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ARTICLE

Application of edible coating and active packaging to extend shelf life of mango under atmosphere temperature

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ABSTRACT

Two types of edible fruit coating and an active packaging were tested for their effect during 15 days of storage at atmosphere condition (24-25°C) with 60-70 % RH. One coating was alginate-based, while the other had palm oil-based as the main ingredient. These two coatings exhibit weight loss reduction and appearance change compared to uncoated, but only the palm-based coating delay ripening can extend 10 days of shelf life during storage. On the other side, Active packaging can effectively delay ripening during 15 days of storage. Moreover, these results show that active packaging might be a viable alternative to extend mango's shelf life because it can maintain weight loss below 3% during storage at atmospheric conditions.

1. Introduction

Mango is a highly perishable fruit with a short post-harvest time due to the intense metabolic activity (Cosme Silva et al., 2017). Therefore, proper technological innovation is needed to extend the fresh life of mangoes. Many different preservation techniques to extend shelf-life are applied. Each of the used technologies is based on certain preservation factors or inactivation mechanisms. These preservation factors can be biological, chemical, or physical. The most important preservation factors for foods to extend the shelf life during storage are high or low temperatures, acidity, water activity, chemical agents, or redox potential (Jaeger, Knorr, Meneses, Reineke, & Schlueter, 2014). Developments in edible coatings and packaging technology for

foods have shown promising results in extending the shelf-life of fresh-cut fruits and vegetables (Yousuf, Qadri, & Srivastava, 2018). Edible coatings are produced from edible biopolymers and food-grade additives (Han, 2013).

Applications of edible coatings are being explored worldwide due to their simplicity and eco-friendly nature. An edible coating acts as a semi-permeable barrier to moisture loss, gaseous exchange, oxidative reactions, and functions as a carrier for active ingredients (Sharma & Rao, 2015). One major advantage of using edible coatings is that several active ingredients can be incorporated into the polymer matrix and consumed with the food, enhancing safety or even nutritional and sensory attributes (Rojas-Graü, Soliva-Fortuny, & Martín-Belloso, 2009).

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On the other side, there are on the other side. A growing number of highly innovative technologies currently in use in fruit packaging often aids in the preservation and extend shelf life, providing a physical barrier to microbial, physiochemical and physical damage (Lim, 2011). Technologies within the active packaging sector, such as packaging that can actively reduce the level of oxygen or even microbial count in a pack, are of great importance. Similarly, intelligent packaging, which can sense an attribute of the product or atmosphere around it, is a key part of recent innovations in the global packaging world (Ghoshal, 2018).

The study's objectives were to determined physical and chemical change of Taiwan Mangoes during storage under atmosphere temperature conditions (24-25°C) and extended shelf-life of these products by using commercial edible coating and active packaging based their changes on their data above and using visual evaluation.

Nomenclature and abbreviation

SSC	Soluble Solid Content
PIDC	Taiwan Plastics Industry Development Center
N	Newton (N)
FFM	Flesh Firmness Measurement

2. Materials and methods

2.1. Material

Mango harvested in Taiwan were purchased as fresh from a local retail market (Fig. 1). Fruits were transferred to the laboratory and they were selected for uniformity, shape, color, and size and any blemished or diseased fruits were discarded.



Fig. 1. Mango selection on Local Retail Market.

In this study, two types of coating solutions were used, one provided by the Center of Agro-industrial Technology - BPPT (palm oil-based) and the other was prepared at the Feng Chia

University Laboratory (Alginate based. Active packaging was supplied by Taiwan Plastics Industry Development Center (PIDC).

2.2. Methods

The method used in the measurement of physical and chemical characteristics of this mango fruit uses 2 methods: destructive method (the measurement of hardness and Soluble Solid Content (SSC) and non-destructive method (the measurement of weight loss). The equipment used in this study is as follows.

Table 1

List of Equipment that uses for an experiment.

No	Equipment	Function
1	Weighing Balance	To Determine Weight loss of mango
2	Hand Refractometer	To determine Soluble Solid Content (SSC) of mango
3	Penetrometer	To determine Firmness of mango

2.3. Sample Preparation

Mangoes that will be used for research are then selected through dipping methods (Fig. 2). They were dipped into a container containing water to see the mango level (sink/float). This method is applied to ensure that the mango used has a uniform level of maturity.

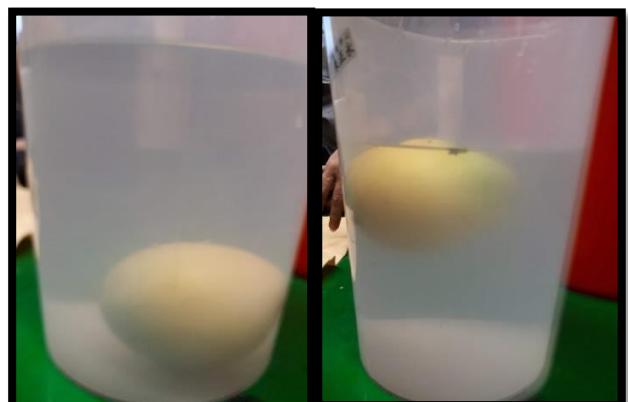


Fig. 2. Dipping method for mango classification

Table 2

Experiment variables.

No	Variable	Mango Quantity
1	Control	16
2	Coating A (Alginate Based)	16
3	Coating B (Palm oil Based)	16
4	Active Packaging	16
5	Normal Packaging	16
	TOTAL	80

Eighty mangoes were separated into five different groups with 16 fruits per experimental and subunit then to treatment with two repetitions. Fruit groups are based on the table above (Table 2).

2.4. Observation

Weight Loss Measurement: The percentage of weight loss was determined according to the following expression:

$$WL(t) \left(\frac{g}{100g} \right) = \frac{W_{(t)} - W_0}{W_0} \times 100$$

where $WL(t)$ is the percentage weight loss at time t , W_0 is the initial sample weight and $W(t)$ is the sample weight at time t . The weight was determined by a digital precision balance (Conte, Scrocco, Brescia, Mastromatteo, & Del Nobile, 2011), shown in Fig. 3.



Fig. 3. Weight Loss Measurement

Flesh Firmness Measurement (FFM): Flesh firmness was evaluated by using a digital penetrometer (Conte et al., 2011) (Fruit Hardness Tester model FR-5105) by using 6 mm diameter plunger (Kitinoja & Hussein, 2005) after skin removal by a slicer, in a position corresponding to the FHT readings. Firmness was recorded as kg-force in Newton (N) by measuring the maximum penetration force (Fig. 4).



Fig. 4. Mango firmness measurement

Soluble Solid Content Measurement: Fruit Juice was used to measure Suspended Sediment Concentration (SSC) with a hand refractometer, and SCC was expressed as % Brix (Fig. 5).

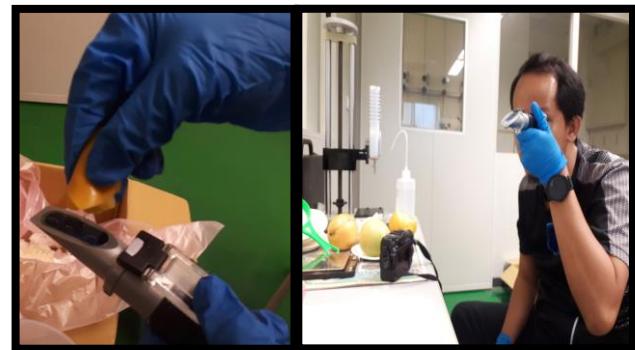


Fig. 5. Soluble Solid Content (SSC Measurement)

3. Results and discussion

3.1. Effect of Storage Period on Weight Loss of Mango

The weight loss of mangoes is related to the respiration and transpiration of the fruits, being a combination of water loss and solutes and seems to be major determinant of storage life and quality of mango fruit (Cosme Silva et al., 2017). Edible coating experienced reduced weight loss during the storage period (Fig. 6) compared to the control, and the largest decrease in weight loss was in the sample with an A (Alginate-based) edible coating treatment, which was almost the same as the control sample weight reduction. At the same time, edible coating B (Palm Oil Based) showed that mango's weight during 15 days of storage was reduced by 5.78%, almost the same as the control weight 5 days of storage. This shows that the use of edible coating B can extend the shelf life for 10 days. Mangoes stored using active packaging and plastic bags show the lowest weight loss of 1.12% and 1.67%, respectively, for 15 days of storage. However, further research is needed with a more extended storage period to see the comparison significantly.

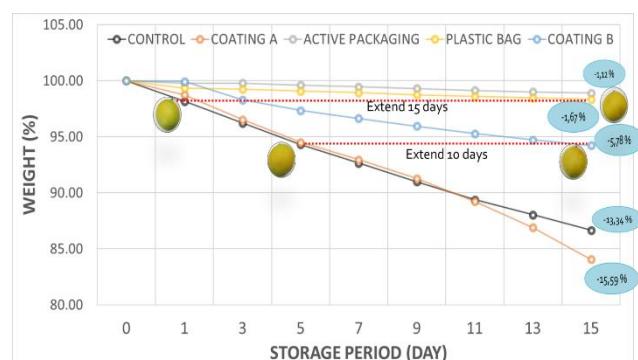


Fig. 6. Weight loss of mango during storage

3.2. Effect of Storage Period on flesh firmness of mango

Firmness is one of the important attributes used by consumers in assessing apple fruit quality. Loss of fruit firmness is closely linked to low water content and it is the most noticeable change

during long-term cold storage. Post-harvest factors such as fruit maturity and storage conditions have an enormous effect on fruit firmness (Mditshwa et al., 2017). Peel firmness was further determined at three positions, i.e., at the top, middle and bottom of the fruit (Jha et al., 2010). Mango and pear were evaluated for their peel firmness from purchased day till 15 days storage period. The results are presented in (Fig. 7) The peel firmness of mango and pear varied from about 20 to 33 N on the purchased day, which further decreased to 2–5 N with an increase in storage period.

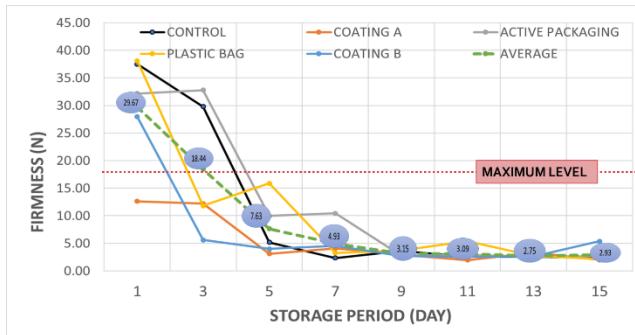


Fig. 7. Flesh firmness of mango during storage

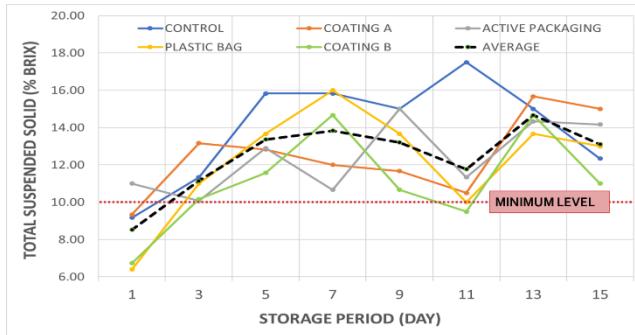


Fig. 8. Soluble Solid Content/Total Suspended Solid of Mango during Storage

3.3. Effect of Storage Period on SSC value of mango

Sugars are the major soluble solids in fruit juices and therefore, soluble solids can be used as an estimate of sweetness. A hand-held refractometer can be used outdoors to measure % SSC (equivalent degrees Brix for sugar solutions) in a small sample of fruit juice (Kitinoja & Hussein, 2005). According to Kader (1999), the minimum value of Soluble Solid Content of mangoes is 10-12% Brix. SSC value of mangoes reached more than 10% Brix during 3 days of storage and showed fluctuating values during the next day's storage (Fig. 8). Inconsistent results SSC measurement on mango contained low uniformity of fruit size and sharpness. Also, because of the difficulty in determining mango maturity at the beginning of the experiment, it fluctuated.

The picture's visual appearance above (Fig.10 and Fig.11) showed the color changes in the fruit's flesh and skin during the 15 days of storage. However, no significant difference was found in mango flesh and skin color during storage. However, the color changes significantly for

control and alginate coated samples related to increasing weight loss.

Minimum %SSC	
Apricot	10%
Blueberry	10
Cherry	14-16
Grape	14-17.5
Kiwifruit	6.5
Mango	10-12
MUSKMEON	10
Nectarine	10
Papaya	11.5
Peach	10
Pear	13
Pineapple	12
Plum	12
Pomegranate	17
Strawberry	7
Watermelon	10

Source: Kader, A.A. 1999. Fruit maturity, ripening and quality relationships. *Acta Hort* 485: 203-208.

Fig. 9. Minimum % SSC value for different fruit



Fig. 10. Mango Skin Color Changes during Storage

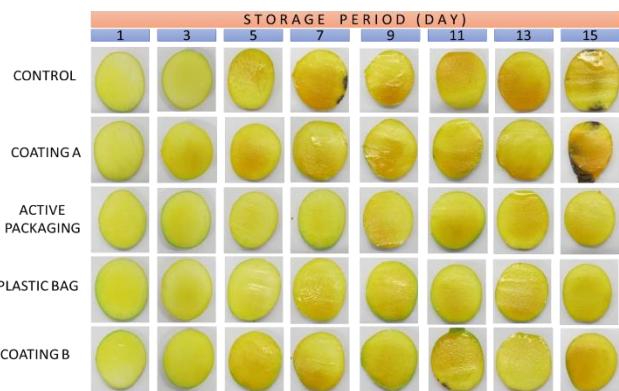


Fig. 11. Mango Flesh Color Changes during Storage

4. Conclusions

The results showed that edible coating palm oil edible coating palm oil-based could extend mango's shelf life 10 days during 15 days of storage. On the other side, edible coating alginate-based did not show significant results on mango's shelf life. Active packaging can effectively delay ripening during 15 days of storage. Moreover, these results show that active packaging might be a viable alternative to extend mango's shelf life because it can maintain weight loss below 3% during storage at atmospheric conditions. Further research is needed to use active packaging and normal packaging with varying storage time and temperature ranges to see mango shelf life's effectiveness.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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