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Synergistic effect of ultraviolet irradiation and peracetic acid immersion on quality attributes of Fresh-cut *Elaeocarpus* Fruit

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Elaeocarpus fruit is rich in polyphenol oxidase. Therefore, fresh-cut *Elaeocarpus* fruit turns brown easily under ambient condition. Browning reaction causes inevitable degradation of quality and commercial value of this product. This research evaluated the synergistic effect of ultraviolet irradiation combined peracetic acid in retarding the browning phenomenon on fresh-cut *Elaeocarpus* fruit. The ultraviolet dosage was verified 10-30 kJ/m² and peracetic acid ranged 60-360 ppm on quality of fresh-cut *Elaeocarpus* fruit. Polyphenol oxidase (U/g/min), peroxidase (U/g/min) and total plate count (log cfu/g) of fresh-cut *Elaeocarpus* fruit were evaluated after 7 days of cool storage at 8 °C. Results noticed that ultraviolet irradiation at 25 kJ/m² combined with 300 ppm peracetic acid was effectively reduced polyphenol oxidase activity, peroxidase activity and total plate count. This research suggested that ultraviolet irradiation incorporated with peracetic acid would create a synergistic effect in controlling not only enzymatic browning but also microbial contamination on fruit and vegetable.

Keywords: *Elaeocarpus*, peracetic acid, peroxidase, polyphenol oxidase, total plate count, ultraviolet irradiation

INTRODUCTION

Elaeocarpus is an underutilized tree. It naturally distributed in Vietnam and other countries. *Elaeocarpus* fruit is rich in carbohydrates, protein, vitamins ideal to human health (Raji et al. 2016; Dadhich et al. 2013; Ying-Hsuan and Chun-Yao, 2020). This fruit also contained numerous bioactive elements such as cardiac glycosides, anthraquinone glycosides, steroids, terpenoids, polyphenols, flavonoids, myricitrin with excellent antibacterial capacity against microbial infections (Kubo et al. 1985; Bijayanta and Shyamapada, 2017). Its fruit is highly valued due to its therapeutic potentials such as antioxidant, anti-inflammatory, anti-mutagenic, and anti-nociceptive activities (Hobbs et al. 2015). Fresh-cut of this fruit is easily browning due to its abundant content of tannins and phenolics under the existing of enzymes and

oxygen (Ragunathan and Senthamarai, 2014).

Ultraviolet, a nonionizing radiation, has powerful germicidal activity widely applied in food industry (Guerrero-Beltrán and Barbosa-Cánovas 2004; Yaun et al. 2004; Cutler and Zimmerman 2011). Ultraviolet irradiation has been considered as an innovative approach in fruit processing due to its low cost and simple manipulation (Zhang and Jiang, 2019). Peracetic acid has been utilized as a food disinfectant on fruit and vegetable (Kitis, 2004). It decomposes spontaneously into acetic acid, water and oxygen without harmful effect to human health (Dell'Erba et al. 2007). PAA has been considered as a powerful oxidant superior to ozone (John et al. 2019).

The browning on fresh-cut fruit and vegetable is mainly happened by polyphenol oxidase catalyzing on phenolic acid substrate with the

presence of oxygen (Luo et al. 2015; Coelho et al. 2018). Ultraviolet radiation and peracetic acid have been demonstrated to be effective in disinfection in municipal wastewater treatment (Basanta et al. 2014). Utilization of ultraviolet irradiation incorporated with peracetic acid on fresh-cut *Elaeocarpus* fruit is not mentioned. Objective of our study was to examine the effectiveness of ultraviolet irradiation incorporated with peracetic acid to control browning and microbial load on the fresh-cut *Elaeocarpus* fruit.

MATERIALS AND METHODS

2.1 Material

Elaeocarpus fruits were naturally harvested from wild plants in Nga Nam district, SocTrang province, Vietnam. They were washed under tap water to remove dirty matters. They were drained, cut 5 verticle lines along the fruit. Ultraviolet irradiation was performed with a mercury low vapour pressure lamp generating light at 250 nm. Peracetic acid was supplied from Rainbow Trading Co. Ltd. Chemical reagents were all analytical grade.

2.2 Researching method

Fresh-cut *Elaeocarpus* fruits were immersed in peracetic acid solution (60, 120, 180, 240, 300, 360 ppm for 3 min). The treated fresh-cut *Elaeocarpus* fruits were then drained and packed in plastic bags. These bags were separately arranged on conveyor belt before passing the ultraviolet lamp in different doses (0, 10, 15, 20, 25, 30 kJ/m²). The treated samples were stored at 8 °C for 7 days. At the end of preservation, samples were taken to evaluate polyphenol oxidase (PPO) and peroxidase (POD) activities, and total plate count (TPC). Polyphenol oxidase (U/g/min) activity was measured following procedure described by Fan et al. (2019). Peroxidase activity (U/g/min) was quantified following procedure described by Liu et al. (2019). Total plate count (log cfu/g) was enumerated by 3M-Petrefilm.

2.3 Statistical analysis

The experiments were run in triplicate with different groups of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTS

3.1 Effect of peracetic acid immersion on quality attributes of fresh-cut *Elaeocarpus* fruit

The impact of peracetic acid immersion on polyphenol oxidase, peroxidase activities and total plate count was clearly presented in table 1. It's obviously noticed that 300 ppm peractic acid solution was appropriate to retard polyphenol oxidase, peroxidase activities and total plate count on fresh-cut *Elaeocarpus* fruit. There was no significant difference of quality attributes on fresh-cut *Elaeocarpus* fruit between 300 ppm and 360 ppm peractic acid. Therefore, 300 ppm peracetic acid should be selected for next experiment. Peracetic acid is an oxidative reagent, interferring directly into sulfhydryl and sulfur bonds in proteins and enzymes contained in the cell membrane (Kitis, 2004; Ronald et al. 2003), meanwhile ultraviolet is a nonionizing radiation agent, damaging DNA mainly through pyrimidine dimerization (Dodd, 2012). They interact differently on microorganism to enhance microbial mortality.

3.2 Effect of ultraviolet irradiation incorporation with peracetic acid on quality attributes of fresh-cut *Elaeocarpus* fruit

The synergistic influence of peracetic acid immersion and ultraviolet irradiation on polyphenol oxidase, peroxidase activities and total plate count was clearly presented in table 2. It's obviously noticed that 300 ppm peractic acid solution combined with ultraviolet irradiation 25 kJ/m² created a synergistic impact to greatly reduced polyphenol oxidase, peroxidase activities and total plate count on fresh-cut *Elaeocarpus* fruit. There was no significant difference of quality attributes on fresh-cut *Elaeocarpus* fruit between 25 kJ/m² and 30 kJ/m². Therefore, 25 kJ/m² ultraviolet irradiation incorporated with 300 ppm peracetic acid was suitable for controlling browning and microbial proliferation in the fresh-cut *Elaeocarpus* fruit.

Ultraviolet treatment retarded browning of fresh-cut pears during storage by enhancing the polyphenol oxidase activity, reduce the phenylalnineammonialyase activity and total phenolic content, and reduce the accumulation of H₂O₂ and MDA (Chen et al., 2020). Zhao et al. (2021) confirmed that ultraviolet treatment (8 KJ/m²) significantly retarded the browning index, polyphenol oxidase and peroxidase activities, and total aerobic plate count on fresh-cut yam.

Table 1: Peracetic acid (ppm) immersion on PPO (U/g/min), POD (U/g/min) and TPC (log cfu/g)

Peracetic acid (ppm)	60	120	180	240	300	360
PPO (U/g/min)	7.60±0.01 ^a	6.45±0.02 ^{ab}	5.73±0.03 ^b	4.58±0.02 ^{bc}	3.23±0.01 ^c	3.01±0.00 ^c
POD (U/g/min)	0.79±0.00 ^a	0.70±0.03 ^{ab}	0.62±0.02 ^b	0.53±0.01 ^{bc}	0.44±0.03 ^c	0.42±0.01 ^c
TPC (log cfu/g)	8.14±0.03 ^a	7.25±0.00 ^{ab}	6.41±0.01 ^b	5.80±0.00 ^{bc}	4.95±0.02 ^c	4.74±0.02 ^c

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant ($\alpha = 5\%$).

Table 2: Peracetic acid (ppm) combined with ultraviolet irradiation (kJ/m²) on PPO (U/g/min), POD (U/g/min) and TPC (log cfu/g)

Ultraviolet (kJ/m ²)	Peracetic acid (300 ppm)					
	0	10	15	20	25	30
PPO (U/g/min)	3.23±0.01 ^a	1.72±0.00 ^b	1.23±0.01 ^{bc}	0.98±0.00 ^c	0.40±0.02 ^{cd}	0.16±0.03 ^d
POD (U/g/min)	0.44±0.03 ^a	0.21±0.01 ^b	0.15±0.00 ^{bc}	0.11±0.03 ^c	0.03±0.01 ^{cd}	0.02±0.00 ^d
TPC (log cfu/g)	4.95±0.02 ^a	2.36±0.03 ^b	2.01±0.02 ^{bc}	1.47±0.02 ^c	1.05±0.00 ^{cd}	0.60±0.01 ^d

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant ($\alpha = 5\%$).

Ultraviolet radiation (900 mJ/cm²) combined with peracetic acid (800 mg/ml) was used to achieve the highest *Salmonella* reduction (2-52 log CFU/g) on lettuce or green onion (Ge et al. 2013). Yaun et al. (2004) used ultraviolet irradiation (1.5–24 mW/cm²) to sanitize *Salmonella* and *E. coli* O157:H7 on different fruits. Fonseca and Rushing (2006) proved that microbial load on the fresh-cut watermelon was reduced by ultraviolet irradiation (410 mJ/cm²).

CONCLUSION

The *Elaeocarpus* fruit is rich in carbohydrates, protein, vitamins, and phenolics beneficial to human health. Fresh-cut quality of this fruit is easily degraded by browning and microbial contamination. This research was successfully investigated the synergistic effect of peracetic acid and ultraviolet irradiation on quality of the fresh-cut *Elaeocarpus* fruit. Ultraviolet irradiation incorporated with peracetic acid should be applied on fruit and vegetable for retard browning and microbial contamination.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

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