Individual Effect of UV-C Radiation and Hot Water Treatment on Harvested Quality of Chili

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Abstract. The aim of study was to determine the individual effect of UV-C radiation and Hot Water Treatments (HWT) in preserving quality of chili packed in Modified Atmosphere Packaging (MAP) under ambient temperature storage. Chili was radiated by UV-C for 15 min and for 20 min, with HWT at 45 °C for 15 min and at 53 °C for 4 min, and untreated as control. After treatments, all fruits were packaged and stored at room temperature (25 °C) for 1 month. The results that untreated chilli could be stored for 7 days, treated chilli with UV-C 15 min and HWT at 45 °C for 15 min could be stored for 14 days, while chilli treated with UV-C for 20 min and HWT at 53 °C for 4 min could be stored for 17 days. Among all treatments, chili treated with UV-C for 20 min suppressed the disease severity and maintained the harvested quality of chilli. This study suggests that combination UV-C irradiated with HWT under low temperature might be extended the shelf life of chili.

Keywords: Chilli, UV-C, Hot Water Treatment, Modified Atmosphere Packaging, Shelf-life

1. Introduction
Chilis are a horticultural product that use largely as ingredient in Indonesian food. The high demand of chili has been encouraged their trading not only in domestic market but also in oversea. However, in high harvesting season, chili supplies in the market become abundant and this condition affects on its marketability. Marketed to other regions is constrained by the lack of technology in quality preservation especially during storage and transportation process. However, chili is perishable commodity and easy
infected by anthracnose disease which makes chili rotten quickly. Fungi is the main cause of disease in chili, and it become major prevalent and widespread postharvest disease [1, 2].

Many treatments have been used to control of chili anthracnose pathagens in chili. Application of chemical fungicides has been used to control chili anthracnose disease, but these treatment cause the fungicide-resistant pathogens [3] and the risks to consumers and environment [4, 5, 2]. Therefore, safe alternative treatments have become an essential requirement for the management of postharvest disease of perishable commodity.

UV-C has also emerged as an alternative method to avoid chemical fungicides. UV-C irradiation increased the disease resistance against anthracnose and improved the harvested quality of perishable commodity. It has been reported that UV-C irradiation reduced disease incidence and severity, and improve quality of mango compared with untreated fruit [6]. HWT also has potential treatment as a non chemical method for controlling postharvest disease. Application of HWT delayed of decayed in pepper fruit compared without treatment pepper fruit [7].

Moreover, Modified Atmosphere Packaging (MAP) has been subject of the many studies for maintaining the quality of perishable commodity during storage and transportation. The ability of MAP to reduce CI is thought as reduction in O2 and elevation of CO2 inside the package as well as a higher humidity inside packaging. It has been reported that MAP preserved the quality of ‘Jiro’ persimmon for export market. The optimal of bulk MAP was also designed for long-term storage of ‘Fuyu’ perssimmon [8].

In order to control postharvest disease and prolong of storage of chili, the individual influence of UV-C irradiation and HWT on chili rot disease and quality were investigated. In this study, chilis were stored at enviroment temperature (25°C) which is actual temperature for storage and transported of chili to the market.

2. Materials and Methods

2.1 Plant Materials and Storage Conditions
Chilli (Capsicum annum L.) at commercial maturity were harvested from Solok Regency, West Sumatra Province, Indonesia and transported immediately to laboratory. Fruits were sorted and selected on the basis of uniform size and absence of visual defects. Chilis were devided on five groups. First group was irradiated using UV-C Germicidal lamp 30 watt (peak emission 254 nm) for 15 min to provide doses 7 kJ/m2. The UV-C radiation doses was measured using UV–Light meter (YK–37UVSD, Taiwan). Second group was irradiated with UV-C for 20 min to provide doses 9 kJ/m2. Thrid group was treated with HWT at 45 °C for 15 min in water bath (WNB14–Memmert, Germany). Fourth groups were treated with HWT at 53 °C for 4 min. The last goup was untreated chilli as control. After treatment, chilis were packaged in in Low Density Poliethylene (LDPE) about 100 g per packaged, and stored at room temperature (25°C) for 1 month.

2.2 Disease Severity
Disease severity of chili was evaluated by visual observation of fruit based on surface area of surface decayed in term of 0–4 index: 0 (no signs of decay; 1 (<25%); 2 (25–50%); 3 (51–75%) and 4 (>75%). Disease severity between 0 and 4 calculated as:

\[ DS = \frac{\sum (DI) \times \text{(number of fruit at index)}}{\text{(Total of fruit)}} \]  

where DS and DI were disease severity and disease index, respectively.

2.3 Quality Evaluation
The weight of chilli from each experimental condition was measured. Weight loss of each fruit in the chamber was calculated as a percentage of initial fresh weight. Skin colour was measured during a lobivon colour measurement (MRM200, China) yielding parameters L*, a* and b*. Skin colour measurement was made at the base, middle, and bottom of the chili. The results were expressed as the
hue angle \( \theta = \tan^{-1} \frac{b^*}{a^*} \). The firmness was measured by using fource gauge (FGS-Japan) expressing as \( F (N) \) represent the force exerted on a sample under compression. Titrable acidity was measured using titrimetric method using with 0.01 N iodine solution. \( \text{pH} \) was measured using \( \text{pH} \) meter to determin the \( \text{pH} \) change during storage.

2.4 Malondialdehyde Content
Malondialdehyde (MDA) was determined according to the method of Hodges et al (1999) with some modifications as mentioned in Fahmy and Nakano (2014b).

2.5 Total of Microbes
Chilis from each packet of treatments were evaluated to determine microbial load as per the standard plate count method. Total plate count agar was used to determine yeast and molds count. A 5 g sample was diluted with 9 mL of 0.86\% NaCl solution, homogenized and was then further diluted to get serial dilutions. Serially diluted samples were plated onto total plate count agar. 1 mL of each dilution was transferred to sterile petri plate and 15–20 mL of sterile agar media at temperature 40–45 °C was poured, mixed well and allowed to set. Plates were incubated at 37 °C for 48 h. At the end of the incubation period the colony forming unit (cfu) were counted and multiplied by appropriate dilution factor to obtain total plate count.

2.6 Statistical Analysis
The design was completely randomised with 3 replications and each replicates consisted 100 g of chilis packaged in LDPE. Statistical significance was determined by subjecting the mean values to analysis of variance and means were compared by Tukey’s test at the 5\% level of significance using R 3.5.1 (R Foundation).

3. Results and Discussion

3.1 Disease severity
Disease severity (DS) increased rapidly on untreated chili and chili treated with HWT at 45 °C for 15 min on day 7, while chilis treated with UV-C for 15 min and 20 min, and HWT at 53°C for 4 min the DS were suppressed, and then increased gradually for all treatments tested until the end of storage. From the result, chili had different shef life among the treatments. Untreated chili (control) had shelf life for 10 days, chili treated with UV-C for 15 min and HWT at 45 °C for 15 had shelf life for 14 days, while chili treated with UV-C for 20 min and HWT at 53 °C for 4 min had shelf life for 17 days. Sripong et al. (2015) reported that UV-C and HWT suppressed the disease severity on mango fruit. HWT at 53 °C for 4 min suppressed of decay on pepper fruit compared with control and HWT at 45 °C for 15 min [7].
3.2 Quality of Chili

Weight loss of chili increased significantly during period of storage at 25 °C for all treatments. Significant increase was shown on untreated chili (control) compared with treated chilis (Figure 2). Among treated chilis, treatment with UV-C for 20 min showed significant suppresses the increasing of the weight loss. Weight loss of mango increased gradually during period of storage treated with UV-C and HWT, however, significant different was not found among them [6].

Figure 1. Disease severity of chili treated with UV-C irradiation for 15 min and 20 min, HWT at 45 °C for 15 min and at 53 °C for 4 min, and untreated (control) during storage at 25 °C packed with LDPE (0.08 mm thick). Vertical bars represent standard error of the means (SE) for triplicate samples.

Figure 2. Weight loss of chili treated with UV-C irradiation for 15 min and 20 min, HWT at 45 °C for 15 min and at 53 °C for 4 min, and untreated (control) during storage at 25 °C packed with LDPE (0.05 mm thick). Vertical bars represent standard error of the means (SE) for triplicate samples.
Skin colour as hue value of chili decreased during period of storage at 25 °C for all treatments (Figure 3), however, significant difference in hue value was not found among them.

Firmness of chilli decreased significantly during period of storage at 25 °C for all treatments. Rapid decrease in firmness was shown on untreated chili compared with treated chilli. However, significant difference was not found among them.
Titrable acidity increased for chili treated with UV-C for 15 min, HWT at 45 °C for 15, and HWT 53 °C for 4 min on day 7, after, the value decreased gradually until the end of storage. While for chili treated with UV-C for 20 min, the titrable acidity was stable relatively during period of storage, however, significant difference was not found among treatments tested. UV-C radiation more effective to maintain the titrable acidity compared with HWT [6].

![Graph of Titrable Acidity](image5)

**Figure 5.** Titrable acidity of chili treated with UV-C irradiation for 15 min and 20 min, HWT at 45 °C for 15 min and at 53 °C for 4 min, and untreated (control) during storage at 25 °C packed with LDPE (0.08 mm thick). Vertical bars represent standard error of the means (SE) for triplicate samples.

pH values of chili decreased below 7 showing on untreated and HWT chilis, while chiles treated with UV-C showed on increases of pH above 7 during period of storage, and significant difference in pH values was found among all treatments. After day 7, pH value decreased significantly on untreated and treated chili with HWT 45 °C for 15 min, while chili treated with HWT at 53 °C for 4 min decreased gradually until day 14 of storage. For chili radiated with UV-C, the pH value was maintained above 7 for both the treatments until the day 14 and 17 for UV-C for 15 min and 20 min, respectively.

![Graph of pH](image6)

**Figure 6.** pH of chili treated with UV-C irradiation for 15 min and 20 min, HWT at 45 °C for 15 min and at 53 °C for 4 min, and untreated (control) during storage at 25 °C packed with LDPE (0.08 mm thick). Vertical bars represent standard error of the means (SE) for triplicate samples.
3.3 MDA Content

MDA content increased on untreated chili and radiated UV-C chili on day 7, and then this value decreased until the end of storage, while on HWT chili, MDA content decreased and then increased gradually. However, significant difference in MDA content was not found among treatments.

![Figure 7. MDA content of chili treated with UV-C irradiation for 15 min and 20 min, HWT at 45 °C for 15 min and at 53 °C for 4 min, and untreated (control) during storage at 25 °C packed with LDPE (0.08 mm thick). Vertical bars represent standard error of the means (SE) for triplicate samples.](image)

3.4 Total Microbes

The total microbes increased during period of storage at 25 °C for all treatments tested. However, significant difference in total microbes was not found among treatments. Nevertheless, chilli treated with UV-C at 53 °C for 4 min showed a lower value of microbes compared with other treatments until the end of storage.

| Storage Days | Control | UV-C 15 min | UV-C 20 min | HWT 45 °C | HWT 53 °C |
|--------------|---------|-------------|-------------|-----------|-----------|
| 0            | 1.5a    | 1.5a        | 1.5a        | 1.5a      | 1.5a      |
| 7            | 1.5a    | 1.6a        | 1.5a        | 1.7a      | 1.6a      |
| 10           | 1.8a    | 1.7a        | 1.7a        | 1.7a      | 1.7a      |
| 14           | 2.2a    | 1.8a        | cnc         | 1.6a      |           |
| 17           |         | 1.8a        |             |           | 1.7a      |

4. Conclusion

In this study, the individual effect of UV-C radiation and HWT on harvested quality of chili were investigated. From the results, chili treated with UV-C for 20 min and with HWT at 53 °C for 4 min prolonged the shelf life of chili compared with others treatments. This study suggests that combination UV-C irradiated with HWT under low temperature storage might be more effective to maintain the harvested quality of chili.
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