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Effect of Chitosan-Starch Enriched with Turmeric Essential Oil Coating on Physical Quality of Strawberry

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Abstract*: *The objective of this paper was to formulate chitosan-starch edible coatings incorporate with turmeric essential oil and plasticized with glycerol using the dip coating technique. The effect of starch on surface tension and turmeric essential oil amounts on firmness and weight loss of the strawberries were studied. The adhesion properties of coatings were greatly influence by starch but not by turmeric essential oil hence 2.0% (w/v) of starch will be used in this study. The findings showed that chitosan-starch coatings enhanced with turmeric essential oil were effective on preserving strawberries. It was found that the weight loss of coated strawberries was significantly lower as compared to the uncoated samples. Based on the results, chitosan-starch edible coating enriched with 150 ppm of turmeric essential oil showed potential coating for extending shelf life during the storage of strawberries.

Keywords*: *chitosan, coating, starch, turmeric essential oil

I. INTRODUCTION

Post-harvest loses for crops especially vegetables and fruits are an important part of the post-harvest activities. These activities started from harvesting, handling, storage, processing, packaging, transportation and marketing. Poor handling results in lower market value of a commodity. The advanced method consists of the technology application by chemical, biological and physical means for fruit protection have been used to solve these problems. Edible coating can be used in controlling the fruits organoleptic properties because of the ability to maintain the moisture transfer, oxidation process and respiration process [1]. It is made up from natural based thus safe to be consumed [2].

Basic edible coatings can be develop from different types of hydrocolloids such as proteins, lipids and polysaccharides to be the main component [3]. It can used by only one hydrocolloid or by the mixture of another types hydrocolloids which is called biocomposite edible coating [4].

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Biocomposite materials can be improved by addition with other type of food preservation for example chelating agent, antioxidant agent and antimicrobial agent to improve the ability of the edible coating [5]. In order to do that, turmeric essential oil has been chosen as the antimicrobial agent in this research. Turmeric essential oil that has secondary metabolites in it such as curlone, cumene, Ar-turmerone and turmerone can perform as antimicrobial agent [6]. With the help of antimicrobial agent in the turmeric essential oil, it may improve the ability to protect fruit from microbial and fungus that can lead to fruit decay.

The blend of starch and chitosan as the biocomposite edible coating was used in this research as based. Starch that has hydrogen bonding connection create the semi-crystalline granules made up of amylose and amylopectin. Hydrating and swelling of granules in the existence of heat and water contributes to increase the solution's viscosity [7]. Unfortunately, starch alone has bad mechanical properties which are fragile and brittle characteristics. Thus, by adding chitosan it could increase the performance of the starch based edible coating because of its excellent film-forming properties and compatibility [8]. Biomaterials like chitosan is one of the developed materials especially to be used in packaging of food products. It is a copolymer that can be described in the form of degree of deacetylation and average molecular weight [9]. Chitosan is derivation of chitin by deacetylation in alkaline media. Chitin can control deterioration of food because of its strong antifungal and antimicrobial activities. Chitosan has a selective permeability to certain gases with a very good mechanical property. By controlling the gas permeability, the respiration rate of food can be decreased [10]. The good miscibility between the two biopolymers shown by their homogeneous blend coatings lead to a better material property. In addition to that, the mechanical and physical properties of biocomposite edible coating can be improved with the addition of plasticizers such as glycerol and sorbitol.

II. MATERIALS AND METHOD

A. Materials

Chitosan at 97% deacetylation was supplied by Nacalai Tesque (Japan) as a biocomposite edible coating. Starch was purchased from local brand Kapal ABC. Co (Malaysia) to be one of the polymer materials.

Glycerol from Merck (Germany) was used as a plasticizer while acetic acid was purchased from Friendemann Schmidt (Australia). Turmeric rhizomes were purchased from the Klang's market while Tween 80 was from Systerm, Lab Sciences Engineering Sdn. Bhd. (Malaysia) [11].

B. Preparation of turmeric essential oil

Extraction of the essential oil from hydrodistillation method has been used to extract the turmeric essential oil. Turmeric of 500g were washed to get rid of any dirty and used paper towel to dry them. The dried turmerics were cut into small pieces and put in a 5L round bottom flask with 1250mL of distilled water for hydrodistillation extraction process [12]. After boiling at about 4 hours, the turmeric essential oil was collected and stored in darkness. The extracted turmeric essential oil was kept at 4℃.

C. Edible Coating Formulation

Chitosan solution was formulated by adding 1.5% (w/v) chitosan in a 0.5% (w/v) acetic acid until completely dissolved. The solution was stirred at 350 rpm for 24 hours to ensure that the chitosan flakes are disappeared. Starch 0.5% (w/v) was dispersed in a 0.25% (v/v) suspensions glycerol water solution [13]. The starch solution is being heated at 75℃ on a hot plate for gelatinization of starch to occur [14]. The starch solution was stirred at 350 rpm for 30 minutes to prevent it from being coagulated. In order to produce blend coatings, the chitosan-acetic acid solution had to be mixed up into the gelatinized starch-glycerol solutions. Surfactant from Tween 80 was added to increase wettability with concentration of 0.1% (v/v) [15]. Then, different concentrations of turmeric essential oil (50, 100, 150 and 200 ppm) was added to the mixture and stirred until complete mixing.

D. Surface Tension and Wettability

Adhesion characteristic of the coating onto the surface of the plate can be examine by evaluating the contact angle of a standard liquid on the surface [16]. The samples have been tested using Contact Angle Goniometer (AST Products, INC.) to analyze the surface tension. Sessile drop method has been used to determine the contact angle by dropping the edible coating solution onto the surface of the sample. Surface energy software (SE2500) has been used to determine surface tension and the wettability value was calculated using the equation as reported by [17]. The spreading coefficient (W_s) could be defined by equation:

$$W_s = W_a - W_c \quad (1)$$

where W_c and W_a reflect the work of cohesion and adhesion, as being written by equation (2) and (3) respectively. Meanwhile (γ) is the surface tension and (Θ) is the contact angle.

$$W_c = 2\,\gamma L \quad (2)$$

$$W_a = \gamma L\,(1+\cos(\Theta)) \quad (3)$$

E. Firmness

The firmness analysis is used to examine the textural property possessed by the sample. It was measured by the Texture Analyzer (TA-XT2 plus Texture Analyzer). Force (N) necessary for a 2mm probe to puncture the sample to evaluate the external firmness [18].

F. Weight Loss

Weight loss analysis was used to evaluate water losses result in shrinkage of fruit and tissue weakening. In order to determine weight loss, the samples were weighted at the starting and final stage of the experiment during the storage time. Weight loss can be expressed as the percentage of losses from the initial total weight minus the final total weight over the initial total weight.

III. RESULTS AND DISCUSSION

A. Surface Tension and Wettability

Chitosan-starch based edible coating solution at different amount starch of 1.0, 2.0 and 4.0% (w/v) had been used in this research. In order to coat fresh fruit with coating solution, the suitable surface tension for was from 28 to 38 dynes/cm [19]. As shown in Fig.1, it is noticeable that when the amount of starch increased, surface tension decreased. More polar groups consumed in the interaction between hydroxyl groups of the chitosan and starch, which contributes to a reduction in the surface tension [20]. As can be seen, surface tension of 1.0% (w/v) concentration of starch with a value of 46.79 (dyne/cm) in coating solution has went beyond the suitable range for the perfect surface tension. Thus, only 2.0% (w/v) and 4.0% (w/v) amount of starch to be added in the formulation. The best solution to be chosen is 2.0% (w/v) amount of starch where it shows the spreading coefficient W_s value nearest to zero. This was indicated to the high ability in spreading. As mentioned by [21], the W_s value should be nearest to zero and in negative form because the higher the value of W_s, incomplete wetting of the surface can occurs (when contact angle greater than 90º). Moreover, the amount of raw materials should be use as minimum as possible so that it can reduce the cost. Normally, synthetic polymers have much higher dispersive component related to the polar component compared to starch coatings. The surface tension of solid for water is 2 to 5 times greater for starch than for synthetic material [22]. It shows that the biomaterial has more hydrophilic groups which could connect with the hydrophilic surface [23].

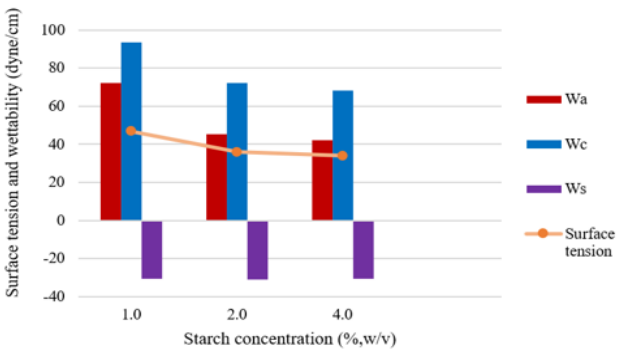

Fig.1: Surface tension and wettability at different amount of starch

B. Firmness

Fig.2 shows the changes of firmness value by comparing among uncoated and coated strawberry samples in 7 days storage time. Initial value for firmness were same for coated and uncoated samples. The uncoated strawberries started to show a significant detriment of firmness at the second day of storage. The firmness of the coated strawberries also decreased gradually but slightly higher as compared to the control samples. With regards to the coated strawberry samples, 150 ppm of turmeric essential oil in edible coating was found to be more efficient in controlling reduction firmness of fruit than the other treatments. It is based on the firmness value of 327.1 $kg.cm^{-2}$ which is the highest value among all at day 7.

Firmness of strawberries treated with 0, 50 and 100 ppm of turmeric essential oil were about the same on the sixth and seventh day of storage while uncoated strawberry shows a huge decreased throughout the storage.

Strawberries treated with biocomposite chitosan-starch coatings enrich with turmeric essential oil can retain the firmness because of deterioration in the cell structure has been protected during the storage time, antifungal activity of lenticels and cuticle increases thus lower down the respiration, infection and other ripening processes [24]. Moreover edible coating for fruit has positive effects in controlling the ripening process and good potential as a physical barrier [25].

C. Weight Loss

Application of chitosan-starch edible coating enriched with turmeric essential oil decelerated the weight loss of strawberries during storage as compared to the uncoated samples. Fig.3 shows that chitosan-starch coatings incorporated with turmeric essential oil significantly reduced the weight loss of strawberries during storage as comparison to the uncoated strawberries. The loss of the weight shows some decrement with the addition of turmeric essential oil concentrations but at some point, the weight loss gets increased. The lowest weight loss was found in 150 ppm turmeric essential oil followed by 100, 200 and 50 ppm of turmeric essential oil with 6.8, 6.9, 7.3, 7.8 and 8.1% respectively after 7 days of storage. While the highest weight loss is 8.7% belongs to uncoated strawberries after 7 days of storage.

The factors contribute to the weight loss in vegetables and fruits are mostly due to the reduced amount of water caused by respiration and transpiration processes [26]. Based on the study by [27], edible coating from chitosan creates an outer layer of smooth and semi-transparent to the pericarp surface. It can acts as a protective barrier through fruit surfaces to reduce transpiration and respiration rates [28]. When there is a barrier over the fruit surface, it can modify the internal atmosphere of the fruit and slows down the respiratory rate. The storage life can be extended by the accumulated carbon dioxide and decreased oxygen in the fruits [29].

It can be seen from this study that coated strawberries can reduce the loss of weight as compared to the uncoated fruit samples, probably because of the cuticles has been covered on the fruit surfaces. Apart from strawberry fruits, chitosan edible coating also effectively in reducing weight loss from other things including cherimoya [30], guava fruit [24], mushroom [31] and many more.

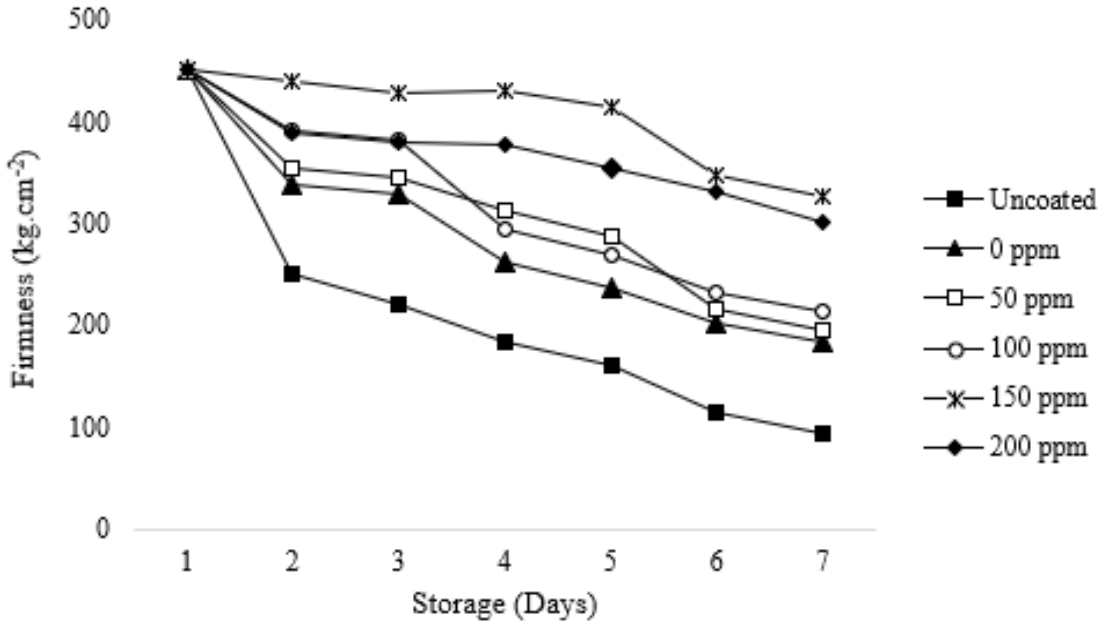

Fig.2: Effect of different cincentrations of turmeric essential oil on firmness

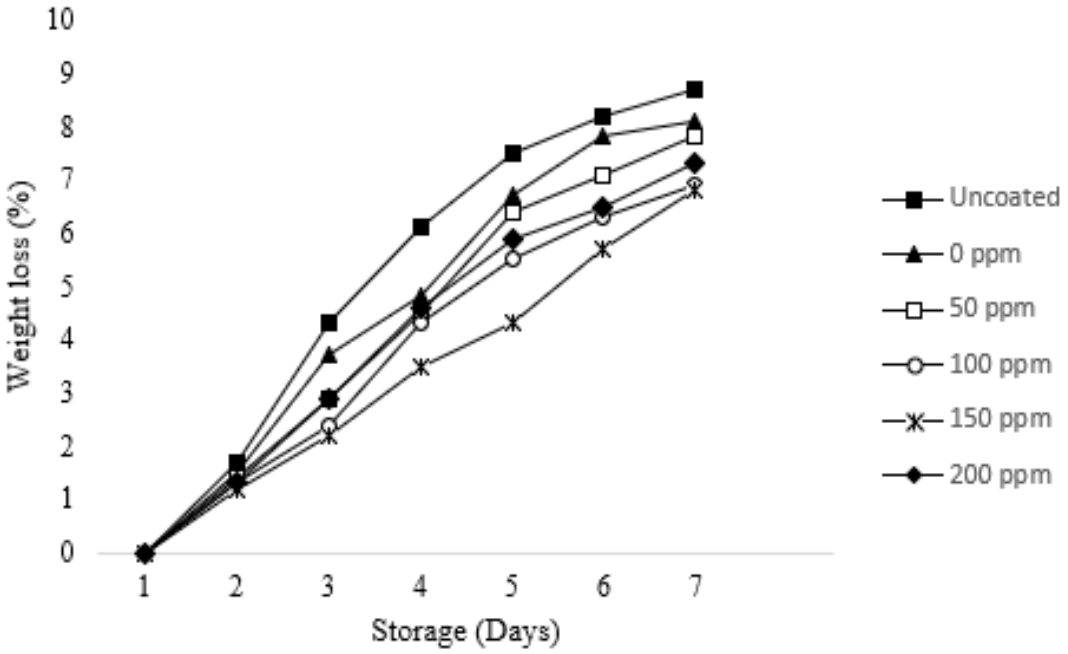

Fig.3: Effect of different cincentrations of turmeric essential oil on weight loss

IV. CONCLUSION

As a conclusion, this study indicated that the application of chitosan-starch coating enriched with turmeric essential oil can reduce fruit ripening and prolong shelf life of the strawberry fruit. The best formulation to be used is 2.0% (w/v) amount of starch indicated to the high ability in spreading. The best results of turmeric essential oil concentration in chitosan-starch coating that can maintain the firmness in the strawberries was at 150 ppm. The results also suggested that positive effects in reducing weight loss throughout the seven days of storage and thus delaying the ripening process in strawberry fruits. Coating the strawberry fruits with chitosan-starch incorporated with turmeric essential oil was greatly efficient to produce a material that can act as a barrier in controlling the ripening and deterioration process.

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