [PubMed]
5. Cunnac, S.; Lindeberg, M.; Collmer, A. *Pseudomonas syringae* type III secretion system effectors: Repertoires in search of functions. *Curr. Opin. Microbiol.* **2009**, *12*, 53–60. [CrossRef] [PubMed]
6. Ishiga, Y.; Ichinose, Y. *Pseudomonas syringae* pv. *tomato* OxyR Is Required for Virulence in Tomato and Arabidopsis. *Mol. Plant-Microbe Interact.* **2016**, *29*, 119–131. [CrossRef]
7. Uppalapati, S.R.; Ishiga, Y.; Wangdi, T.; Urbanczyk-Wochniak, E.; Ishiga, T.; Mysore, K.S.; Bender, C.L. Pathogenicity of *Pseudomonas syringae* pv. *tomato* on tomato seedlings: Phenotypic and gene expression analyses of the virulence function of coronatine. *Mol. Plant-Microbe Interact.* **2008**, *21*, 383–395. [CrossRef]
8. Morán-Diez, M.E.; Tranque, E.; Bettiol, W.; Monte, E.; Hermosa, R. Differential Response of Tomato Plants to the Application of Three *Trichoderma* Species When Evaluating the Control of *Pseudomonas syringae* Populations. *Plants* **2020**, *9*, 626. [CrossRef]
9. Elsharkawy, M.; Derbalah, A.; Hamza, A.; El-Shaer, A. Zinc oxide nanostructures as a control strategy of bacterial speck of tomato caused by *Pseudomonas syringae* in Egypt. *Environ. Sci. Pollut. Res. Int.* **2020**, *27*, 19049–19057. [CrossRef]
10. Quattrucci, A.; Balestra, G.M. Antibacterial activity of natural extracts in *Pseudomonas syringae* pv. *tomato* control. *Acta Hortic.* **2009**, *808*, 339–341. [CrossRef]

11. Quaglia, M.; Bocchini, M.; Orfei, B.; D'Amato, R.; Famiani, F.; Moretti, C.; Buonaurio, R. Zinc phosphate protects tomato plants against *Pseudomonas syringae* pv. *tomato*. *J. Plant Dis. Prot.* **2021**, *128*, 989–998. [CrossRef]
12. Carvalho, F.P. Agriculture, pesticides, food security and food safety. *Environ. Sci. Policy.* **2006**, *9*, 685–692. [CrossRef]
13. Canzoniere, P.; Francesconi, S.; Giovando, S.; Balestra, G.M. Antibacterial activity of tannins towards *Pseudomonas syringae* pv. *tomato*, and their potential as biostimulants on tomato plants. *Phytopathol. Mediterr.* **2021**, *60*, 23–36. [CrossRef]
14. Aktar, M.W.; Sengupta, D.; Chowdhury, A. Impact of pesticides use in agriculture: Their benefits and hazards. *Interdiscip. Toxicol.* **2009**, *2*, 1–12. [CrossRef]
15. Vásquez-López, A.; Villarreal-Barajas, T.; Rodríguez-Ortiz, G. Effectiveness of neutral electrolyzed water on incidence of fungal rot on tomato fruits (*Solanum lycopersicum* L.). *J. Food Prot.* **2016**, *79*, 1802–1806. [CrossRef]
16. Li, X.; Yue, H.; Xu, S.; Tian, J.; Zhao, Y.; Xu, J. The effect of electrolyzed water on fresh-cut eggplant in storage period. *LWT. Food Sci. Technol.* **2020**, *123*, 109080. [CrossRef]
17. Guentzel, J.L.; Callan, M.A.; Liang Lam, K.; Emmons, S.A.; Dunham, V.L. Evaluation of electrolyzed oxidizing water for phytotoxic effects and pre-harvest management of gray mold disease on strawberry plants. *Crop Prot.* **2011**, *30*, 1274–1279. [CrossRef]
18. Fujiwara, K.; Fujii, T.; Park, J. Successive spraying efficacy of acidic electrolyzed oxidizing water and alkalic electrolyzed reducing water on controlling powdery mildew infection and suppressing visible physiological disorder on cucumber leaves. *Hortic. Environ. Biotechnol.* **2011**, *52*, 387–392. [CrossRef]
19. Zhang, C.; Li, B.; Jadeja, R.; Hung, Y. Effects of electrolyzed oxidizing water on inactivation of bacillus subtilis and bacillus cereus spores in suspension and on carriers. *J. Food Sci.* **2016**, *81*, M144–M149. [CrossRef] [PubMed]
20. Pangloli, P.; Hung, Y. Efficacy of slightly acidic electrolyzed water in killing or Reducing *Escherichia coli* O157:H7 on iceberg lettuce and tomatoes under simulated food service operation conditions. *J. Food Sci.* **2011**, *76*, M361–M366. [CrossRef] [PubMed]
21. Shiroodi, S.G.; Ovissipour, M. Electrolyzed Water Application in Fresh Produce Sanitation. In *Postharvest Disinfection of Fruits and Vegetables*, 1st ed.; Mohammed, W.S., Ed.; Academic Press: Kolkata, India, 2018; pp. 67–89. [CrossRef]
22. Huang, Y.; Hung, Y.; Hsu, S.; Huang, Y.; Hwang, D. Application of electrolyzed water in the food industry. *Food Control* **2008**, *19*, 329–345. [CrossRef]
23. Rahman, S.M.E.; Khan, I.; Oh, D.H. Electrolyzed water as a novel sanitizer in the food industry: Current trends and future perspective. *Compr. Rev. Food Sci. Food Saf.* **2016**, *15*, 471–490. [CrossRef] [PubMed]
24. Ovissipour, M.; Al-Qadiri, H.M.; Sablani, S.S.; Govindan, B.N.; Al-Alami, N.; Rasco, B. Efficacy of acidic and alkaline electrolyzed water for inactivating *Escherichia coli* O104:H4, *Listeria monocytogenes*, *Campylobacter jejuni*, *Aeromonas hydrophila*, and *Vibrio parahaemolyticus* in cell suspensions. *Food Control* **2015**, *53*, 117–123. [CrossRef]
25. Hao, J.; Li, H.; Wan, Y.; Liu, H. Effect of slightly acidic electrolyzed water (SAEW) treatment on the microbial reduction and storage quality of Fresh-Cut cilantro. *J. Food Process. Preserv.* **2015**, *39*, 559–566. [CrossRef]
26. Arya, R.; Bryant, M.; Degala, H.L.; Mahapatra, A.K.; Kannan, G. Effectiveness of a low-cost household electrolyzed water generator in reducing the populations of *Escherichia coli* K12 on inoculated beef, chevon, and pork surfaces. *J. Food Process. Preserv.* **2018**, *42*, 1–6. [CrossRef]
27. McCarthy, S.; Burkhardt, W. Efficacy of electrolyzed oxidizing water against *Listeria monocytogenes* and *Morganella morganii* on conveyor belt and raw fish surfaces. *Food Control* **2012**, *24*, 214–219. [CrossRef]
28. Al-Qadiri, H.M.; Smith, S.; Sielaff, A.C.; Govindan, B.N.; Ziyaina, M.; Al-Alami, N.; Rasco, B. Bactericidal activity of neutral electrolyzed water against Bacillus cereus and Clostridium perfringens in cell suspensions and artificially inoculated onto the surface of selected fresh produce and polypropylene cutting boards. *Food Control* **2019**, *96*, 212–218. [CrossRef]
29. Joshi, K.; Mahendran, R.; Alagusundaram, K.; Norton, T.; Tiwari, B.K. Novel disinfectants for fresh produce. *Trends Food Sci. Technol.* **2013**, *34*, 54–61. [CrossRef]
30. Ramírez-Orejel, J.C.; Cano-Buendía, J.A. Applications of Electrolyzed Water as a Sanitizer in the Food and Animal-By Products Industry. *Processes* **2020**, *8*, 534. [CrossRef]
31. Santoyo, L.M.; Saavedra, T.M.; Elos, M.M.; García, U.M.L.; López, M.A.C.; Martínez, T.O.M. Antibacterial activity of electrolyzed water on *Pseudomonas syringae* and *Clavibacter michiganensis* and its effect on seed germination. *Cienc. Rural* **2024**, *54*, e20220416. [CrossRef]
32. Abbasi, P.A.; Lazarovits, G. Effect of acidic electrolyzed water on the viability of bacterial and fungal plant pathogens and on bacterial spot disease of tomato. *Can. J. Microbiol.* **2006**, *52*, 915–923. [CrossRef] [PubMed]
33. Aires, A.; Dias, C.; Carvalho, R.; Oliveira, M.; Monteiro, A.; Simões, M.; Rosa, E.; Bennett, R.; Saavedra, M. Correlations between disease severity, glucosinolate profiles and total phenolics and *Xanthomonas campestris* pv. *campestris* inoculation of different Brassicaceae. *Sci. Hortic.* **2011**, *129*, 503–510. [CrossRef]
34. Casierra-Posada, F.; Aguilar-Avendaño, Ó.E. Calidad en frutos de tomate (*Solanum lycopersicum* L.) cosechados en diferentes estados de madurez. *Agron. Colomb.* **2008**, *26*, 300–307.
35. Peñaloza-Vázquez, A.; Preston, G.M.; Collmer, A.; Bender, C.L. Regulatory interactions between the Hrp type III protein secretion system and coronatine biosynthesis in *Pseudomonas syringae* pv. *tomato* DC3000. *Microbiology* **2000**, *146*, 2447–2456. [CrossRef] [PubMed]
36. Arah, I.K.; Ahorbo, G.K.; Anku, E.K.; Kumah, E.K.; Amaglo, H. Postharvest Handling Practices and Treatment Methods for Tomato Handlers in Developing Countries: A Mini Review. *Adv. Agric.* **2016**, *2016*, 2–8. [CrossRef]

37. Thole, V.; Vain, P.; Yang, R.; Almeida Barros da Silva, J.; Enfissi, E.M.A.; Nogueira, M.; Martin, C. Analysis of Tomato Post-Harvest Properties: Fruit Color, Shelf Life, and Fungal Susceptibility. *Curr. Protoc. Plant Biol.* **2020**, *5*, 1–17. [CrossRef] [PubMed]
38. Ilahy, R.; Tlili, I.; Siddiqui, M.W.; Hdider, C.; Lenucci, M.S. Inside and Beyond Color: Comparative Overview of Functional Quality of Tomato and Watermelon Fruits. *Front. Plant Sci.* **2019**, *10*, 1–26. [CrossRef] [PubMed]
39. Kim, C.; Hung, Y. Inactivation of *E. coli* O157:H7 on blueberries by electrolyzed water, ultraviolet light, and ozone. *J. Food Sci.* **2012**, *77*, M206–M211. [CrossRef] [PubMed]
40. Sun, J.; Zhang, S.; Chen, J.; Han, B. Efficacy of acidic and basic electrolyzed water in eradicating *staphylococcus aureus* biofilm. *Can. J. Microbiol.* **2012**, *58*, 448–454. [CrossRef] [PubMed]
41. Buck, J.W.; Van-Iersel, M.W.; Oetting, R.D.; Hung, Y. Evaluation of acidic electrolyzed water for phytotoxic symptoms on foliage and flowers of bedding plants. *Crop Prot.* **2003**, *22*, 73–77. [CrossRef]
42. Hirayama, Y.; Asano, S.; Watanabe, K.; Sakamoto, Y.; Ozaki, M.; Okayama, K.; Tojo, M. Control of *Colletotrichum fructicola* on strawberry with a foliar spray of neutral electrolyzed water through an overhead irrigation system. *J. Gen. Plant Pathol.* **2016**, *82*, 186–189. [CrossRef]
43. Mueller, D.S.; Hung, Y.; Oetting, R.D.; Van Iersel, M.W.; Buck, J.W. Evaluation of electrolyzed oxidizing water for management of powdery mildew on gerbera daisy. *Plant Dis.* **2003**, *87*, 965–969. [CrossRef]
44. Zarattini, M.; De Bastiani, M.; Bernacchia, G.; Ferro, S.; De Battisti, A. The use of ECAS in plant protection: A green and efficient antimicrobial approach that primes selected defense genes. *Ecotoxicology* **2015**, *24*, 1996–2008. [CrossRef]
45. Nassiri, S.M.; Tahavoor, A.; Jafari, A. Fuzzy logic classification of mature tomatoes based on physical properties fusion. *Inf. Process. Agric.* **2022**, *9*, 547–555. [CrossRef]
46. Sugiharta, L.; Maretta, G.; Pawhestri, S.; Eka, A. Electrolysis of Water Using Iron Electrode to Boost the Growth of Hydroponic Plant of Water Spinach. *J. Phys. Conf. Ser.* **2019**, *1155*, 012054. [CrossRef]
47. Zhou, C.; Pei, L.; Zhao, J.; Gao, W.; Qi, F.; Ye, Z.; Zhu, S. Effect of Irrigating with Slightly Acidic Electrolyzed Water on Lettuce Photosynthesis under Mild Water Stress. *Appl. Eng. Agric.* **2014**, *30*, 789–795. [CrossRef]
48. Yeshiwas, Y.; Tolessa, K. Postharvest quality of tomato (*Solanum lycopersicum*) varieties grown under greenhouse and open field conditions. *Int. J. Biotechnol. Mol. Biol. Res.* **2018**, *9*, 1–6. [CrossRef]
49. Cantwell, M.; Stoddard, S.; LeStrange, M.; Aegerter, B. *Report to the California Tomato Commission. Tomato Variety Trials: Postharvest Evaluations for 2006*; UCCE Fresh Market Tomato Variety Trial 2006 Postharvest Evaluation; UC Davis: Davis, CA, USA, 2006; 16p.
50. Okolie, N.; Sanni, T. Effect of post harvest treatments on quality of whole tomatoes. *Afr. J. Food Sci.* **2012**, *6*, 70–76. [CrossRef]
51. Sinha, S.R.; Singha, A.; Faruquee, M.; Jiku, M.A.S.; Rahaman, M.A.; Alam, M.A.; Kader, M.A. Post-harvest assessment of fruit quality and shelf life of two elite tomato varieties cultivated in Bangladesh. *Bull. Natl. Res. Cent.* **2019**, *43*, 185. [CrossRef]
52. Cardona, C.; Arjona, H.; Araméndiz-Tatis, H. Influencia de la fertilización foliar con Ca sobre la pudrición apical en tomate (*Lycopersicon esculentum* Mill.). *Agron. Colomb.* **2005**, *23*, 223–229.
53. Urrieta-Velázquez, J.A.; Rodríguez-Mendoza, M.; Ramírez-Vallejo, P.; Baca-Castillo, G.A.; Ruiz-Posadas, L.; Cueto-Wong, J.A. Production and Quality Variables of Three Selections of Ribbed Tomato (*Solanum lycopersicum* L.). *Rev. Chapingo Ser. Hortic.* **2012**, *18*, 371–881. [CrossRef]
54. Cruz-Crespo, E.; Martínez-Rodríguez, O.G.; García-Paredes, J.D.; Can-Chulim, A. Influencia del riego y sustrato en el rendimiento y calidad de tomate. *Rev. Mex. Cienc. Agríc.* **2017**, *8*, 51–63.
55. Roberts, K.P.; Sargent, S.A.; Fox, A.J. Effect of Storage Temperature on Ripening and Postharvest Quality of Grape and Mini-Pear Tomatoes. *Proc. Fla. State Hortic. Soc.* **2002**, *11*, 80–84.
56. Camelo, A.; Gómez, P. Comparison of color indexes for tomato ripening. *Hortic. Bras.* **2004**, *22*, 534–537. [CrossRef]