Development and Characterization of Chitosan-Based Edible Coating Incorporated with Curcuma Longa (Turmeric) Essential Oil

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Abstract— **Common problems related with fruits and vegetables such as foodborne pathogens that can cause foodborne illnesses, precocious decaying and economic losses related with fresh fruits retention have led to the development to find a technologies and systems for the main reason to protect the fruits and vegetables. One of the advance technology used nowadays is edible coatings based on natural compound. In this research, chitosan which is most widely used natural compounds in the edible coating development have been chosen. This paper provides a review on the effects of main edible coating components, chitosan (100 ml), turmeric essential oil (0, 5, 10, 15, 20 µl) and starch (4g, 6g, 8g Tapioca powder) on the analysis of appearance, color, texture and surface tension of coated strawberry were studied during 5 days of storage at room temperature (26˚C±2˚C) and 50-60% relative humidity. Results showed that all the analysis give the same results which is addition of 20 µl of turmeric oil and 6g of tapioca powder into the chitosan solution possible to extend the shelf-life of strawberry except for the surface tension analysis which is addition of 5, 10 and 15 µl of turmeric oil and 6g of tapioca powder give a good results for surface tension values.**

Keywords— Strawberry, edible coating, chitosan, turmeric oil, tapioca powder, appearance, color, texture, surface tension

1. INTRODUCTION

Definition of edible coatings and films are thin layers of edible component that are applied to the surface of the fruits or vegetables in addition to or as a replacement for natural protective waxy coatings and act as physical barrier to control moisture, oxygen, carbon dioxide, flavor and aroma exchange between the food components and the atmosphere surrounding them (Pavlath & Orts, 2009b). Wax is the first edible coating used in history for the food packaging especially for fruits and vegetables (Han, 2013). In history of food packaging, the main reason of edible coating are used to prevent loss of moisture and to create a shiny fruit surface for appearance purposes.

According to Pavlath & Orts (2009b), in 1967, edible films and coating had very little commercial use, and were limited mostly to wax layers on fruits. Today, edible films and coatings use had expanded rapidly for retaining quality of a wide variety of foods, with total annual revenue exceeding $100 million (Pavlath and Orts, 2009). Edible coatings and films can be differentiated by three main groups of natural polymer which are polysaccharides (starch, cellulose and its derivatives, chitosan, alginate, gellan gum), proteins (collogen, zein, soybean and gluten proteins, milk proteins) and fats (bee wax, candelilla wax, carnauba wax, fatty acids, glycerols). These polymers are generally biodegradable, nontoxic, and some of them are effective barriers to oxygen and carbon dioxide (Tarun Pal Singh;Manish Kumar Chatli; Jhari Sahoo, 2014).

For this paper, chitosan which is most widely used natural compounds in the edible coating development have been chosen. Chitosan is a natural polymer consisting of (1, 4)-linked 2-amino-deoxy-b-D-glucan, deacetylated derivative of chitin, which is the second most abundant polysaccharide found in nature (Dutta, Dutta, & Tripathi, 2004). The reasons why chitosan based edible coating is chosen because chitosan has been found to be nontoxic, biodegradable, biofunctional, biocompatible and also having antimicrobial characteristics (Miteluț, Tănase, Popa, & Popa, 2015). Furthermore, chitosan-based coatings have also been claimed as effective carriers of many functional ingredients, such as antimicrobial agents and antioxidants to extend storage quality of food (Tripathi et al. 2008, Pranoto et al. 2005, Park and Zhao 2004).

The addition of Curcuma Longa (turmeric) essential oil in the preparation of chitosan-based edible coating is in order to increase and to improve the antioxidant agent for the chitosan solution. Essential oils are aromatic, natural antioxidant, and antimicrobial substances extracted from vegetables by physical means. Because essential oils can lower lipid oxidation, their presence in food products could extend the shelf life (TONGNUANCHAN et al., 2013; PERDONES et al., 2014). In other reasons, besides their high antioxidant capacity, essential oil can also improve the water barrier properties of the film because of their hydrophobic nature characteristic of lipids (Eça, Sartori, & Menegalli, 2014). Therefore, the objective of this study were to develop chitosan-based edible coating in order to improve the shelf-life of strawberry fruits and to investigate the physical properties of strawberry before and after the coatings experiment. Appearance, color, texture and surface tension of coated strawberry were selected as response variables.

2. MATERIALS AND METHODOLOGY

A. Strawberry sample

In this research paper the strawberry species tested was produced and harvested in Cameron Highlands, Malaysia. In Malaysia, Cameron Highlands is the center of strawberry production along with tea plantations and vegetable market. The cold climate is the main reason why makes it suitable for cultivating strawberries all year round throughout the highlands, with most of the farms are at Tanah Rata, Brinchang and Kea Farm ("Strawberry farms," n.d.). Thus, samples of strawberries provided for development of this project have guaranteed quality and homogeneity of the fruit samples. The entire process of postharvest period was followed, from harvesting (December, 2016) to packaging and transportation, in order to maintain the integrity of the fruit.

B. Chitosan solution preparation.

The coating solution formulations were based in three-level factorial design with 100ml of distilled water, 1g of chitosan flakes, 2ml of glycerol, 0.1ml of tween 80 and three differences weight of tapioca powder (starch) which are 4g, 6g and 8g. Table 1 shows the formulation of tested chitosan-based solutions. Firstly, 4g (6g and 8g) of tapioca powder was weighed by using electronic weigh scale. The weighed tapioca starch was then dissolved in 100ml of distilled water for 40min at 80˚C. 2 ml of glycerol os added into the solution as a plasticizer (Guerra et al., 2015). Second step is preparation of chitosan solution. The chitosan solution was prepared by dissolving the chitosan in dilution of 0.5ml of acetic acid. Then, 1g of chitosan flakes, 2ml of glycerol and 0.1ml of tween 80 were added into the solution containing diluted acetic acid and the mixture was stirred for 24 hours at room temperature (Santos et al., 2012). After that, the pH of the chitosan solution will be adjusted by using 0.1M NaOH until it reached 5.6 while being stirred. 100ml of prepared chitosan was continuously stirred at room temperature. Then, 2ml of prepared starch solution was added into the chitosan solution. The prepared solution was being stirred and 20µl of turmeric essential oil was added. This process was repeated by using different concentrations of turmeric oil (0, 5, 10 and 15µl) for every 100ml of prepared chitosan and 2ml of starch solutions.

Table 1: Tested chitosan-based solutions.

Formulation	Distilled water (ml)	Chitosan (g)	Starch (g)	Glycerol (ml)	Tween 80 (ml)
1	100	1.0	4	2	0.1
			2 ml		
2	100	1.0	6	2	0.1
			2 ml		
3	100	1.0	8	2	0.1
			2 ml		

C. Strawberry preparation and coating.

Strawberry fruits were harvested from an orchard in Cameron Highland, Malaysia. Strawberry with uniform size and color, and free physical damage and fungal infection were selected. The strawberries were washed and cleaned using distilled water to remove solid particles from post-harvest. After the strawberries were cleaned, the strawberries were immersed in coating solution according to different formulations for 1min 30seconds. Then, the coated strawberries were dried with a fan for 4 to 5hours at room temperature and after the strawberries were fully dried, the strawberries were placed into a plastic containers and sealed with a lid. The sealed container then were kept in the room temperature.

D. Physical changes of strawberries.

Strawberry from each treatment according to 2.3 was evaluated for physical changes every day for 5 days. There are five physical changes observation which are appearance, texture (firmness), color, and surface tension.

i. Appearance.

For the appearance analysis, five strawberries have been chosen with the same degree of ripeness and same average of weight. After the strawberries have been dip in the different types of chitosan solution according to the weight of tapioca starch and amount of essential oil, the strawberries then be dried for three to four hours with a fan at room temperature. In order to observe the changes of the appearance of the strawberries, use a camera to snap and record the pictures to know the condition and appearance of the strawberries. The strawberries image should be captured for five days to determine the degree of changes for the appearance of the strawberries with different type of solutions.

ii. Colour.

The CIE L* a* b* colour system is a uniform colour scale and this model was chosen to specifying a three-dimensional space and can be represented on a graphic whose coordinates x, y and z which are related to the L*, a*, and b* respectively. This is because, based on the fact that the human eye has three types of colour sensors which are sensitive to the colours green, blue and red and that all colours are seen as a mixture of these colours. The external skin colour parameters (L*, a*, b*) were measured using a Konica Minolta CR400 chromameter. L* corresponds to luminance, a* and b* to the chromaticity coordinates (on green to red and blue to yellow tones, respectively). L* represents the darkness of black and the brightness white, with the darkest black at L* = 0 and the brightness white at L* = 100. The value of a* represents red/green with red at positive values and green at negative values. The value of b* represents yellow/blue with yellow at positive values and blue at negative values. The readings were taken from 17 fruits/treatment.

iii. Texture (Firmness).

In food texture testing, standard tests such as tension, flexure, and compression are used to measure hardness/firmness, crispiness, crunchiness, softness, springiness, tackiness and other properties of food. In this experiment, penetration method was used to measure the firmness/hardness of the strawberries fruit by using a Texture Analyzer TA.XT plus equipped with a 2 kg load cell. A 2mm diameter flat head stainless steel cylindrical probe was set to penetrate 4 mm into the strawberry at a constant speed of 1 mm/s. The measurements were taken from 17 strawberries of different treatments.

iv. Surface Tension.

Optimum wettability requires the greatest possible area for contact between coated surface and the solution in order to avoid the disruption of air between the surface and the solution. In order to get the best solution for the edible coating solutions to apply on the strawberries surfaces, the surface tension analysis need to be observe by using Water Surface Analysis System (VCA-3000S). These systems are specially designed for use in semiconductor wafer processing quality control. The system provides accurate and quick contact angle or surface energy analysis on wafer surface to evaluate coatings, cleanliness and adhesion. The VCA 3000s also provide precision camera and advanced PC technology in order to capture static or dynamic images of the solution droplets and determine tangent lines for the contact angle or surface tension measurement. It also provides manual and automatic syringe for easy dispensing of test liquid.

3. RESULTS AND DISCUSSION

A. Appearance.

Effect of chitosan, starch, and turmeric essential oil on the appearance of the strawberry fruits can be shown in the Figure 2(a), 2(b) and 2(c). The different between the figures are the treatment used to dip the strawberry fruits. For Figure 2(a), the strawberries are dip into a solution that contain 100 ml of chitosan solution, 4g of tapioca starch (2 ml starch) together with 0,5,10 and 20 µl of turmeric oil. For Figure 2(b), the strawberries are dip into a solution that contain 100 ml chitosan, 6g of tapioca starch (2 ml starch) together with 0, 5, 10, 15 and 20 µl of turmeric oil. For Figure 2(c), the strawberries are dip into a solution that contain 100 ml chitosan, 8g of tapioca starch (2 ml starch) together with 0, 5, 10, 15 and 20 µl of turmeric oil.

As clearly observed in Figure 2(a), after five days of storage, the strawberry that has been dip into a chitosan solution contain 5µl of TO has a better appearance followed by 20µl of TO, 10µl of TO, 0µl of TO and lastly uncoated strawberry. Besides that, observation for strawberries appearance shown in Figure 2(b), showed that the strawberry dip into a 20µl of TO has a better appearance followed by 15µl of TO, 10µl of TO, 5µl of TO, 0µl of TO and uncoated strawberry. Same goes to Figure 2(c), the strawberry that has been dip with 20µl of TO have a better appearance as compared to other strawberries treatment. However, from the figures, uncoated strawberries for all treatments start to damage after two days of storage .Figure 1 showed the days taken for strawberries begins to ripen and damaged at a different treatments.

From the Figure 1, chitosan solution contain 20µl of TO give a longer shelf-life for the strawberries from ripen and damaged. This is due to the characteristic of turmeric essential oil which is enrich with antimicrobial and antioxidant agent. By increasing the concentrations of turmeric essential oil into a chitosan solution, it can help to increased and enhanced the antioxidant agent for the coating solution. For the uncoated strawberries, it clearly observed that, without any protection on the surface of the strawberries give a shortest shelf-life. This is because, edible coating give an extra protection barrier for the strawberries from microorganisms such as botrytis cinerea. This barrier also aimed to extend shelf life of strawberry by decreasing moisture and solute migration, gas exchange, oxidative reaction rates and respiration as well as to reduce physiological disorders on fresh fruits (CMPA, 2014; Park, 1999).

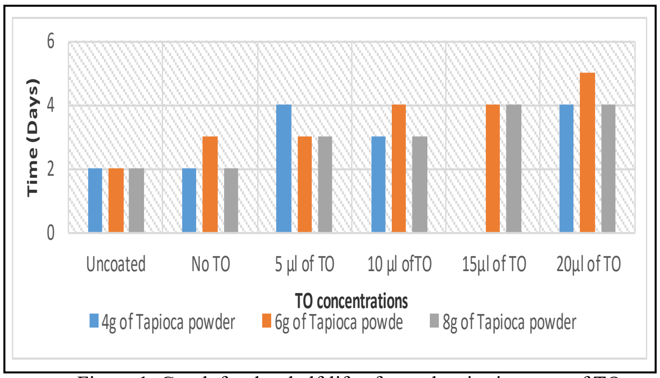

Figure 1: Graph for the shelf-life of strawberries in terms of TO concentrations as a function of time and weight of tapioca powder.

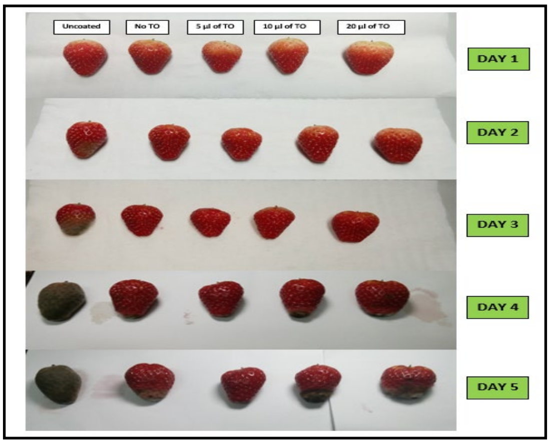

Figure 2(a): Changes of strawberries appearance for chitosan solution with 4g of tapioca powder.

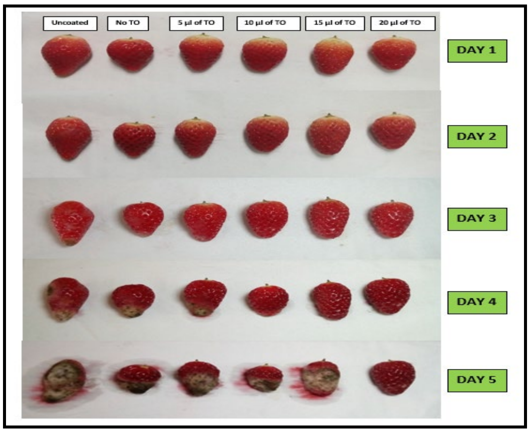

Figure 2(b): Changes of strawberries appearance for chitosan solution with 6g of tapioca powder.

Figure 2(c): Changes of strawberries appearance for chitosan solution with 8g of tapioca powder.

B. Colour.

i. Brightness or lightness intensity (L) of strawberry fruits.*

Based on Figure 3(a), 3(b) and 3(c), the storage period has significant effect on the brightness intensity of strawberries for all coating treatments. After four days of storage, the L* values decreased for all treatments (4g of tapioca, 6g of tapioca, and 8g of tapioca). These observations showed that, reduction of brightness of strawberries was occurred by increasing the storage periods. Furthermore, by passing the storage period, brightness reduction is more slowly and uniformly for strawberry samples coated by chitosan-20µl of TO. It shows that the samples coated by chitosan-20µl of TO has more effective and color stability during the storage. However, for the uncoated strawberries and strawberries dip into chitosan without turmeric oil, the L* values decreased rapidly by passing through the storage periods. This indicate that, the strawberries become darker compared to other samples due to the presence of grey molds or microorganism called botrytis cinerea that covered the strawberries surfaces. It also shows that, the coated strawberries for all treatments have higher L* values compared to uncoated strawberries due to the fact that chitosan incorporate with turmeric essential oil affects the surface of the coated strawberries by improving the brightness of the skin surface. Chitosan coating also enhanced the activity of some antioxidant enzymes, preventing flesh browning and reducing membrane damage resulting for the brighter skin surface (Petriccione et al., 2015).

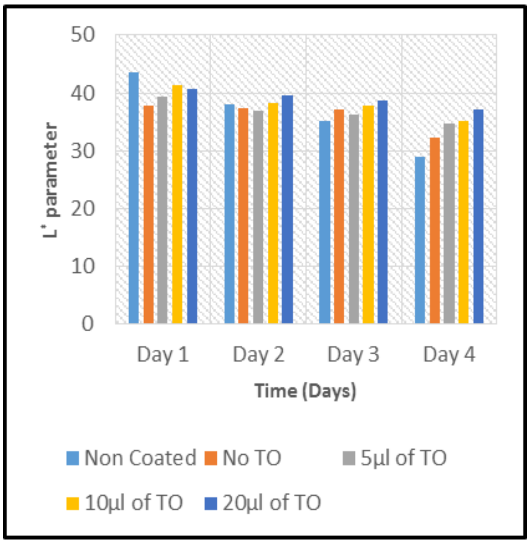

Figure 3(a): Relationship between L* parameter values and storage period for different chitosan coating solution (4g of tapioca powder)

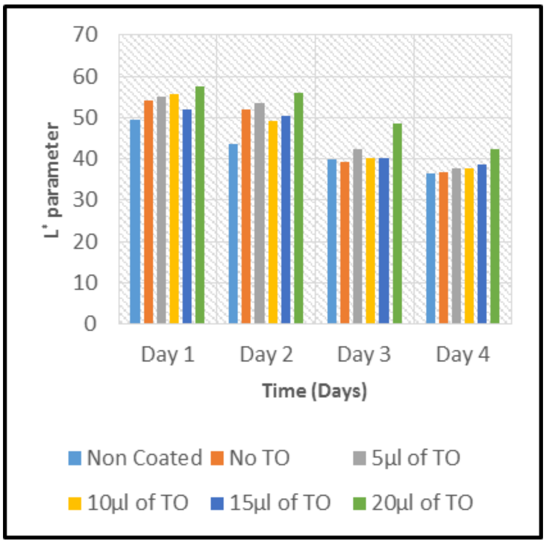

Figure 3(b): Relationship between L* parameter values and storage period for different chitosan coating solution (6g of tapioca powder)

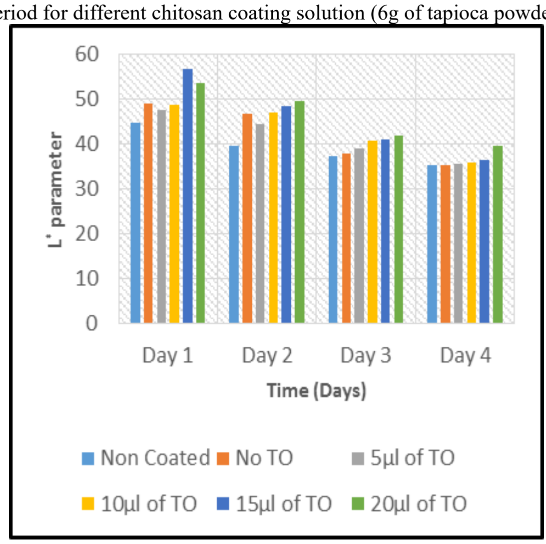

Figure 3(c): Relationship between L* parameter values and storage period for different chitosan coating solution (8g of tapioca powder)

ii. Redness intensity (a*) of strawberry fruits.

Increasing of redness intensity means the strawberry color changing from green to red. For the marketability, buyers are prefer and choosing strawberries that look reddish and fresh. Figures 4(a), 4(b) and 4(c) shows the relationship between color quality (a*) and storage period for seventeen strawberry samples for different treatments. All of the figures, showed that the inconsistency of a* values for the all treatments. These are due to the difficulty to choose strawberry fruits that have same degree of ripeness at the market. From the figures, sample coating strawberries of 15 and 20 µl of TO for 6g and 8g of tapioca shows the increasing of a* values. This result can be explained by the fact that, the longer the storage period, the strawberries will become ripper and the skin become redder. However, based on the figures, 20 µl of TO has a lower a* values compared to 15 µl of TO. From the observations, it can be stated that the samples coated by chitosan-20 µl of TO has a more effective and color stability during the storage. This is because, by increasing the concentration of turmeric essential oil into the chitosan solutions, it enhanced and enriched the antimicrobial and antioxidant agents of the solution. The increment of concentration of turmeric essential oil enhanced permeability of prepared coating towards O_2 and finally the coating changed internal atmosphere of coated strawberry. The chlorophyll content in the strawberry peel decrease slowly with ripening of strawberry as result of chlorophyllase action (Cano et al., 2005). High CO_2 concentrations and low O_2 concentrations can reduce the activities of chlorophyllase (Stewart et al., 2005). The result of present research and study was in agreement with the findings of Banks (1984), Zhang and Quantick (1997) and Plotto et al. (2007). All of these researchers found that edible coatings based on polysaccharides changed internal atmosphere of fruits and strongly delayed the color changes of the fruits.

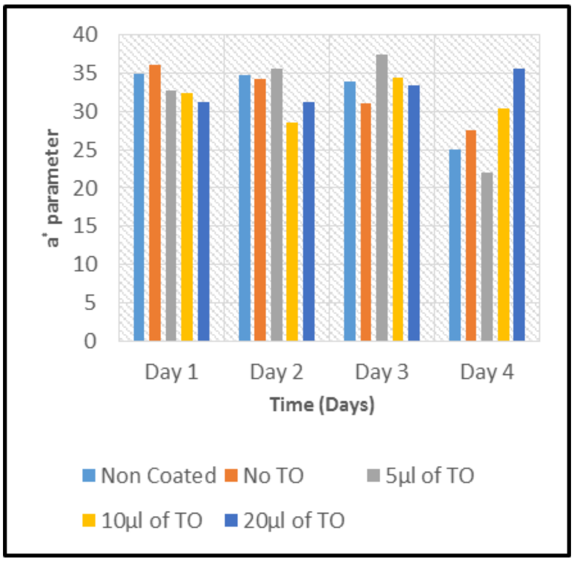

Figure 4(a): Relationship between a* parameter values and storage period for different chitosan coating solution (4g of tapioca powder)

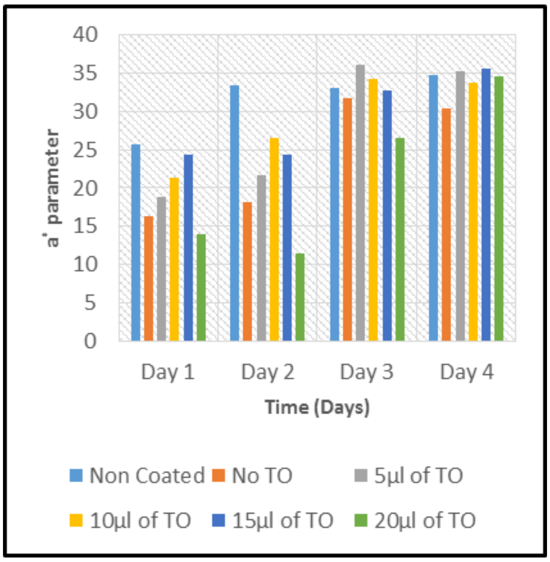

Figure 4(b): Relationship between a* parameter values and storage period for different chitosan coating solution (6g of tapioca powder)

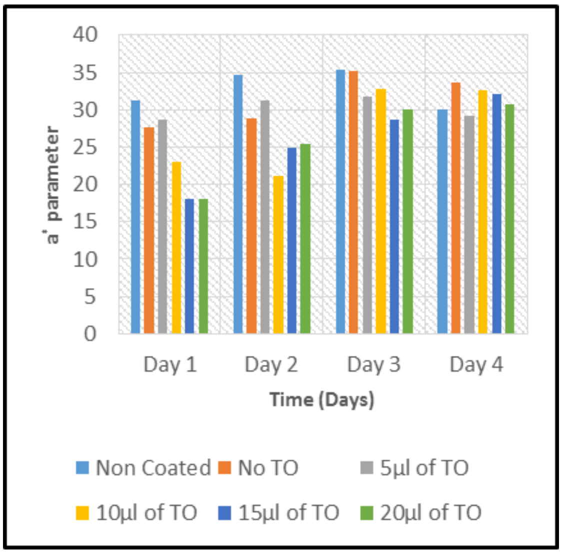

Figure 4(c): Relationship between a* parameter values and storage period for different chitosan coating solution (8g of tapioca powder)

C. Texture (Firmness).

One of the main factors that limiting the quality and the postharvest shelf-life of fruit and vegetables is the loss of texture. According to Perkins-Veazie (1995), strawberries soften considerably during ripening which mainly occurs as a result of degradation of the middle lamella of the cell wall of cortical parenchyma cells. There are also other characteristics influencing fruit firmness which are cellular turgor, cell wall strength and cell to cell contact (Harker et al., 1997). Figure 5, Figure 6 and Figure 7 shows the changes in flesh firmness of control and treated strawberry fruits during the storage period of four days at room temperature (28˚C). All the figures shows almost the same result which are the firmness of uncoated strawberries are the least as compared to the treated strawberries. Based on the Figure 5, after fourth days of storage the loss of firmness in uncoated fruit was around 34% whilst firmness in chitosan incorporated with turmeric essential oil (0µl, 5µl, 10µl, 20µl) were in the range of 8% to 30%. Same goes to Figure 6 and Figure 7, which are the loss of firmness in uncoated fruit after fourth days of storage was higher compared to treated strawberries.

In other observations, strawberries dipped in the chitosan solution incorporated with higher concentration of turmeric essential oil (20 µl) have the higher values of firmness (in force, N) as compared to other concentration of turmeric essential oil. From the observation, it has been shown that chitosan coatings and other edible biopolymers are selective barriers to O_2 and CO_2, modifying internal atmospheres and also slowing down the rate of respiration of strawberry fruits. The main reason of the loss of firmness is the high percentage of water loss by the strawberry especially for the uncoated strawberry which can contribute to high firmness differences. So that, addition of turmeric essential to the coating formulation can helps to increase the flesh firmness values of strawberry fruits. Essential oil can act as alternative antioxidants that can enhanced the antioxidant agent of the chitosan formulation. Antioxidants also can prevent sensorial and nutritional quality loss and improve stability of lipids, to lengthen the fruit's shelf-life (PONCE et al., 2008). According to ATARÉS et al., (2010), besides their high antioxidant capacity, turmeric essential oils can also improve the water barrier properties of the edible coating because they display the hydrophobic nature characteristics of lipids. Since, the water barrier was improved by the addition of turmeric essential oil, it can prevent the water loss of strawberry and this can increase the firmness of the fruits

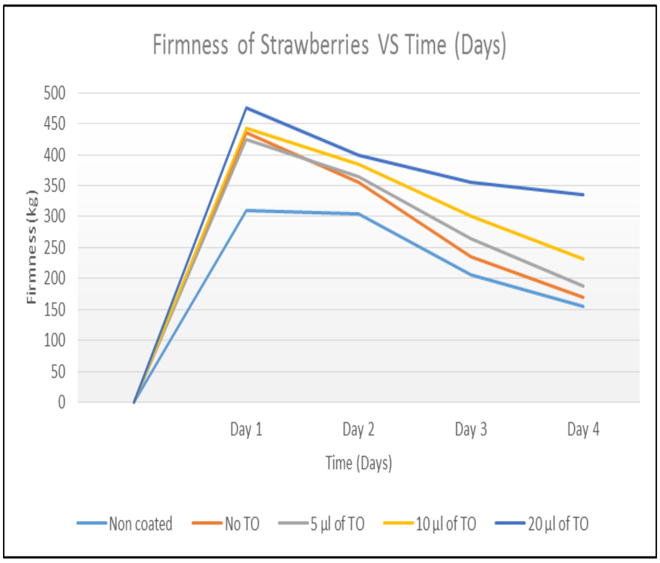

Figure 5: Effect of chitosan solution, addition of TO (Turmeric essential oil) and 4 gram of tapioca powder (2ml of starch) to chitosan coating formulation on the firmness of strawberries

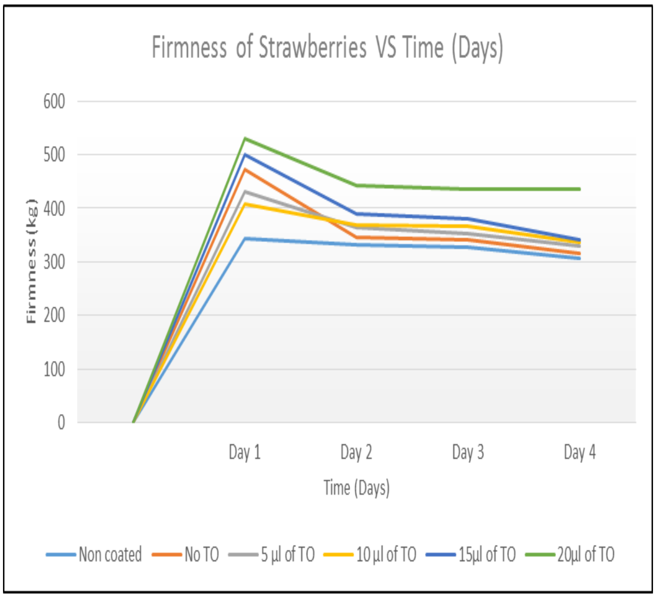

Figure 6: Effect of chitosan solution, addition of TO (Turmeric essential oil) and 6 gram of tapioca powder (2ml of starch) to chitosan coating formulation on the firmness of strawberries

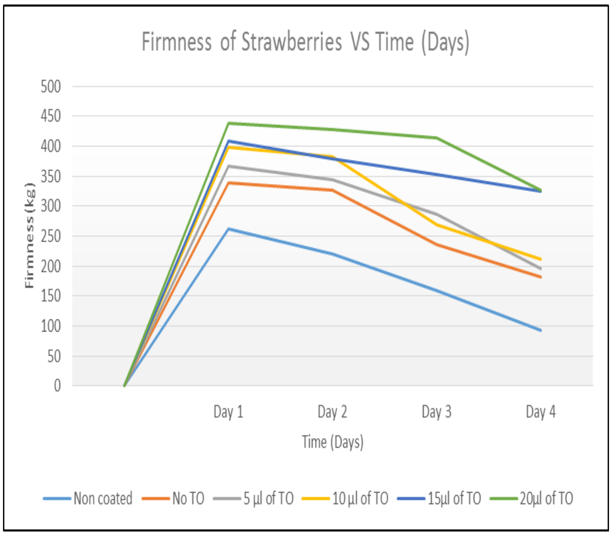

Figure 7: Effect of chitosan solution, addition of TO (Turmeric essential oil) and 8 gram of tapioca powder (2ml of starch) to chitosan coating formulation on the firmness of strawberries

D. *Surface tension.*

i. *Wettability of various coating solutions on a solid surfaces.*

Wettability involves the interaction between a solid and a liquid surfaces. When a droplet of a liquid which is chitosan solutions is deposited on a solid surfaces (glass slide), two possibilities can occur. In the first situation, the solid surface is well wetted by the liquid and the contact angle is low. However, the surface tension will be high. In the second situation, the solid is poorly wetted, the contact angle is high and the surface tension is low. Table 2 show the different chitosan formulation and the result of surface tension and contact angle analysis.

From the Table 2, the surface tension value (in dynes/cm) for 6 gram of tapioca powder (starch) is higher as compared to 8 gram of tapioca powder. This show that the higher the weight of tapioca powder for making starch solution, the more concentrated the chitosan solution then affected the result of contact angle and surface tension. As shown in the table, chitosan solution containing 6 gram of tapioca powder and 20 µl of turmeric oil has a surface tension value of 30.92 dyne/cm compared to 8 gram of tapioca powder which is 25.43 dyne/cm. From the observation, conclude that the higher the amount of tapioca powder in the formulation, the lower the surface tension, thus the wettability of the solution on the strawberry surface will decreased. On other hand, the presence of surfactant which is tween 80 in the chitosan formulation also affect the contact angle and the surface tension. However, concentration of tween 80 for all chitosan formulations are fixed to 0.1 ml. The surfactant classified as a surface active agents of an amphiphilic nature and are able to reduce the surface tension of water-lipid or water-air interface (Lin & Zhao, 2007). Furthermore, according to Lin & Krochta (2005), an addition of tween 80 in the chitosan formulation also can increases the hydrophilicity and coatability of the strawberry surfaces, thus can enhances oxygen barrier of the coating.

Weight of tapioca powder (g)	Coating solution	Average contact angle	Surface tension (dynes/cm)
6	Chi+2ml starch+no TO	82.10	35.57
	Chi+2ml starch+5µl TO	84.00	34.41
	Chi+2ml starch+10µl TO	87.40	32.34
	Chi+2ml starch+15µl TO	88.10	31.92
	Chi+2ml starch+20µl TO	89.75	30.92
8	Chi+2ml starch+no TO	96.00	27.72
	Chi+2ml starch+5µl TO	96.40	26.99
	Chi+2ml starch+10µl TO	98.55	25.74
	Chi+2ml starch+15µl TO	98.40	25.83
	Chi+2ml starch+20µl TO	99.10	25.43

Table 2: Average contact angle and surface tension for difference coating solution and weight of tapioca powder.

ii. *Turmeric essential oil effect.*

Values of the surface tension of the chitosan coating solutions with the addition of different amount of Turmeric essential oil: 0, 5, 10, 15, 20 µl are shown in the Table 2 and Figure 8. The surface tension of chitosan coating solution without turmeric essential oil for 6 gram of tapioca powder was 35.57 dyne/cm, but was reduced to 34.41 dyne/cm after addition of 5 µl of turmeric oil (TO). When addition of turmeric essential oil is increased from 5 µl to 10, 15 and 20 µl, the surface tension were reduced gradually. Same goes to the surface tension for 8 gram of tapioca powder which is without turmeric essential oil the surface tension was 27.72 dyne/cm and after the addition of different concentrations of turmeric oil, the surface tension were reduced gradually. The experimental data for the surface tension analysis are plotted using bar chart in the Figure 8 below.

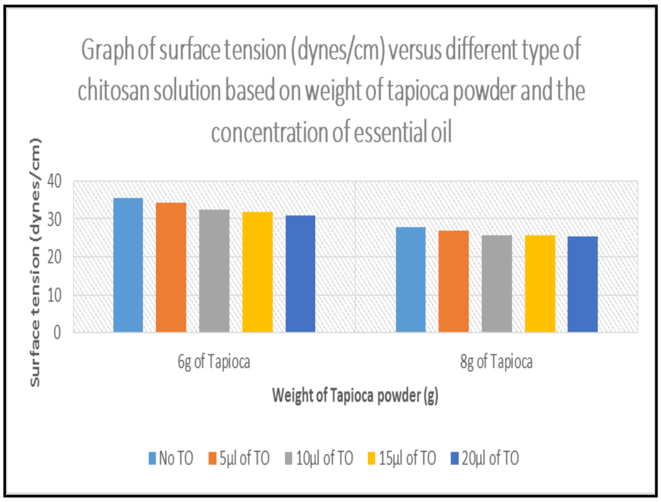

Figure 8: Graph of surface tension (dynes/cm) versus different formulation of chitosan solution based on weight of tapioca powder and the concentration of essential oil.

In other observation, the value of contact angle shows the properties of the solution whether it is hydrophobic or hydrophilic towards the solid surface. The solution contact angle increases with the increase of surface hydrophobicity (S.GALUS et al, 2013). Based on the Figure 9 and Figure 10, the droplet of coating solution without turmeric essential oil (a) deposited on the solid surface was spread, low contact angle thus high in wettability while droplet of coating solution with 20 µl of turmeric essential oil (e) on the solid surface was shrink, large contact angle and low in wettability. This results shows that, addition of turmeric essential oil has a positive and negative effect on the solution. Although the addition of turmeric essential oil helps in enhanced and improved the antimicrobial agent of the chitosan solution, however, too much concentration of turmeric oil will reduced the wettability and coatability of the solution on the strawberry surfaces. From the past study, the suitable surface tension for fresh fruit coating solution was in the range of 28 to 35 dynes/cm (Cothran Charles DE., 1945). Since, the value of surface tension for chitosan solution with addition of 6 gram tapioca powder (2 ml starch) and 20 µl of TO was 30. 92 dyne/cm which is still in the acceptable range, the formulation solution was acceptable for edible coating on the strawberry surfaces. However, for chitosan formulation with addition of 8 gram tapioca powder and 20 µl of TO give a surface tension value of 25.43 dyne/cm which is exceeding the acceptable range thus, not suitable for the coating on strawberry surfaces.

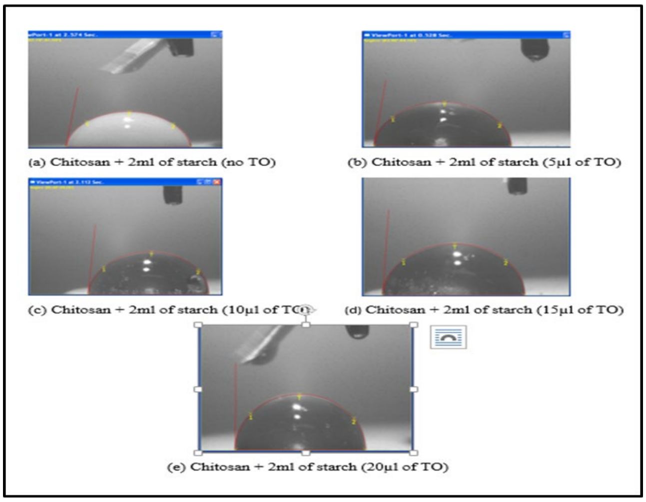

Figure 9: Contact angle and surface tension of tested chitosan liquid for 6 gram tapioca powder on solid surface using Water Surface Analysis System (VCA-3000S)

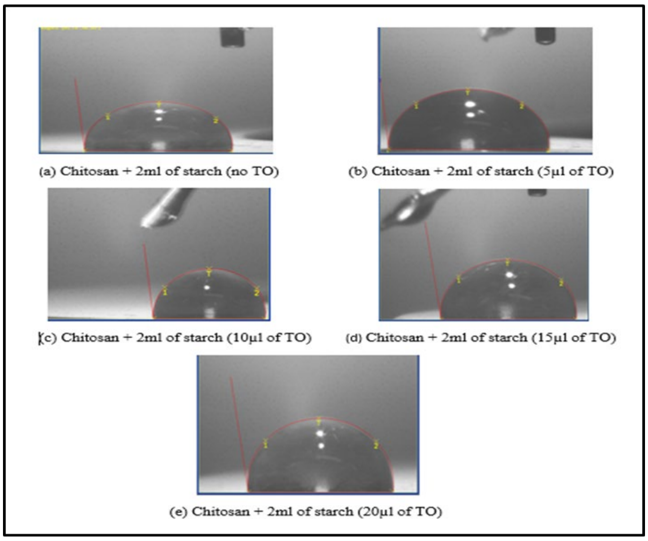

Figure 10: Contact angle and surface tension of tested chitosan liquid for 8 gram tapioca powder on solid surface using Water Surface Analysis System (VCA-3000S)

4. Conclusion

Edible coatings can improve fruit quality and extend its shelf life by providing the fruit with a barrier to gases and moisture. Using chitosan as a main substance in the formulation is able to give antimicrobial agent to the coating formulation. Turmeric essential oil added to the coating solution also improved and enhanced its performance against fungal and contamination by giving additive antimicrobial activity and improve antimicrobial effectiveness. As expected, in the experiment of different analysis which are appearance, color, texture and surface tension analysis showed that the coated strawberries give a better result as compared with uncoated strawberries. All the strawberries are coated with different treatment but were kept in the same temperature (room temperature) and humidity. For the appearance analysis, strawberry coated with chitosan solution and addition of 0, 5, 10, 15 and 20 µl of turmeric oil have longer shelf life compared with uncoated strawberry. However, if compared between different concentrations of turmeric essential oil, 20 µl of TO have a longer shelf-life since by increasing the concentration of turmeric oil give extra antimicrobial agents to the chitosan formulation solution. Same goes to color and texture analysis which are coated strawberries give a better results compared with uncoated strawberries. This shows that incorporation of chitosan solution with turmeric essential oil can enhanced the effectiveness of edible coating solution and indirectly provides a novel way to improve safety and shelf-life of strawberries. For surface tension analysis, the addition of 6 gram of tapioca powder to make starch solution into the chitosan solution give an acceptable result compared with addition of 8 gram of tapioca powder. The synergy between storage conditions and application of edible coatings based on chitosan and turmeric essential oil in strawberry has great potential in expanding the shelf-life of the strawberry. This is explained and demonstrated in this research through the experiment of appearance, color and texture analysis. From these experiment, it shows that by coating the strawberry with chitosan formulation solution, it can create very low O_2 environment and could provide replacement of natural layers to prevent moisture loss and control the exchange of gases that involved in the respiration process such as O_2, CO_2, and C_2H_4.For the other hand, chitosan edible coating incorporated with turmeric essential oil could be an attractive natural alternative against fungi especially Botrytis Cinerea that attack fruits and vegetables, avoiding application and excessive use of chemicals, and indirectly avoiding the occurrence of health and environmental problems.

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