CHAPTER 5

Effect of EO water and US wave on Postharvest Quality Changes of Pineapple Fruit during Storage

5.1 Introduction

Pineapple is one of the most important crops in the Thailand. It is tasty, high nutrition value and riches source of vitamin C, consumption is in the form of fresh fruit rather than canned fruit. Phu Lae variety refer to the Queen Group, this is another Phuket species. The fruit is small, weighing 150-1,000 grams; the skin is rather thick and suitable for long distance transport. When the fruit is ripe, the skin will be yellow or greenish yellow. The pineapple fresh color is relatively light yellow, crispy and aromatic. The core is crispy and edible. On the postharvest handling process, the pineapple crown will be removed due to requirements of the markets, which may causes pathogens penetration through that wound. Even though postharvest loss cause by fungus could be reduce with chemical disinfection. These chemical may also cause toxic residue and environmental pollution. Most people are concerned about the effect on food safety. Thus, postharvest management for food safety is needed. Advanced oxidation processes generate the highly reactive hydroxyl radical (•OH) to attack the most organic molecules rapidly and non-selectively. Our research point out to two kind of advanced oxidation technology for control postharvest disease in de-crowned pineapple fruit. First is electrolyzed oxidizing water or EO water. EO water is produced by applying a low-voltage electrical charge to salt solution. Sodium ions form sodium hydroxide (NaOH). Chloride ions form hypochlorous acid (HClO), which is a powerful disinfectant (Buck *et al.,* 2002). Second is ultrasound (US) wave. US wave is high sound wave with a frequency greater than the human hearing range. US wave in liquids causes gas bubbles to form and then often collapse violently. When those bubbles implode in cleaning solutions, they destroy some microbes (Piyasena *et al.,* 2003;

Adekunte *et al.*, 2010; Gogate and Kabadi, 2009).Thus, the objective of this study was to evaluate the effect of EO water and US wave on quality of pineapple after treated and during storage at room temperature and cold temperature because the most important of marketing pineapple is high quality.

5.2 Materials and methods

The spore suspension was prepared as described on the chapter 4. About 0.1 of it was artificially inoculated on to the center of de-crowned pineapple fruit. All fruits were incubated at room temperature for 3 h, before application of respective washing treatments. All inoculated fruits were treated with the following treatments. For US wave treatment, inoculated samples (36 fruits) were subjected to ultrasonic waves of 3 watts and at a constant frequency of 1 MHz. The experiments were carried out in an ultrasonic water bath (Honda Electronics Company (Toyohashi, Aichi, Japan) dimensions: 44.5 × 51.5 × 35 cm). The capacity of the device was 50 liters; large enough to wash 10 Kg of pineapple fruits. For the EOW treatment, inoculated samples were immersed in 50 liters with a concentration of free-chlorine at 100 ppm. For the combined treatments, pineapple fruits were immersed into the ultrasonic chamber containing EOW with a free-chlorine concentration of 100 ppm and subjected to simultaneous continuous US at 1 MHz. Pineapple fruits, treated with tap water, were used as controls. After the treatments, fruit samples were placed in a basket and air-dried. Fruit were then covered with a commercial plastic bag and maintained at 13 or 25 °C. Samples were taken initially and at 5-day intervals for those stored at 13 °C and every day for those stored at 25 °C for days, for quality evaluation and analyses.

5.2.1 Fruit firmness and fruit weight loss percentage

Flesh firmness was measured after slicing the fruit into half along its core. The maximum force (Newton) to rapture the fresh tissue was determined 3 measurements on top, middle, and base of each fruit with a stable micro-systems TA-TXT2i texture analyzer (Texture Technologies Crop, UK) equipped with 6 mm cylinder probe (P/6) type penetrating at a velocity of 10 mm/min. to a final depth of 15 mm. To determine fruit weight loss, fruit samples in each treatment, three replicates of four fruits, were weighed, and recorded. After a period of time, the fruit was reweighed. The percent of weight loss was calculated as follows:

$$\% \text{ weight loss} = \frac{\text{initial fruit weight} - \text{final fruit weight}}{\text{Initial fruit weight}} \times 100$$

5.2.2 Pulp color

The pulp color of pineapple fruit was measured with a colorimeter (Minolta CR-200, Japan) after calibrating it with a white and black tile. L*, a* and b* coordinates were recorded and the L* a* and b* values converted to hue angle (H°) according to Mclellan et al., 1995 formulation where (Hue angle (H°) = $\tan^{-1}$b*/a*). A low L* value corresponded to a low brightness and a higher L* value meant a brighter fruit. The a* value measured the greenness and redness on a scale of -60 to +60. A minus a* value meant a green color and a positive value of a* meant red color. The b* value measured the blueness and yellowness on a scale of -60 to +60. A minus b* value meant a blue color and a positive value of b* meant yellow color. The results were expressed as a mean value from 3 replications of each treatment.

5.2.3 Total soluble solids, titratable acidity, TSS/TA ratio and ascorbic acid content

For total soluble solids (TSS) and organic acids analysis, a juice sample was taken from each of three fruits of the three replications in each treatment. TSS was measured by a digital refractometer (ATAGO PAL-1, Japan) and expressed as %Brix. Titratable acidity (TA) was determined by the titrimetric method, involving the titration of fruit juice with 0.1 M sodium hydroxide, and the formation of pink precipitate was monitored using phenolphthalein. The results were calculated as equivalents of citric acid, which is the main organic acid in tangerine fruit. Ascorbic acid content was determined by the 2, 6-dichloroindolephenol titrimetric method. Ascorbic acid reduced indicator dye, 2, 6-dichloroindophenol, to a colorless solution. At the end point, excess unreduced dye was rose pink in acid solution.

5.2.4 Sensory evaluation

A panel of four trained people (four women and one men; aged 23-33) analyzed visual appearance, aroma, taste, and crispy. Sensory evaluation were scored based on a hedonic nine-point scale (1 = dislike extremely, 3 = neither like, 5 = like moderately, 7 = like and 9 = like extremely). The overall appreciation of a sample was measured on the same scale and referred as overall quality.

5.3 Statistical analysis

The Statistical Package for the Social Science (SPSS version 17) software for Windows was used for the Analysis of Variance (ANOVA) and least-significant difference (LSD) at the 95 % confidence level of each variable value under completely randomized design (CRD). Each experiment had tree replicates and all experiments were run two times with similar results.

5.4 Results and discussion

5.4.1 Effects of EO water and US wave on fruit firmness and fruit weight loss percentage

De-crowned pineapple fruit may change in texture during storage. Fruit firmness constitutes the critical quality attributes of 'Phu lae' species, crispy and edible of the core very important of this variety. The results show that the firmness of pineapple before treated varied between 13.53 – 13.67 N, and rapidly decreased during 5 and 3 days of storage at 25 and 13 °C respectively (Figure 5.1A, B). After that the treatments did not promote significant changes in firmness and only a slight trend to a decrease after storage was found. This was probably due to the firmness did not effect by treatments, and also attributed to the low water loss which kept the firmness.

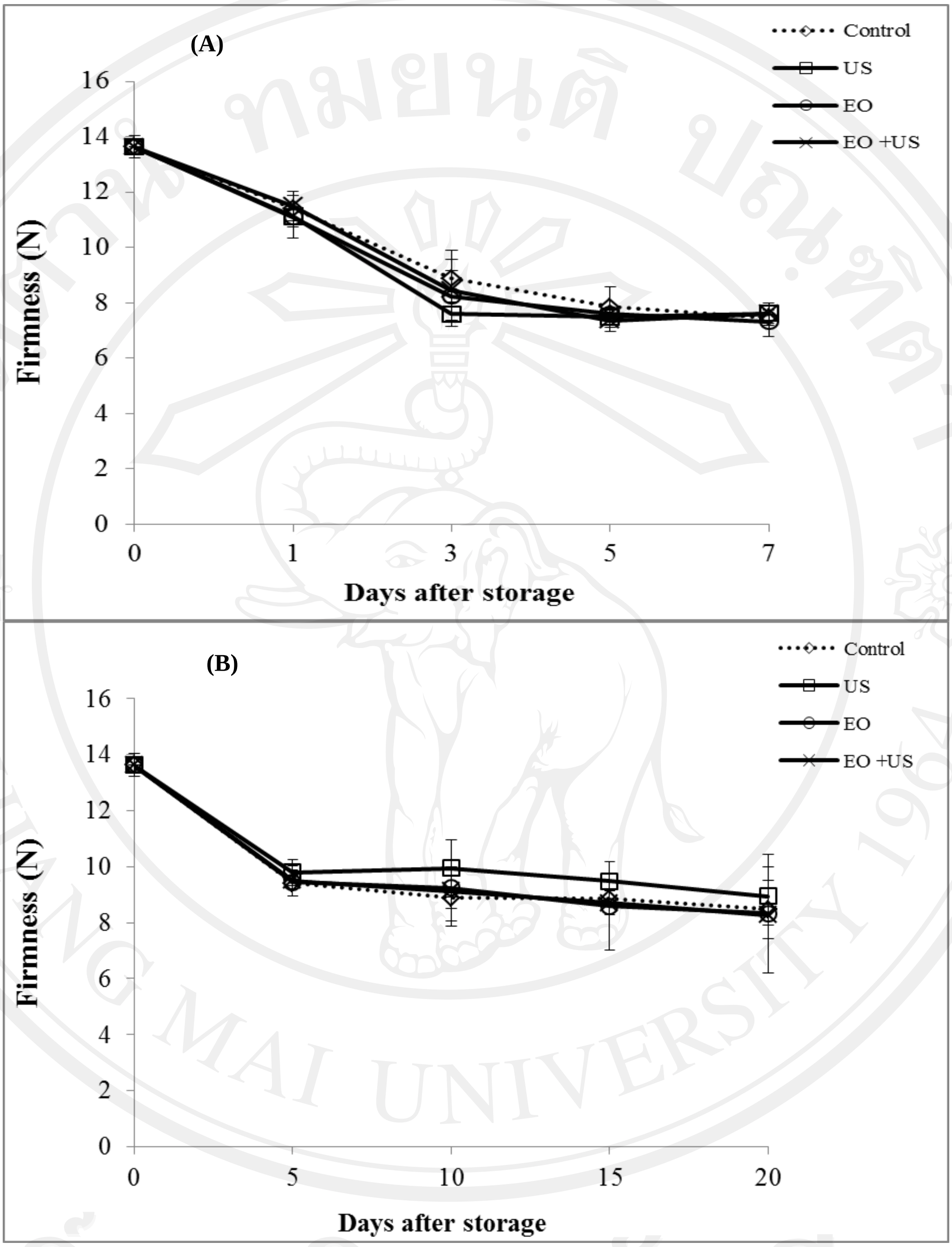

Figure 5.1 Change of firmness of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25 °C (A) and 13 °C (B).

The weight loss percentages of pineapple fruit after storage at 25 and 13 °C for 7 and 20 days were shown in Figure 5.2A and 5.2B, respectively. The results showed that the weight loss percentages of all treatment increased continuously with storage time and non-significantly affected by treatments. At the end of storage at 13 °C, the highest weight loss (9.17 %) was found in control treated fruits and the lowest weight loss (7.74%) was found in combination treatments, loss of weight due to water evaporation during storage (Artés *et al.*, 2009). The loss of weight of control greater than that of combined treatments but did not significantly differences, indicating that treatments were delayed the weight loss, and might be described as a consequence of fungal development on de-crowned pineapple fruit. The US wave and EO water treatments did not affect weight loss compared to the control, confirming results reported in other plant produce (Palou *et al.*, 2002; Tomás-Callejas *et al.*, 2011).

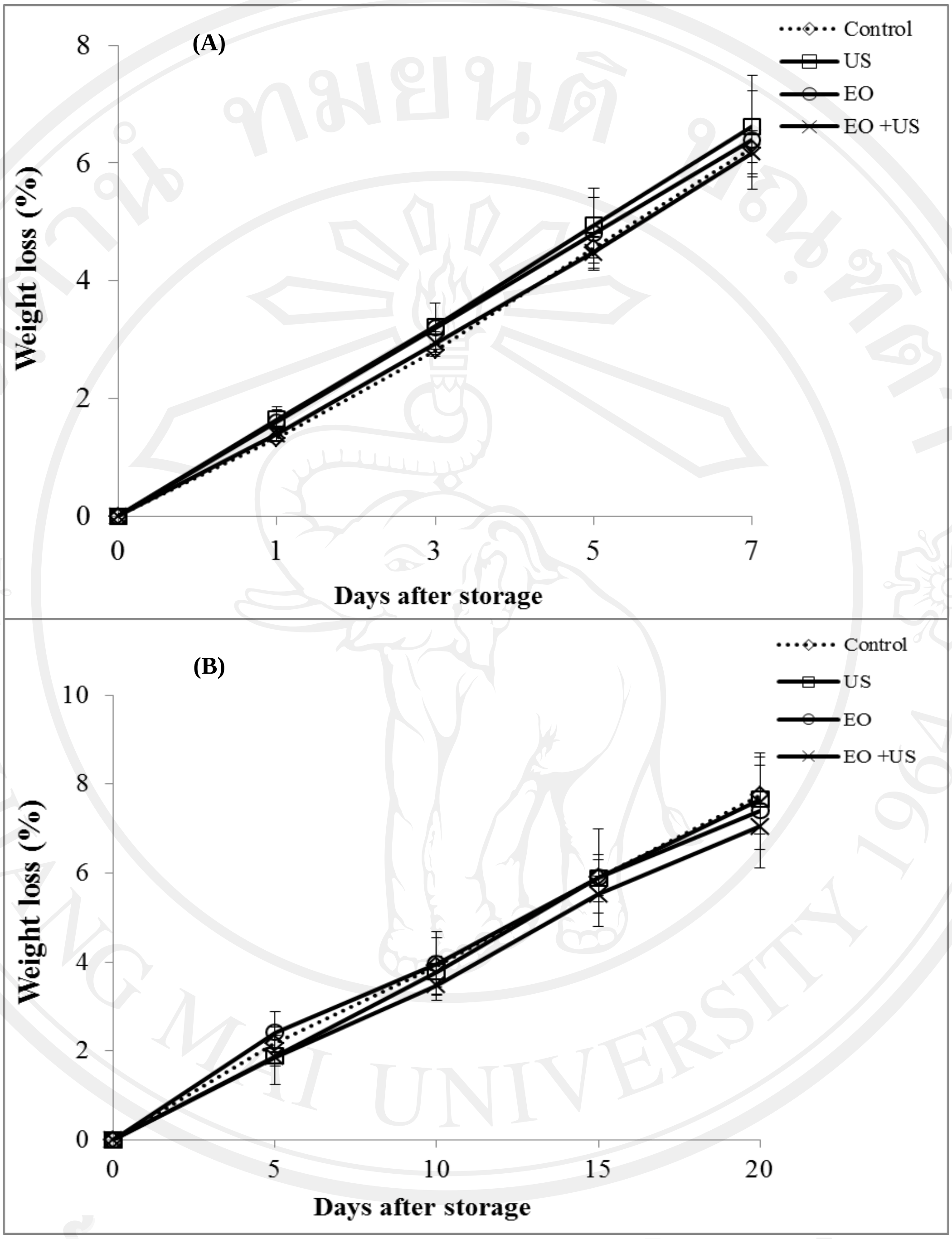

Figure 5.2 Change of weight loss of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25 °C (A) and 13 °C (B).

5.4.2 Effects of EO water and US wave on pulp color of pineapple inoculated with *Fusarium* sp.

The pulp color analysis based on the L* value showed that no statistical difference was found between the washing treatments and fruit storage at 25 °C (Figure 5.3A) and 13 °C (Figure 5.3B) when compared to the control. There was a slight increase in this parameter with the storage period for all treatments, attributed to the increase of the samples lightness. The values varied between 62.38 -75.06 and 67.51 – 75.62 during the period of cold and room temperature storage respectively (Figure 5.3 A, B). From this study, the increased of L* value pointed out that pineapple fruit pulp were brighter than the initial color. The EO water and US wave treatment resulted in non-significant differences hue angle values of the pulp color when compared to the control (Figure 5.4 A, B). The hue angle value or actual color of the pineapple pulp decreased with an increase in storage time. The change in color of the pineapple pulp when stored at 25 °C was faster than when stored at lower temperature conditions. At the 5 days of the storage period, the color of the pineapple flesh stored at 25 °C had turned an orange-yellow color, while the color of the pineapple flesh stored at 13 °C retained a slightly yellow color.

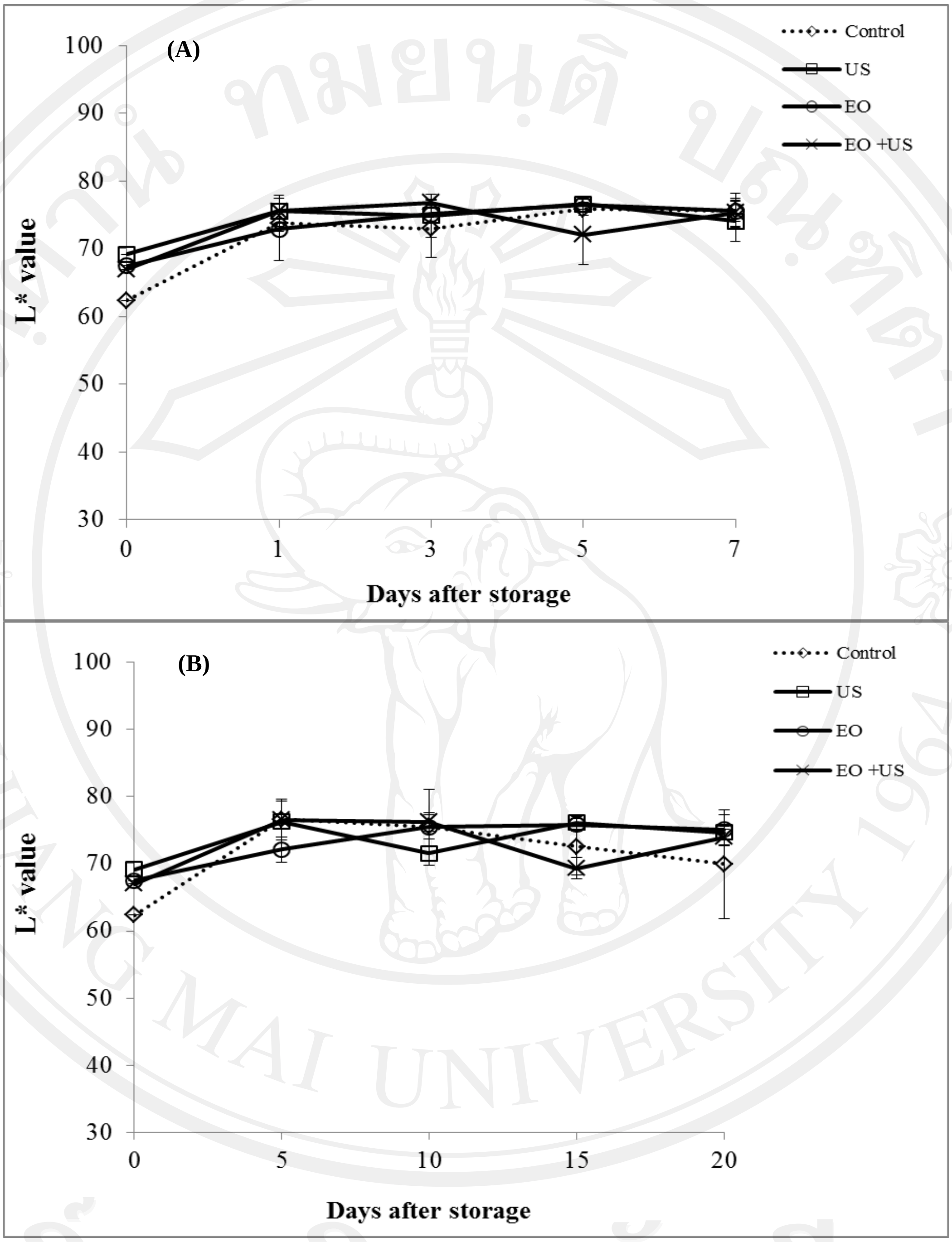

Figure 5.3 Change of Pulp L* value pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25°C (A) and 13°C (B).

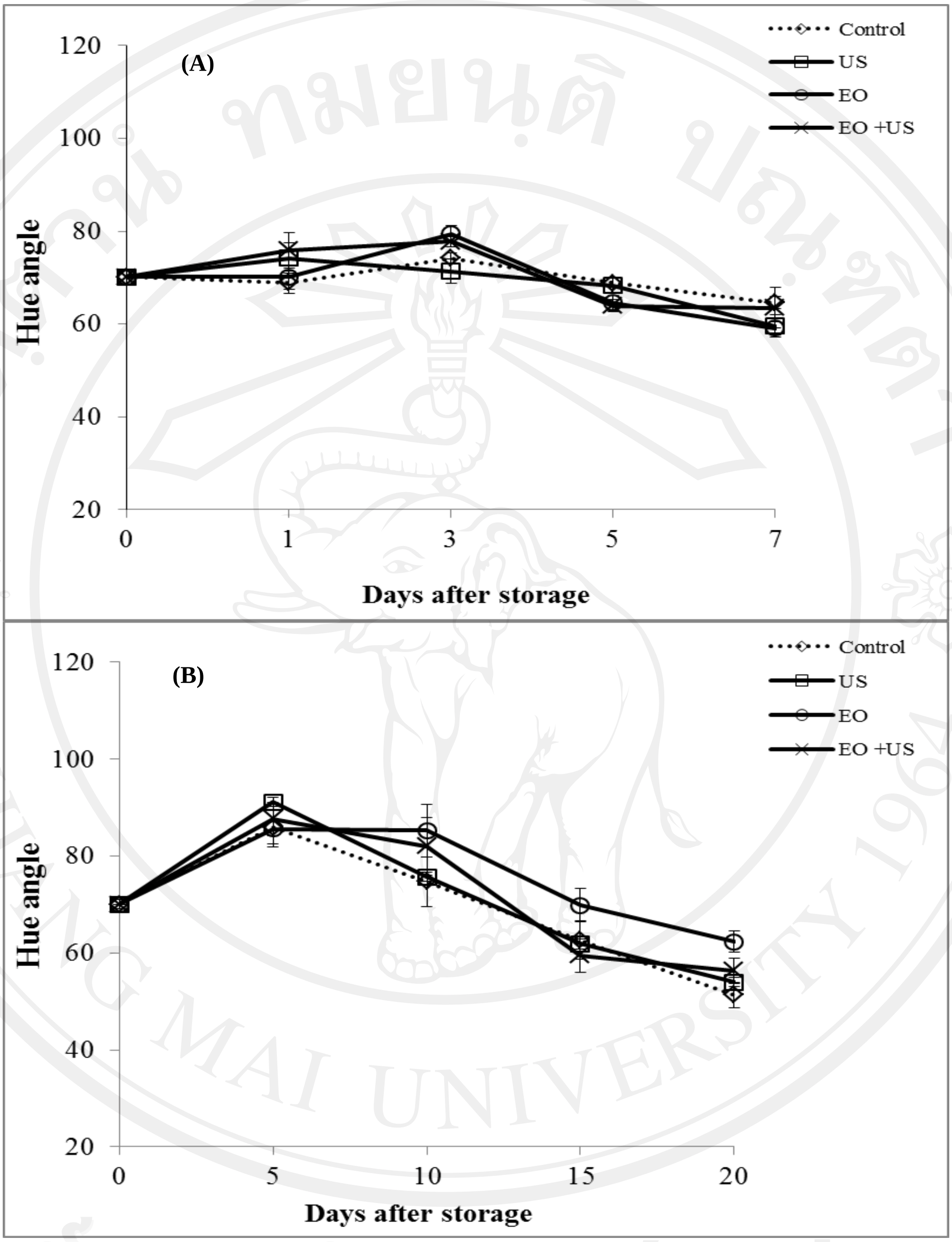

Figure 5.4 Change of pulp hue angle value of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25 °C (A) and 13 °C (B).

5.4.3 Effects of EO water and US wave on TSS, TA, TSS/TA ratio and ascorbic acid content

TSS, TA and ascorbic acid are important factors to assess the storage effect and marketability. The TSS of juice pineapple after treated with EO water and US wave then immediately evaluated, the TSS value varied between 15.9 – 16.5 % and non-significant differences among treatments. TSS value was remaining stable throughout storage period for 7 day kept at 25 °C (Figure 5.5A) and 20 days kept at 13 °C (Figure 5.5B). The treatments had no effect on TSS content when compare with the control treatment in both kept in cold and room temperature.

TA content of pineapple juice was not significant affected by EO water and US wave treatments, with treatments having higher level of TA than control throughout storage. During storage, the TA content of the pineapple fruit initially increased but not significantly and reached peak value at 3 and 10 days of kept at room and cold temperature respectively(Figure 5.6A,B), then underwent a downward trend, following a similar pattern in all treatments. On the other hand, TSS/TA ratio trend to increased but non- significant differences during the storage time for all room and cold temperature (Figure 5.7A, B).

Ascorbic acid is one of the most important nutritional quality factor in pineapple fruit and has many biological activities in the human body. The average value of ascorbic acid content in all treatments was 16.77 mg/100 mL after treatments (Figure 5.8). All treatments decrease the level of ascorbic acid content during storage for 7 and 20 days in room and cold temperature, and treatments with EO water and US wave presented higher ascorbic acid content as compared with the control but non statistic significant difference. The results of this experiment revealed that the fruits kept at 13 °C (Figure 5.8B) had higher ascorbic acid content than those stored at 25 °C (Figure 5.8A). The loss of ascorbic acid in fruits stored at high temperature could be due to the acid's antioxidant property, being used to remove free radicals for maintaining plant health status and act jointly with antioxidant enzymes (Seung and Kader, 2000).

In this experiment, no significant changes were found in TSS, TA and ascorbic acid during storage for any treatment. This observation similar to that reported of Cao *et al.,* 2010 that treatments with 25 and 28 kHz ultrasound had no significant effects on fruit decay and quality deterioration of strawberry fruit. The non-statistical difference among treatments pointed out that EO water and US wave had no effect on quality of fruit. The results agree with that EO water in combination with ozone to postharvest decay of tangerine fruit and the treatments had any effect on the quality of fruit (Whangchai *et al*., (2010). Moreover, Yang *et al.,* 2011also reported that the application of ultrasound in combination with SA did not impair quality parameters such as firmness, TA, TSS and vitamin C of peaches fruit.

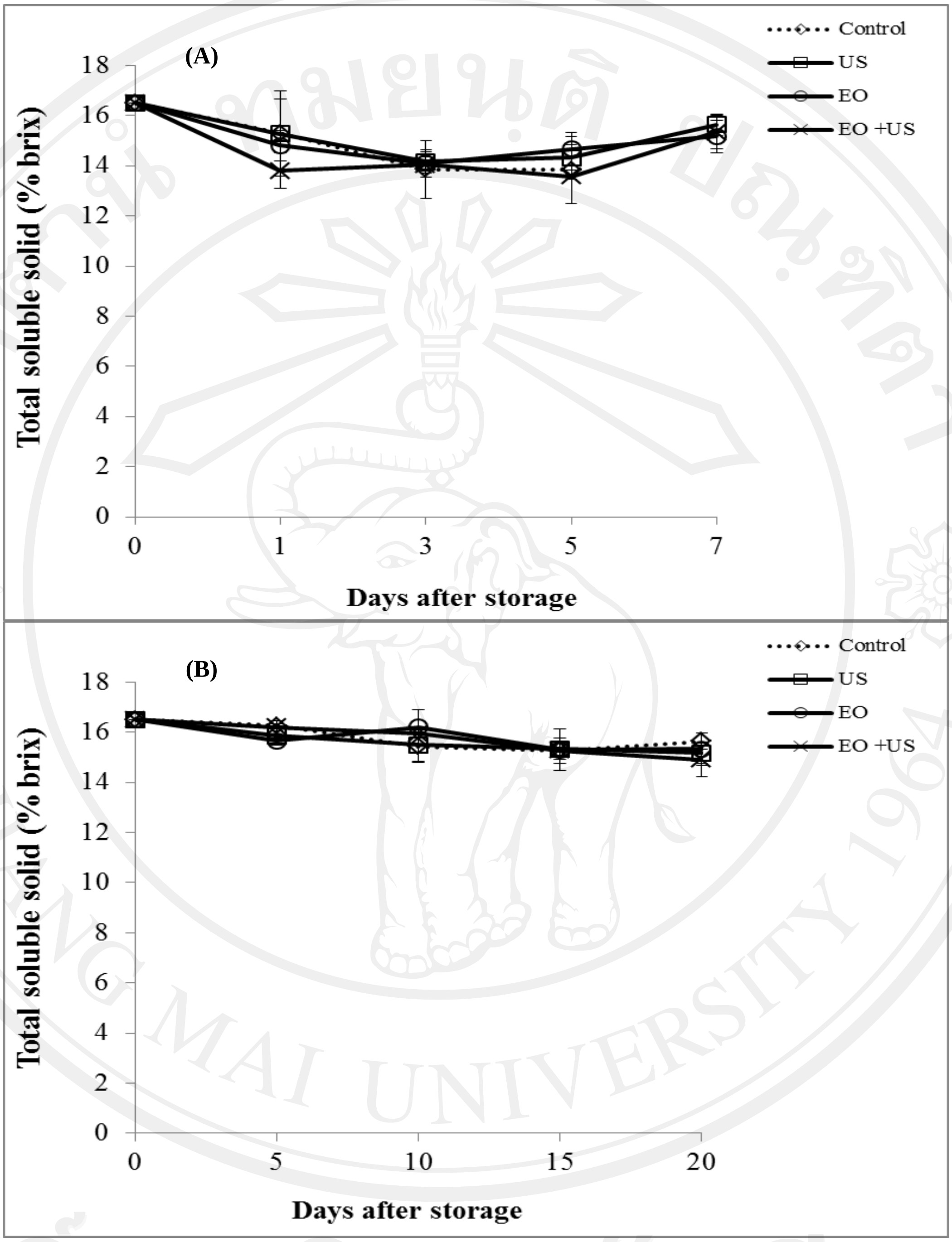

Figure 5.5 Change of total soluble solids (TSS) of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25°C (A) and 13°C (B).

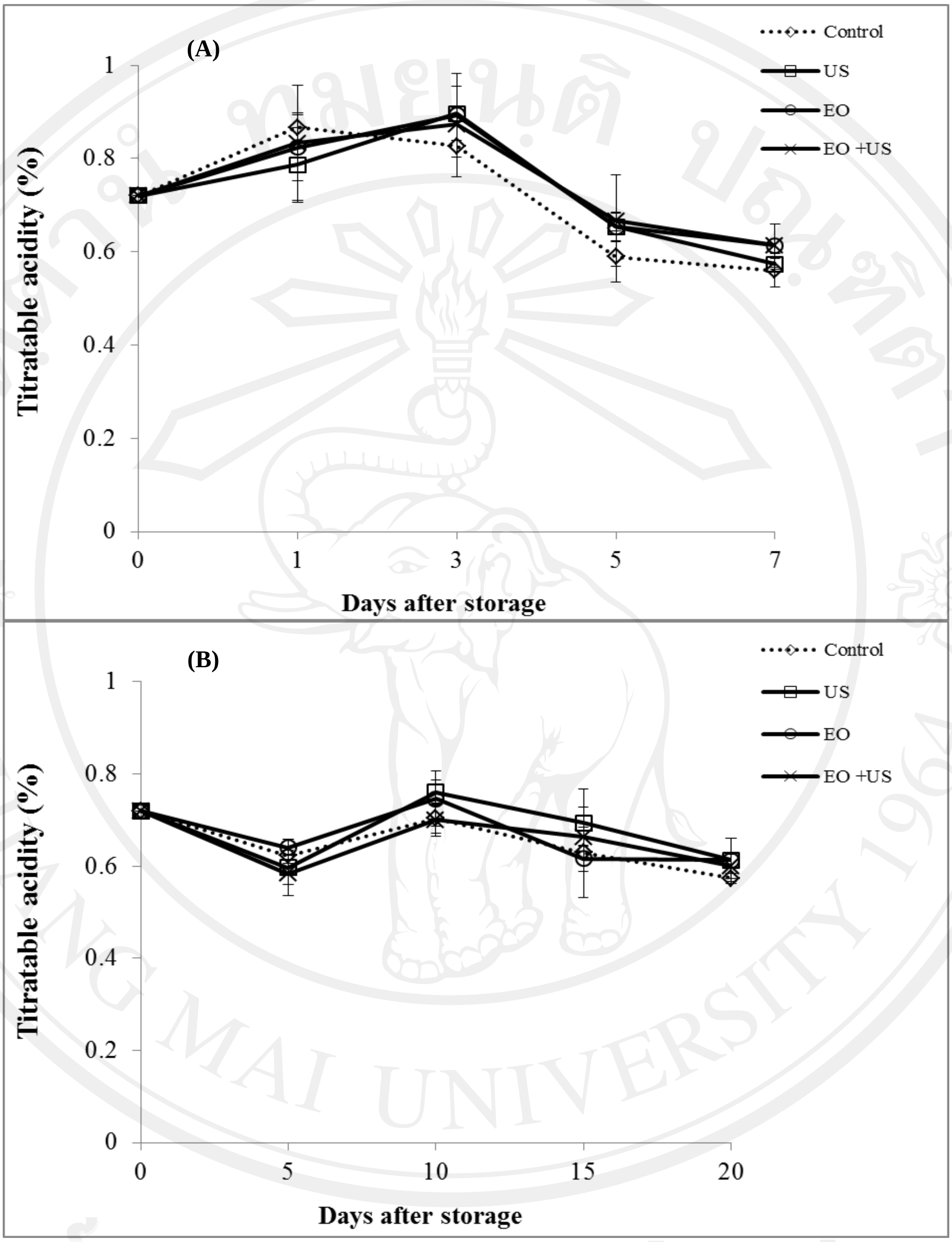

Figure 5.6 Change of titratable acidity (TA) of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25°C (A) and 13°C (B).

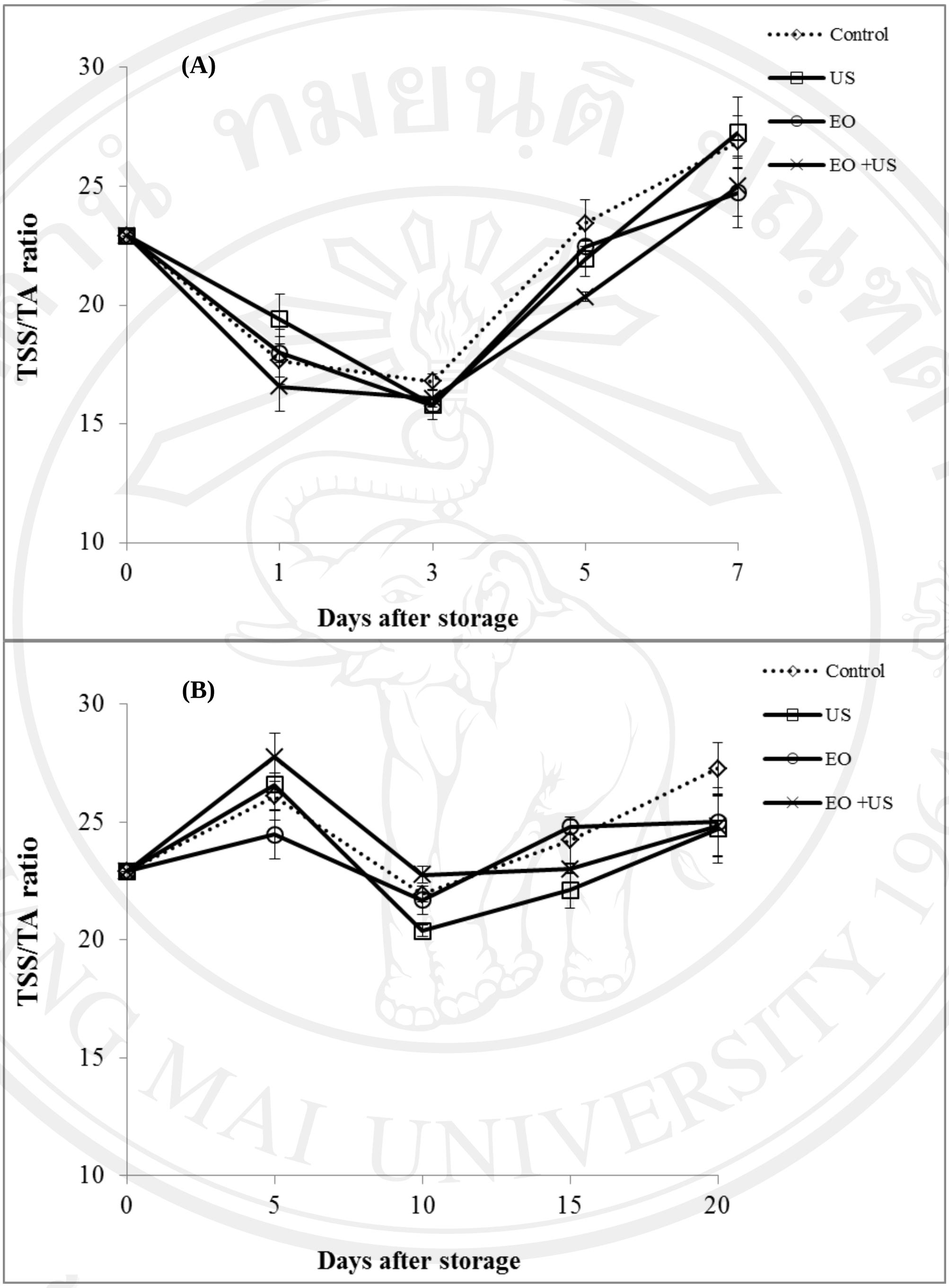

Figure 5.7 Change of TSS/TA ratio of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25 °C (A) and 13 °C (B).

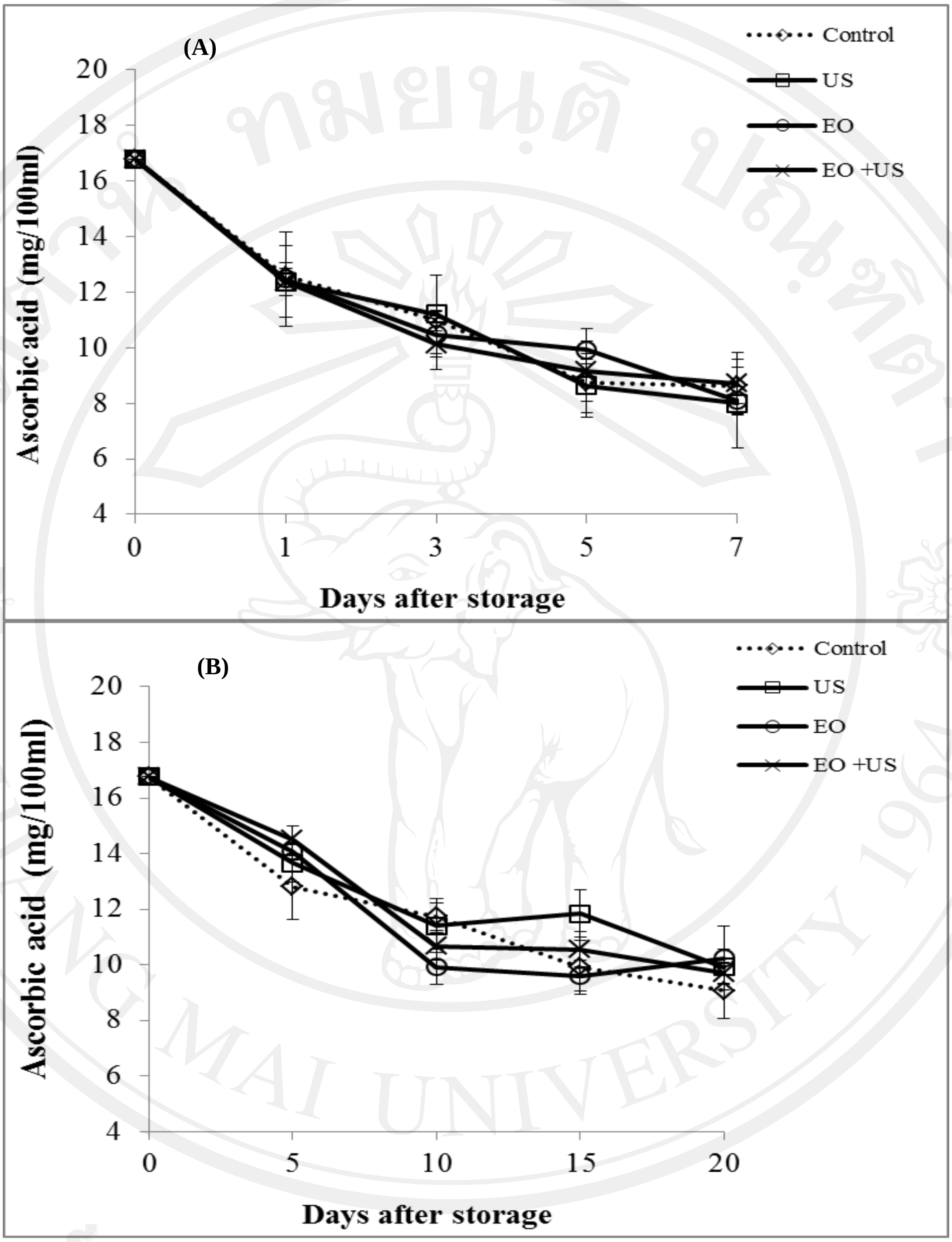

Figure 5.8 Change of ascorbic acid of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25°C (A) and 13°C (B).

5.4.4 Effects of EO water and US wave on sensory evaluation

Pineapple variety Phu lae (Queen Group) was famous for its crisp with sweet aromatic flavor in Thailand. All treatments showed a slightly decrease of their sensory quality after storage at 25 and 13 ◦C for 7 and 20 days respectively, while still being acceptable for consumption. No significant differences in the same sensory quality attribute between the control and the treated samples were detected by the panelists immediately after treatment (Figure 5.9 – 5.12). Sensory quality declined in all samples as storage time prolonged. No noticeable differences in crispy, taste, aroma and overall acceptability scores among treatments were found. The treated samples maintained higher sensory quality scores compared to the controls during storage. From the sensory quality point of view, a shelf-life prolongation of 7 and 20 day was achieved by the EO water and US wave treatments, respectively, which was consistent with the data of the overall acceptability. Our previous work and that of other authors revealed that EO water and US wave treatment could maintain sensory quality of fruit and vegetables (Yang *et al.,* 2011; Cao *et al.,* 2010; Chen *et al.,* 2011; Kim *et al.,* 2010).

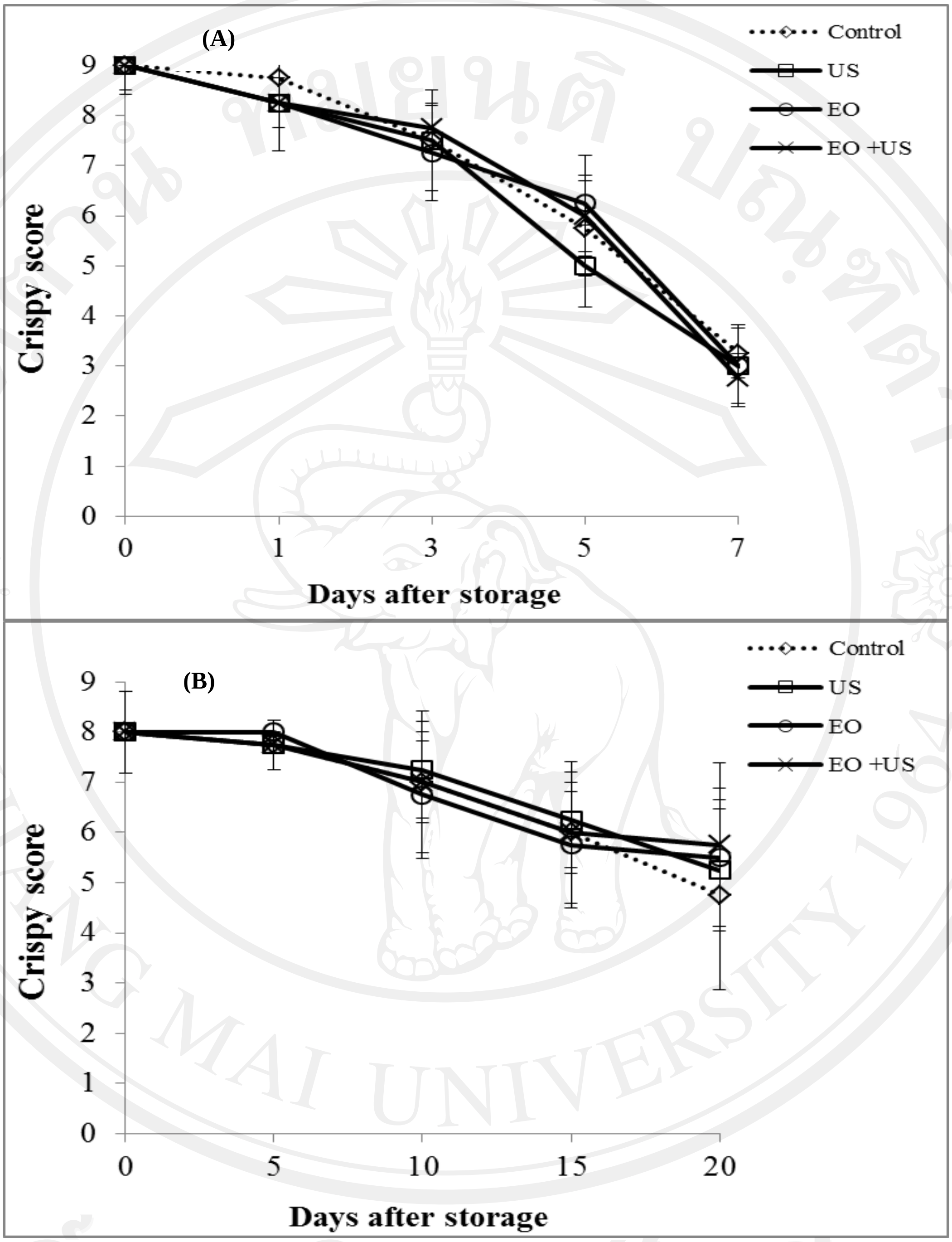

Figure 5.9 Change of crispy score of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25°C (A) and 13°C (B).

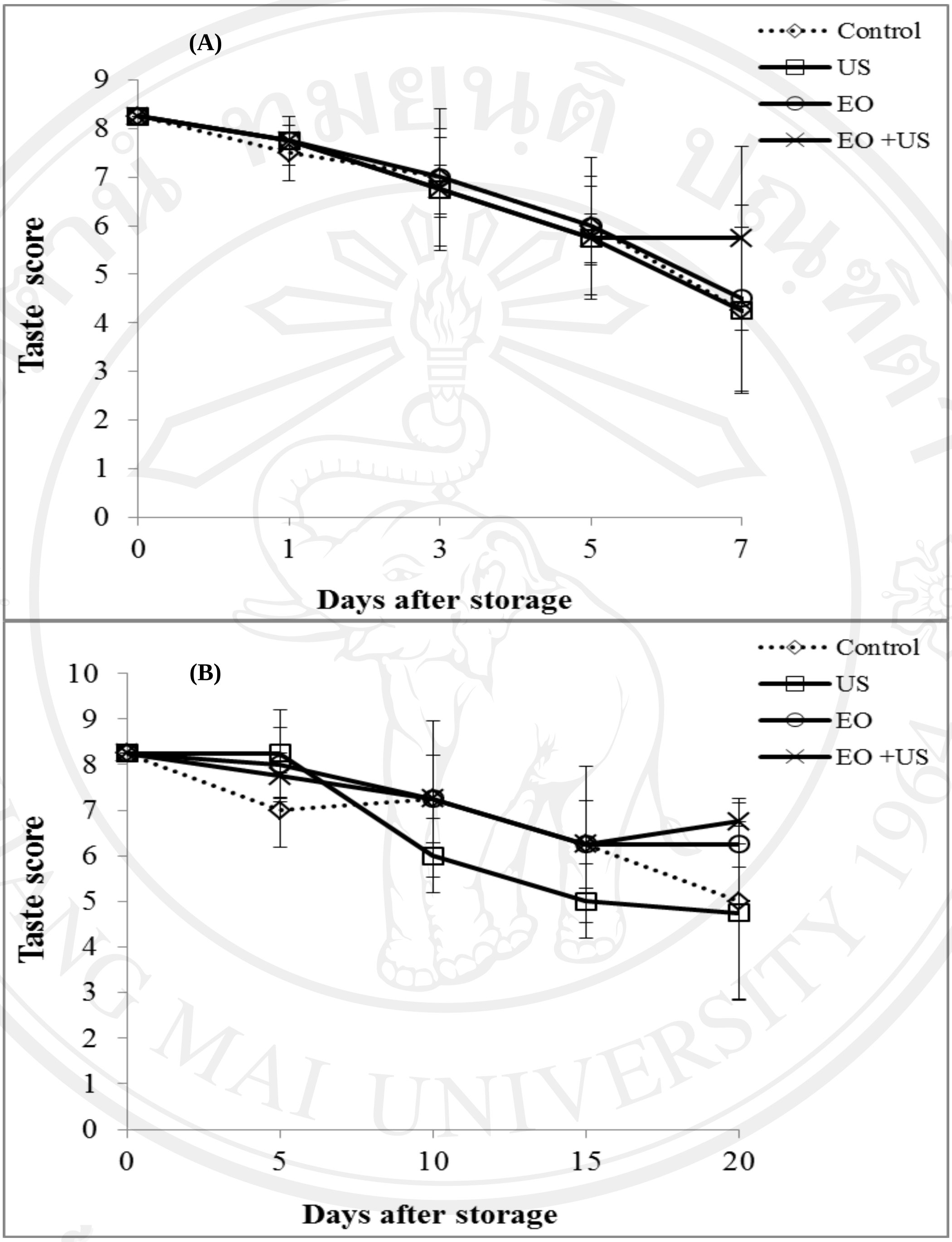

Figure 5.10 Change of taste score of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25°C (A) and 13°C (B).

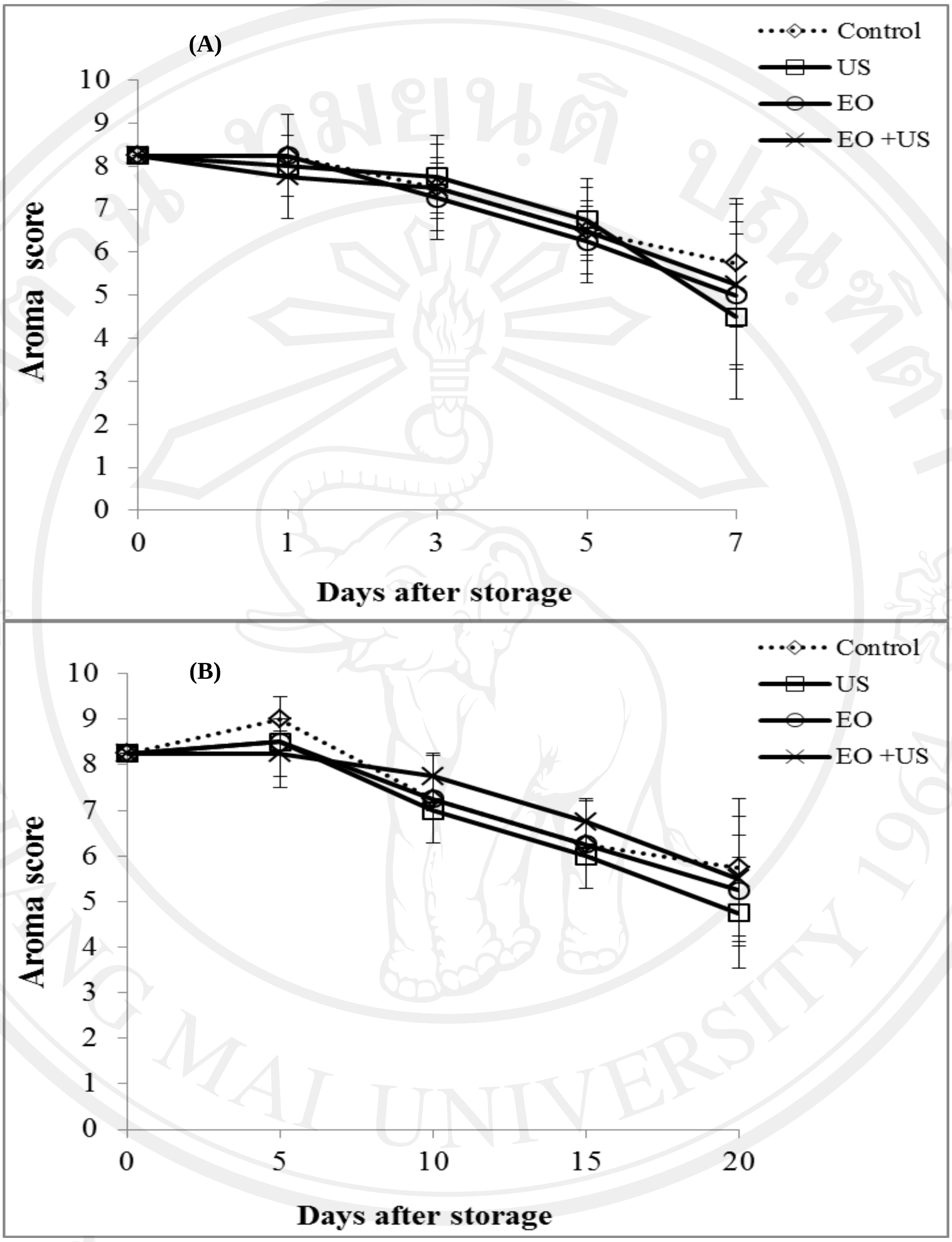

Figure 5.11 Change of aroma score of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25°C (A) and 13°C (B).

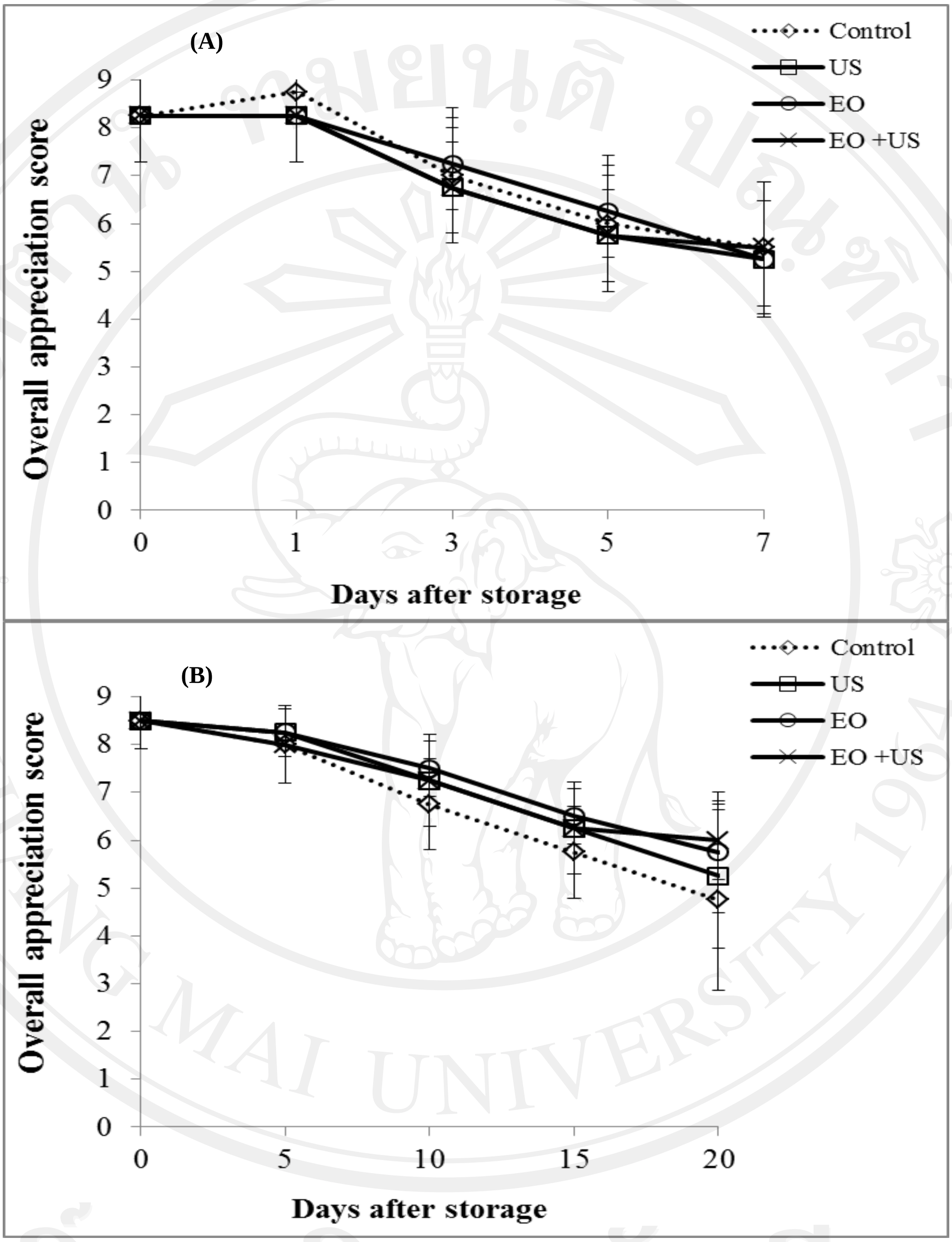

Figure 5.12 Change of overall appreciation score of pineapple fruit inoculated with *Fusarium* sp. After being treated with EO water and US wave. The fruits were kept at 25°C (A) and 13°C (B).

5.5 Conclusion

The results presented in this study showed that EO water and US wave treatments had no deleterious effects on qualities of pineapple fruit. Instead, it was trending to maintenance some quality parameter such as ascorbic acid and weight loss percentage. It maintained ascorbic acid levels, this effect has important nutritional quality implication. On the other hand, combined treatments prior to 13°C storage are promising as it markedly decreased browning symptoms. Although, this results show that the treatments could keep some fruit qualities parameters and better than the control treatment. It would probably not because it directly affected the fruit but treatments reacted directly with the pathogenic fungi which could delayed the fungal decay and preserved the fruit qualities longer than the control groups or US wave treated alone.