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EFFECT OF RATIO OF BEES WAX AND CARNAUBA WAX IN MIXED WAX ON RESPIRATION RATE, WEIGHT LOSS, FRUIT DECAY AND CHEMICAL QUALITY OF VIETNAMESE PASSION FRUITS DURING LOW TEMPERATURE STORAGE

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ABSTRACT

This research aims at studying the impacts of ratio of bees wax and carnauba wax in mixed wax (MW) on weight loss, respiration rate, fruit decay and the chemical quality of the Vietnamese fresh purple passion fruit in storage period at low temperatures. Firstly, the MW1, MW2 and MW3 were made from bees wax and carnauba wax with 2 to 1, 1.5 to 1 and 1 to 1 ratios respectively at concentration of 8%. After that, passion fruits were coated in MW1, MW2 and MW3 for thirty seconds and dried for eight hours at room temperatures. After that, they were stored at 5±1°C for 42 days. The control was uncoated fruits. The rate of respiration, weight loss and fruit decay and total microorganism, chemical quality, content of total soluble solids (TSS), total titratable acidity and content of vitamin C were monitored during the storage period. According to the results, the MW1 treatment had the lowest rate of respiration rate, fruit weight loss, fruit decay and total microorganisms for a 42 day duration in storage. Besides, this control and all treatments could preserve the chemical quality of the passion fruit in terms of TSS content, total titratable acidity and content of vitamin C during storage time with insignificant difference ($P \geq 0.05$).

Key words: Purple passion fruit, bees wax, carnauba wax, mixed wax coating, respiration rate, weight loss, fruit decay.

INTRODUCTION

The purple passion fruit, *Passiflora edulis* Sims, is a tropical climacteric fruit with a unique flavor of its juicy pulp (Biale, 1975; Wills *et al*., 1982). Due to the rising demand for not only fresh fruit but also processed juice, Purple Passion is a fruit of great commercial potential. Its commercial value chain, however, is impacted by its short shelf life and its postharvest losses (caused by postharvest decay, shrivel and wilt). The loss of nutrients and moisture contents, microbial contamination deteriorate the acceptable look of fresh fruit (for example wrinkles, darkening color peels, etc). These factors negate the commercial value of Purple Passion fruit (Arjona and Matta, 1991; Bora and Narain, 1997). In order to maintain the commercial value of the fruit, both during season and out of season, it is important to consider the storage process of passion fruit after harvesting and in long distance of exportation to international markets. The existing studies in Vietnam indicates that although the combination of 3% HPMC and 6% carnauba wax can create a good quality membrane appropriate for preserving and maintaining natural aroma of passion fruits for 28 days at 5°C, the rate of weight loss still remains high (19.7%) (Van and Hue, 2017). To lengthen the shelf life of purple passion fruit (to over 28 days) and reduce the weight loss (much lower than 19.7%), an alternative method is developed by using edible coatings with bees wax and carnauba wax. Under the FDA regulation, these waxes and coatings are approved and recognized as safe food flavors for human consumption (Thirupathi *et al*., 2006). The ester of aliphatic acid chain and the aliphatic alcohol chain of wax are structured from a fatty acid and a high molecular weight alcohol. Bee wax is naturally produced in the beehive of honeybees. Carnauba wax is a natural wax produced from the leaves of the palm (*Copernicia prunifera*), a plant indigenous to the northeastern Brazil. According to Shahid and Abbasi (2011), the use the combination of 5% Bees wax and 0.5% benlate is an effective method which can improve the quality of oranges and prolong their shelf life. The findings from Navarro-Tarazaga *et al*. (2011) demonstrate that weight loss in plums is reduced when bees wax is used at 5%. It also has been reported in Sargen *et al*., (1995) Carnauba wax has high potential use as an alternative for paraffin wax in storage cassava root. Recent research has suggested that wax would be used as an effective alternative to boost postharvest fruits and vegetables quality. It can slow and reverse the process of weight loss, moisture loss, and shriveling; diminishing the production of respiration and ethylene; reducing rate of transpiration; lengthening fruit freshness and shelf life; preventing fruit from mold growth; and improving attractiveness (Hagenmaier and Shaw, 1992; Kolattukudy, 2003; Thirupathi *et al*., 2006; Hung, 2008; Torres *et al*., 2009; Hu *et al*., 2011; Shahid and Abbasi, 2011).

This study was undertaken to investigate how the respiration rate, fruit decay, weight loss, and

the chemical quality of fresh Purple Passion fruits which were stored in low temperature storage and impacted by the ratio of bee's wax and carnauba wax in mixed wax (MW).

MATERIALS AND METHODS

Plant materials: This research used mature purple passion fruits (85-90 days after fruit set) from a commercial orchard during the harvesting crop of 2019 in Son La, Northwest of Vietnam, for the experiment. 20 kg Purple Passion fruit were cut in the early morning, and then packaged in baskets, lined with paper and carried to the laboratory within three hours. Before this experiment, we selected non-defected fruits according to its similarity in size, color and shape.

Studying methods: the bees wax and carnauba wax, ratio 2 to 1(MW1), 1.5 to 1 (MW2) and 1 to 1 (MW3) were carefully mixed and melted for thirty minutes under temperature at 80-85°C. After that, Palmitic acid (0.5%) and Oleic acid (4.8%) were added to the mixtures (MW1, MW2 and MW3). Water was added to the mixtures for adjustment concentrations of mixtures to 8% weight/volume before the mixtures were centrifuged at 24.000 rounds/min.

In the second stage of the experiment, selected passion fruits were coated in MW1, MW2 and M W3 for thirty seconds before drying it for eight hours at room temperatures. The control fruits were not coated. After the second stage, 10 coated and control fruits per bag were packaged in the same type of polypropylene bags. The bags has 4 holes (0.8 cm^2 per hole), size 305 x 457 mm x 0.035 mm. After packing, the fruit bags were stored a cold room at 5±1ºC for 7 days intervals before sampling/analyzing. There were three duplications for each treatment. We used a randomized design for the experiment as follow:

(I) The respiration rate was determined with gas chromatographs, 500g of fruits sealed in a glass chamber for two hours at 5ºC. About 5 ml gas sample was withdrawn with a gas-tight hypodermic syringe and analyzed by gas chromatography (GC-7820A, Agilent Technology). The rate of respiration was determined as ml CO2/kg.h (fresh weight) (Yumbya et al., 2014).

(II) Before and after storage, the entire fruits were weighed in polypropylene bags (taken as 100%) to calculate the rate of weight loss

(III) Fruit decay was evaluated as the percentage of decay fruit with the below formulation:

$$\text{Percentage of fruit decay} = \frac{\text{Number of decay fruits}}{\text{Total fruits}} \times 100$$

(IV) The total population of microorganism on fruit surface was estimated following the method suggested by Whangchai *et al*., (2006). At room temperature, the sampled fruits were shaken in sterile distilled water at 180rpm for thirty minutes. For each treatment, a sample (1 ml) of the suspension was distributed across a PDA medium, which were incubated at 25°C within seventy-two hours. The microorganisms which survived were shown as the mean number of colonies forming units (CFU/ml).

(V) To determine the total content of soluble solid, a digital refractometer was used (PAL-1, Atago, Japan).

(VI) The AOAC (2000) indicates that the titratable acidity (TA) was determined as citric acid by titrating against 0.1NaOH.

(VII) Vitamin C content was determined by the use of the detective dye 2.6 dichlorophenol-indophenol by standardizing 0.1% standard 2.6 dichlorophenol-indophenol dye solution against 0.1% ascorbic acid solution (AOAC, 2000).

(VIII) The sensorial quality of stored passion fruits was evaluated with the method suggested by Maniwara et al., (2015). The 15 trained experts including of 9 females and 6 males (age from 21 to 34). Stored passion fruits were rated overall on pericarp color (darkening), pericarp shriveling, taste and flavor by using score scale (1 = unusable, 2 = poor quality, 3 = moderate, 4 = good and 5 = excellent). Fruits with sensorial quality score below 3.0 were evaluated unacceptable.

This study use the SPSS (version 20.0) together with Duncan's Multiple Range Test ($P \leq 0.05$) for Statistical analysis to identify the difference of means between the control and treatments.

RESULTS AND DISCUSSION

Respiration rate: Passion fruits after harvested were measured respiration rate, and the initial rate of respiration was 21.6ml CO_2/kg.h. Figure 1 presents the difference in respiration rate in coated and control passion fruits throughout 5ºC storage time. As seen in Figure 1, MW coating ($P \leq 0.05$) remarkably decreased the respiration rate of passion fruits over the storage. During the 7th day of storage, the uncoated control fruits had considerably higher respiration rate with the respiratory peak at 44ml CO_2/kg.h. In contrast, during on the 14^{th} day of storage, the coated fruits delayed respiratory peak and it was significantly smaller (from 29.3 to 32.7ml

CO_2/kg.h) compared to uncoated control fruits. After reaching respiratory peak, the rate of respiration of both coated and control fruits had tendency to be reduced when the storage time increases. On the day 42 of the storage, the rate of respiration of control fruits was 11.7 ml CO_2/kg.h while the rate of respiration of coated fruits ranged from 4.8 to 6.5 ml CO_2/kg.h. The rate of respiration of fruits in MW1 treatment was considerably different from those of MW2 and MW3 treatment during the storage period (except by day 14 and 21). During the storage time, the respiration rate of the control fruits was remarkably higher than that of coated fruits ($P \leq 0.05$). (Figure 1). These results provide an explanation that MW coating considerably constrained the rate of respiration of passion fruits during storage period. Typically, harvested passion fruits have a high rate of respiration (Shiomi *et al*., 1996a). The surface covering of Purple According to Thirupathi *et al*., (2006), passion fruits were highly resistant to O_2 and CO_2 and water. Hagenmaier and Shaw (1992) asserted that commercial fruit wax was used to minimize the respiration rate of coated fruits. The rates of respiration on oranges, lemons and grapefruits were decreased by using Wax emulsions Fruitex, Britex-561 and SB 65 (Farooqi *et al*., 1988). Packaging reduced the rate of respiration in harvested passion fruits throughout storage (Yumbya *et al*., 2014; Maniwara *et al*., 2015). The respiration percentage of fruits can be decreased because of the ethylene absorber laminated in MAP filming material. The respiratory process might be retarded if the ethylene concentration is decreased (Maniwara *et al*., 2015). Theoretically, the oxygen permeability at 10˚C is lower than it would be at 23˚C. Due to the limitation of O_2 in the packaging, this would impact respiration rate (Maniwara *et al*., 2015). MAP can create a decrease of fruits' respiration rate, ethylene production, weight loss, sensitivities, and retard changes related to the ripening process as it can produce the high CO_2, low O_2 and high relative humidity conditions. Therefore, it can maintain the quality of postharvest fruit (Diaz-Mula *et al*., 2011). Observation of Yumbya *et al*., (2014) on the decrease in ethylene evolution rate in packaged fruits was also credited to the modified gas composition (high CO_2 and low O_2). The research result of Artés *et al*., (2006) indicates that low levels of O_2 can reduce 1- aminocyclopropane-1-carboxylic acid oxidase, one of the key enzymes regulating ethylene biosynthesis. Similarly, high CO_2 levels were reported to deter ethylene biosynthesis, which consequently, retarded fruit ripening and deterioration in several commodities. In this research, the passion fruits coated in 8% MW including carnauba wax and bees wax in the ratio of 2 to 1 (MW1) had the lowest rate of respiration during storage period (Figure 1). This result presents that at 5°C, MW1 coatings significantly reduce the rate of respiration in passion fruits during the storage time.

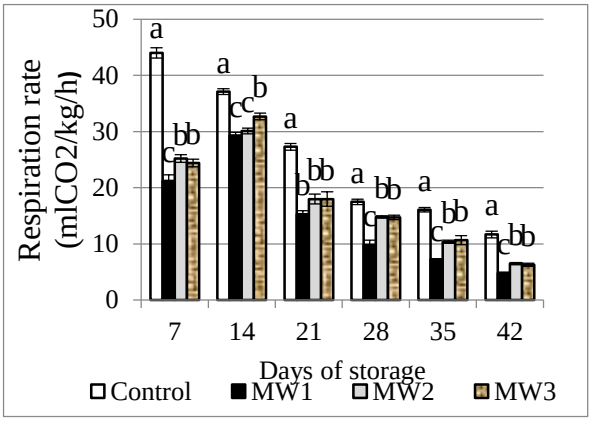

Figure 1: Changes in respiration rate of coated and control passion fruits during storage period. Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

The rate of weight loss: The rate of weight loss of stored passion fruits is shown in Figure 2. It shows a considerable difference in the rate of weight loss between treated and control fruits during the storage time ($P \leq 0.05$). During the first 7 days of the storing time, the percentage of weight loss in control passion fruits was 1.6%, and it reached 16% by day 42. The weight loss of treated fruits ranged from 0.4 to 0.6% by the 7th day of the storage time and reached from 3.0 to 3.4% by 42nd day of the storage time, and there was no considerable difference in weight loss between MW1, MW2 and M W3 treatments ($P \leq 0.05$). After being harvested, purple passion fruits lose their weight quickly, which causes fruits to shrivel in normal packaging conditions. A higher moisture loss could be observed in fruit peels than in fruit pulps. Therefore, peels become wrinkled and, therefore, fruits were visually inattractive although the inside was accepted by consumers (Pruthi, 1963; Shiomi *et al*., 1996). Maniwara *et al*., (2015) asserted that weight loss of passion fruits which were packaged in P-UAP was greater; fruit samples continually lost their moisture content through perforated films and became shriveled during the storage time. According to Kader *et al.,* (1989), a higher moisture loss in horticultural commodities is corresponding to higher respiration and ethylene response. Special plastic films could help to minimize shriveling in passion fruits and, thus, could help to avoid peel respiration and excessive weight loss, (Kader, 1986; Kader *et al*., 1989). After 21 days in storage at different low temperatures, treated purple pass-

ion fruits had the weight loss ranging from 10.1 to 24.02% (Van and Hue, 2017). As can be seen in Figure 2, the weight of treated and control fruits decreased when the storing time increased. The control fruits had much greater percentage of weight loss than treated fruits in the storage duration. After 42 days of storage period, the MW1 treatment had the lowest percentage of weight loss. Our results justify that the MW containing bees wax and carnauba wax (ratio 2:1) at doses of 8% used in this study is the most effective in decreasing weight loss in passion fruits during the storing period. The wax coating was used to reduce the percentage of weight loss in fruits and vegetables (Thirupathi *et al*., 2006). Weight loss means the loss of water in fruits and vegetables, which is related to the shelf life of the produce (Shahid and Abbasi, 2011). Baldwin *et al*. (1999) asserted that carnauba wax coating remarkably reduced water loss in coated mango fruits in comparison with uncoated mango fruits. In pineapple fruits, Sta-Fresh 2952 wax (60g /l) was found to be effective in decreasing weight loss (Hu *et al*., 2011). Shahid and Abbasi (2011) reported that 5% bees wax the minimum weight loss in sweet orange fruits cv. Blood red during storage at room temperature. Waxing can delay weight loss in tomato fruits (Torres *et al*., 2009). Wax emulsions Fruitex, Britex-561 and SB 65 coated on oranges, kinnow, lemons and grapefruits reduced fruit weight loss and made the fruits firmer and thus, maintained their fresh appearance (Farooqi *et al*., 1988). Sornsrivichai *et al*., (1990) reported that weight loss was reduced when Xiang Sui and Pien Pu pears were waxed at storage temperatures.

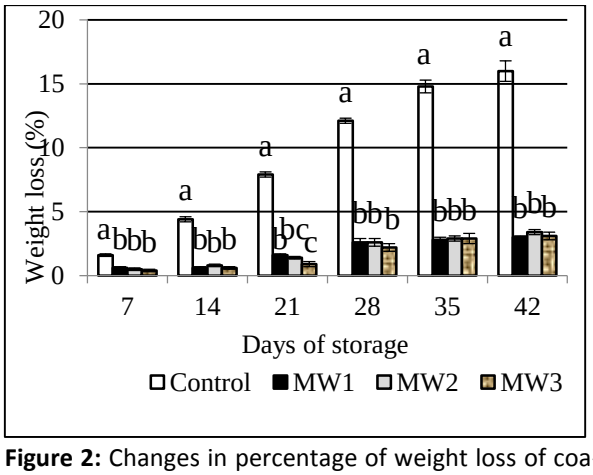

Figure 2: Changes in percentage of weight loss of coated and control passion fruits during storage period. Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

The percentage of fruit decay: The percentage of fruit decay of treated and control fruits increased with the increase of storage time, and a considerable difference could be seen in fruit decay between control fruits and fruits of MW1, MW2 and MW3 treatments ($P \leq 0.05$) (Figure 3). As can be seen in Figure 3, the control fruits started to decay (3.5%) after 7days in storage, and thereafter decaying accelerated with increasing storage time (61.4 and 79.4% after 35 and 42 days respectively). Meanwhile, treated fruits began to decay (1.7 to 1.8%) after 14 days in storage and reached 14.4 to 15.7% after 42 days in storage. The MW1, MW2 and M W3 treatments maintained low percentage of fruit decay, and no great difference ($P \leq 0.05$) was observed during storage period. From these results, it can be concluded that the MW coating was effective in controlling fruit decay in passion fruits for 42 days. This study also illustrates that low fruit decaying is correlated with low total microorganism populations (Table 1 and Figure 3). According to Figure 3, the lowest percentage of fruit decay was seen in the MW1 treatment during the storage period and 14.4 % of fruit decay was reported by day 42 in storage. This result demonstrates that the MW containing beeswax and carnauba wax with the ratio of two to one at doses of 8% used in this study is the most effective in reducing fruit decay in passion fruits during the storage time. The common fungal attacking passion fruits were *Alternaria passiflorae*, which causes sunken, circular, and brown spots on the surface of fruits, and septoria blotch caused by *Septoria passiflorae* (Rodriguez-Amaya, 2003), by white fungus (*Fusarium oxysporum*), blue fungus (*Penicillium expansum*), and black fungus (*Aspergillus niger and Rhyzopus nigricans*) (Pruthi, 1963). Waxing is primarily applied to protect fruits and vegetables from mold development (Thirupathi *et al*., 2006). Carnauba wax is potential as a natural wax substitute for paraffin wax to store cassava root (Sargen *et al*., 1995). Baldwin *et al*. (1999) asserted that the carnauba wax coating could decrease fruit decay in mango fruits throughout storage time. Waxing works as a barrier preventing fungal and bacterial pathogens from entering into the product. A film of free moisture on the product's skin is typically required for postharvest pathogens to grow. Waxing creates a hydrophobic (non-water compatible) surface which prevents pathogen from growing (Postharvest Handling Technical Bulletin, 2004). Waxed fruits had less spoilage than uncoated samples (Hagenmaier and Shaw, 1992).

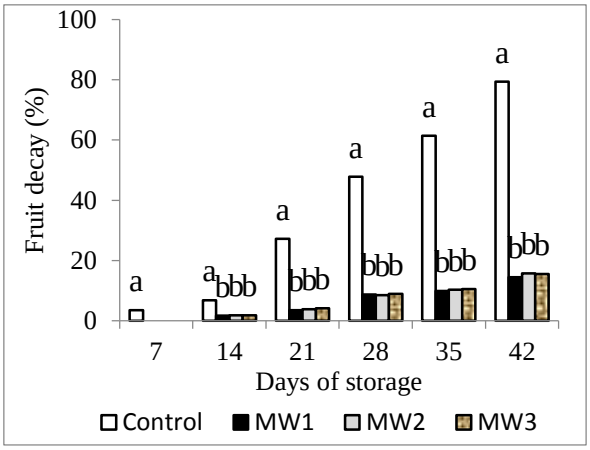

Figure 3: Changes in percentage of fruit decay of coated and control passion fruits during storage period. Vertical bars represent standard errors. Columns with different letters of each storage period indicate significant differences ($P \leq 0.05$).

Total microorganisms: With the time spent in storage, the total populations of microorganism on the surface of the fruit consisting of yeasts, fungi and bacteria of control and treated passion fruits are likely to grow. After 42 days in storage, the treated fruits grew from 1.9 x 10^4 to 7.0 x 10^4 CFU/ml while the control increased from 2.3 to 15.3 x 10^6 CFU/ml (Table-1). The difference in total microorganism between control fruits and treated fruits was marked. The total microorganism of the control is much higher than the total microorganism of treated fruits during the storage period. These results indicate that MW coating played significant role in reducing total microorganism population on the passion fruits' surface. According to Pruthi (1963), The *Alternaria passiflorae* with sunken, circular, and brown spots on the surface of fruits, and septoria blotch caused by *Septoria passiflorae* (Rodriguez-Amaya, 2003), by white (*Fusarium oxysporum*), blue (*Penicillium expansum*), and black (*Aspergillus niger and Rhyzopus nigricans*) fungus are considered as the common fungal attack passion fruit. The use of waxing can protect fruits and vegetables from the growth of mold (Thirupathi *et al*., 2006). A barrier against fungal and bacterial pathogens entering the product are established when waxing are used (Postharvest Handling Technical Bulletin, 2004). The Table 1 presents the lowest total microorganism on fruit surface of passion fruit during the storage period and total microorganism was 6.2 x 10^4 CFU/ml by day 42 in storage thanks to the use of the MW1 treatment. This result supports that the MW1 (including beeswax and carnauba wax with the ratio of two to one at doses of 8%) used in this study has the best effectiveness in deterring the growth of total microorganism on the surface of passion fruit over the period of storage.

Table 1: Change in total microorganism populations on fruit surface during storage period

Treatments	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Control	2.3 ± 0.6 x 10^6	2.6±0.9 x 10^6	4.9 ± 0.6 x 10^6	7.4 ± 0.5 x 10^6	10.3 ± 0.8 x 10^6	15.3± 0.6 x 10^6
MW1	1.9 ± 0.5 x 10^4	4.4 ± 0.5 x 10^4	4.9± 0.5 x 10^4	5.8 ± 0.6 x 10^4	5.8 ± 0.5 x 10^4	6.2 ± 0.2 x 10^4
MW2	2.4 ± 0.4 x 10^4	4.9± 0.4 x 10^4	5.2± 0.4 x 10^4	6.0± 0.5 x 10^4	6.7± 0.4 x 10^4	7.0 ± 0.5 x 10^4
MW3	2.1 ± 0.7 x 10^4	4.9 ± 0.7 x 10^4	5.6 ± 0.5 x 10^4	6.4± 0.4 x 10^4	6.6± 0.6 x 10^4	6.7± 0.8 x 10^4

Total soluble solids content (TSS): Change in TSS content of the control fruits and treated fruits during the storage process was well monitored. The results of this process are presented in the Figure 4. The two methods of treatments do not have difference in TSS contents during storage ($P \leq 0.05$). The TSS content of the control fruits and of treated fruits are likely to decline when the storing time increases. The TSS content of control fruit samples and treated fruit samples are fluctuated between 13 to 14% after 42 days in storage (Figure 4). The findings in this study are consistent with the results of experiments conducted by Maniwara *et al*., (2015). The result from Maniwara *et al*., (2015) shows that the total soluble solids over storage time are decreased when passion fruits packaged in all conditions; the fruit lost rough 10% of its initial TSS. Soluble solids (mostly organic acids and sucrose molecules) are naturally accumulated in the pulp of a completely ripe passion fruit. When passion fruits are picked, however, it can convert certain compounds with aerobic respiration or anaerobic processes (Arjona *et al*., 1992; Shiomi *et al*., 1996b). The passion fruits' TSS fluctuated between 10.8% and 12.5%. The TSS in passion fruits among treatments does not have significant differences (Arjona and Matta, 1991). During the passion fruits ripening progress, TSS grew gradually. Packaging (P= 0.05) contributed to significantly decreasing the rate of growth of TSS in fruits which were harvested at stage 2 and stage 3. In stage 2 (when fruits were unpackaged), TSS were rapidly reduced from an initial 12.4° brix to the peak of 13.9° brix on day 6 of storage. It decreased steadily until day 9 (at the end of storage). MAP packaged fruits remained considerably low TSS degree till the last day of storing time (Yumbya *et al*., 2014). Within this research, the TSS content of control fruits and treated fruits did not have difference (Figure 3). The findings assumes that during the storage time, the

ratio and dose of MW using in the experiments do not have any effect on the TSS content of passion fruits.

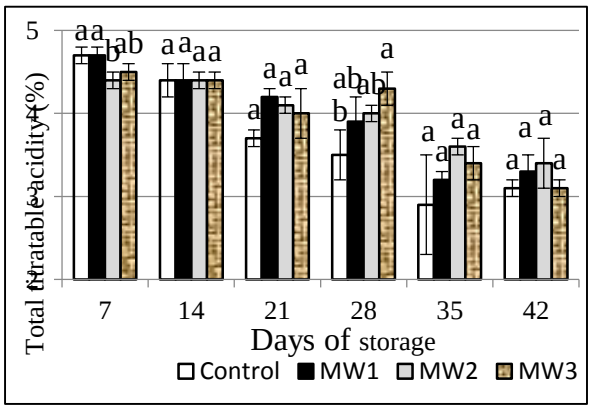

Figure 4: Changes in TSS content of coated and control passion fruits during storage period. Vertical bars represent standard errors. Columns with same letters of each storage period are not significantly different ($P \leq 0.05$).

Total titratable acidity (TTA): Figure 5 presents the fluctuations in total titratable acidity (TTA) of control fruits and treated fruit during the storage time. No difference in TTA between treatments, and between treatments and control sample by day 14, 21, 35 and 42 in storage ($P \leq 0.05$) can be seen. According to Figure 5, the TTA of control fruits and of treated fruits are likely to decline when the fruits are placed longer in the storage (from 4.4 to 4.7% by day 7 and from 3.1 to 3.4% by day 42 in the storage). The result in this research has consistency with the result of the study conducted by Maniwara *et al*., (2015). According to Maniwara *et al*., (2015) in all packaging conditions, the TTA in passion fruit juice outstandingly reduced over time; the juice of passion fruit lost roughly 40% of organic acids (from 4.0% to 2.5%) over the time of storage. The acid metabolism and degradation causes the reduction of organic acids including citric acids and ascorbic acids in passion fruits (Arjona and Matta, 1991). Because of the high level of respiration and the increase of related enzymatic acidic degradation, once purple passion fruits are picked, in ambient temperatures and atmosphere, they quickly lose acids and moisture (Shiomi *et al*., 1996a; Shiomi *et al*., 1996b). The passion fruits TTA is reduced over the storage time. After 14-day storage, the TTA of control fruit dropped considerably (from 6.85 to below 3%) (Van and Hue, 2017). Gradually, levels of TTA declined with an increase of time in storage after fruits were harvested at both maturity stages. The initial level of TTA of fruits harvested at stage 3 (0.43% citric acid) is lower than the initial level of TTA of fruits harvested at stage 2 (0.55% citric acid). Packaging significantly contributed to reducing the TTA levels during the storage time (Yumbya *et al*., 2014).

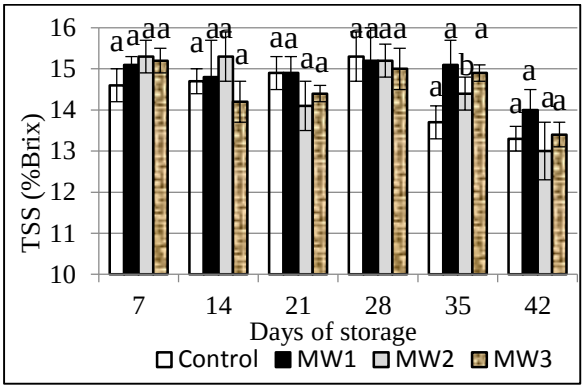

Figure 5: Changes in total titratable acidity of coated and control passion fruits during storage period. Vertical bars represent standard errors. Columns with same letters of each storage period are not significantly different ($P \leq 0.05$).

Vitamin C content: The Figure 6 present the changes in the contents of vitamin C in the control and treated fruits during storage. The contents of vitamin C in the control and treated fruits during the storage period are similar ($P \leq 0.05$). Overall, vitamin C content in passion fruits of treated samples and control sample gradually decrease with increasing storage time (from 52.7 to 56.9 by day 7 and from 33 to 34.4 mg/100g by day 42 in storage). These findings are in line with those of Maniwara *et al*., (2015). Vitamin C is one of the major organic acids which enrich the juice. Maniwara *et al*., (2015) concludes that vitamin C in passion fruit juice decreased during the storage time. The degradation of Vitamin C in fruits occurs due to the exposure to light, O_2 and high temperatures (Maniwara *et al*., 2015). According to Vinci *et al*., (1995) passion fruit juice lost 40% of its ascorbic acid after only one week of storage in a normally cool room (at 4ºC). Vitamin C content of passion fruits significantly decreased during storage period and Vitamin C content of control fruit decreased more than 50% (Van and Hue, 2017). Yumbya *et al*., (2014) indicates that the levels of ascorbic acid gradually diminished with ripening packaged and unpackaged fruits; level of ascorbic acid reduced from 42.9 mg/100ml to 29 mg/100ml (day 9 –at the end of the storage time). The loss of Vitamin C occurring during ripening is partly because of the degrading ascorbic acid through oxidation (Appiah *et al*., 2011). Moreover, the previous research also shows that the decrease of Vitamin C can be happened due to the water loss through transpiration as Vitamin C is a water-soluble vitamin (Valero and Serrano, 2010; Siddiqui *et al*., 2011).

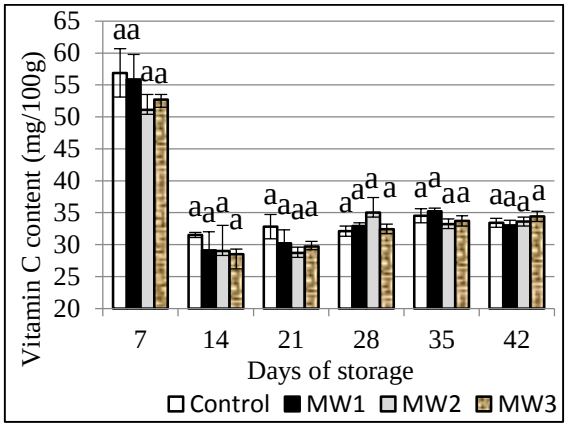

Figure 6: Changes in vitamin C content of coated and control passion fruits during storage period. Vertical bars represent standard errors. Columns with same letters of each storage period are not significantly different ($P \leq 0.05$).

CONCLUSIONS

Coating Vietnamese purple passion fruits in M W1 (8% mixed wax including bees wax and carnauba wax with the ratio of 2 to 1) can be used to reduce the respiration rate, weight loss, fruit decay, and total microorganism populations better than other treatment and maintained chemical quality (TTS, TA and Vitamin C content) during the 42-day period of storage at 5°C.

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