

## Tumeric oil as the antioxidation agent in edible coating film

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**Abstract.** Turmeric oil (TO) has been studied for its potential as an antioxidation agent in starch edible coating for fresh cut apples and its degree of oxidation was analysed. TO incorporate with starch edible coating was examined using FT-IR Spectroscopy to determine the presence of secondary metabolites. The presence of alcohol and aromatic ring in the edible coating film proved that the secondary metabolites from TO were existed. The fresh cut apples were underwent the sensory test and six out of ten panellist concluded that coated fresh cut apples have good appearance and surface colour. Fresh cut apples were coated with edible coating incorporated with different concentrations of TO (uncoated, 0 $\mu$ L, 5 $\mu$ L, 10 $\mu$ L, 15 $\mu$ L. Percentage weight loss for 15 $\mu$ L were the least which were 1.98% (day 6) and 3.95% (day 12). Colour measurement were done for few days and it shows that the total colour difference ( $\Delta E$ ) for 15 $\mu$ L were the lowest. Thus, the oxidation activities for 15 $\mu$ L is the slowest compared to the others. These can be proved through the degree of oxidation analysis using UV-Vis spectroscopy. Uncoated fresh cut apples have the highest degree of oxidation while those with 15 $\mu$ L have the lowest. This study can be illustrated that the oxidation activities of fresh cut apples could be postponed using edible film incorporated with TO.

### 1. Introduction

Fresh cut fruits are basically ones that have been trimmed or reshaped from its original state to become another usable products but still remain in its fresh state. However, it is hard to maintain its fresh state mainly due to the removal of their pure vigilant skin and cutting process [1]. The tissue of the fruits will become wounded and it will lead to the enzymatic browning process on the product. Nowadays, consumers are aware about the importance of healthy eating habits. Therefore, the basis appearance and the freshness of the fresh cut fruits during the time of the purchase will be judged by the consumer. Enzymatic browning process occurred is due to presence of polyphenol oxide (PPO), which is a copper-containing oxidoreductase basically driven the browning reactions to occur where it catalyses two different reactions involving phenolic compounds and oxygen. Through this reaction, O-quinones will be developed from the oxidation of O-diphenols and will lead to the build-up of melanin and the development of brown compounds [2]. Accordingly, there are ways to improve their quality and postponing the enzymatic browning of the fresh cut fruits by coated them with edible coatings incorporated with antioxidation agents [3]. Antioxidation agent is needed to prevent the enzymatic browning towards the fresh cut fruits by prohibiting the initiation of browning by reacting with the oxygen such as turmeric oil. Turmeric oil has been showing antibacterial and antioxidant properties.

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Most of the turmeric oil components are bisabolane type sesquiterpenoids [3]. The application of edible coatings from the turmeric oil and the use of turmeric oil as antioxidant, anti-browning and texture enhancers to improve the quality and functionality of fresh cut fruits will be further reviewed.

## 2. Materials and Methodology

### 2.1. Coating materials

Materials used in this experiment were cassava starch (Cap Kapal ABC.Co), glycerol (Merck, United State) as plasticizers and turmeric oil (Soul, Malaysia) as antioxidation agent. Apple was purchased from the local market located in Shah Alam prior to start this experiment. Undamaged apple in uniform size and similar maturity stage was selected.

### 2.2. Coating Preparation

The coating formulation were made by dissolving starch (2 % and 3 % w/v) in 100 ml of distilled water with constant agitation at temperature of 70 °C until it reached homogeneity. Ratio of starch: glycerol ratio were at 1:0.25, and glycerol was added after starch's gelatinization. Afterwards, turmeric oil (0.05 % to 0.30 % v/v) was added to the formulation and stirred for 5 minutes at 1600 rpm [4].

### 2.3. Fruits selection and preparation

The apples that were bought from the local market at Shah Alam were clear up by cleaning it and sorted to remove damaged apples and foreign materials. The apples were sliced in equal slices of 1.5 cm in length to minimize browning [5]. Apples were divided into two parts, apples coated with emulsion and apples without coating for blank. The fresh cut apples were dipped in the emulsion for 30 s and then dried at room temperature before stored in the chiller (4 °C) [6].

### 2.4. Weight loss determination

The weight losses of non-coated and coated apples during storage were compared. Weight loss in this matter happened because of the water loss during storage. Weight loss were disclosed as percentage decrease in fruit weight, using the following formula

$$\text{Weight Loss} = \frac{W_i - W_t}{W_i} \times 100\% \quad (1)$$

where,  $W_i$  is initial weight (g) and  $W_t$  is fruit weight after a designated period of storage (g) [7].

### 2.5. Colorimetric determination

Colour was measured using a colorimeter HUNTERLAB-D25-9000 to obtained CIE values ( $L^*$ ,  $a^*$ ,  $b^*$ ). The subscript 0 in the equation stand for the colour parameters of fresh apple slices. The greater the total of  $\Delta E$ , it represents greater colour transition from the fresh apple [8]

$$\Delta E^* = [\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}]^{1/2} \quad (2)$$

### 2.6. Sensory Evaluation

For the sensory evaluation, coated and uncoated apples were analysed. Ten sensory panellists were picked and for each sensory test panel, in coded dishes, samples containing coated and uncoated apples were given. The panellists were given a hedonic questionnaire to test appearance and surface colour of coded samples of apples. Below table 1 are the sample for the hedonic questionnaire and the scoring scale [6].

**Table 1.** Scorecard of Hedonic Rating Scale [9].

Scorecard- Hedonic Rating Scale	
<b>Dish Number:</b>	<b>Name:</b>
In front of you are the samples of coated and uncoated apple slices inside a numbered dish. Please rate the apple inside the dish according to the scale given below:	
Food Characteristics	
Appearance	Surface colour

**Table 2.** Scale and description for the Scorecard of Hedonic Rating Scale [6].

Scale	Description
5	Excellent
4	Very Good
3	Good
2	Fair
1	Poor

### 2.7. Methods to Monitor Enzymatic Browning Oxidation (Assay for PPO Activity)

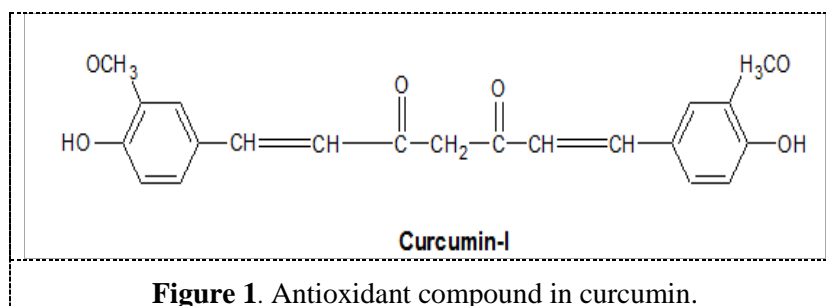
Enzymatic activity was assayed by checking the rate of increment in absorbance at a range of 420 nm and at 25 °C in a double beam model UV-1601 UV/VIS spectrophotometer. The reference cuvette has only the substrate solution. Meanwhile, the straight-line section of the activity curve as a function of time was used to figure out the enzyme activity (Units/g of fruit/min). A unit of enzyme activity was defined as the change of 0.001 in the absorbance value under the conditions of the assay [10]. When a lag phase happened, the reaction rate was measured after the lag phase [11].

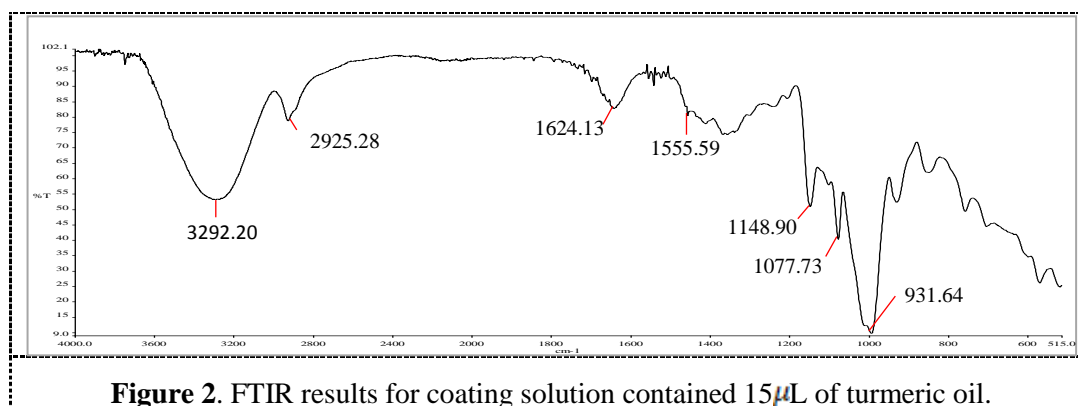
## 3. Results and Discussion

### 3.1. FTIR Analysis

Turmeric consists more than 500 bioactive components which major of them gives benefits to medical value. Turmeric rhizomes can be extracted as essential oils and has being discovered that turmeric oil has the potential to be used as antimicrobial and antioxidant agents due to the presence of curcumin [12].

As it can be seen in Figure 1, the functional groups that can be found in curcumin are alkane, alkene, alcohol, aromatic ring, and ketone. Thus, an analysis of coating mixture contains 100 mL distilled water, 5 g of starch, 1.25 mL of glycerol and 15  $\mu$ L of turmeric oil was done. The result can be seen on Figure 2 and Table 3 below. From the result obtained all functional groups that contain inside the curcumin except for ketone were presence. However, even the presence of the aromatic ring is enough for the turmeric oil to show its antioxidant properties.





**Figure 2.** FTIR results for coating solution contained 15 $\mu$ L of turmeric oil.

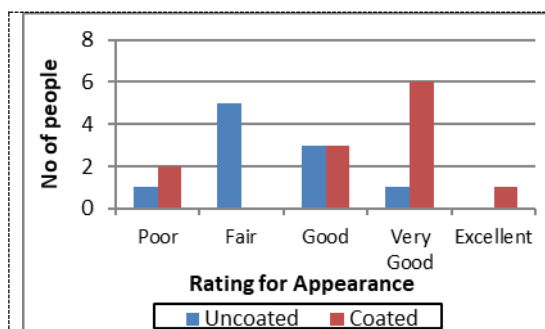
**Table 3.** Functional groups in edible coating film incorporated with turmeric oil.

Functional Group	Type of Vibration	Characteristics Absorptions (cm <sup>-1</sup> )
<b>Alcohol</b>		
O-H	Stretch, H-bonded	3292.20
C-O	Stretch	1148.90
<b>Alkane</b>		
C-H	Stretch	2925.28
<b>Alkene</b>		
C=C	Stretch	1642.13
=C-H	Bending	931.64
<b>Aromatic</b>		
C=C	Stretch	1555.59
<b>Ether</b>		
C-O	Stretch	1077.73

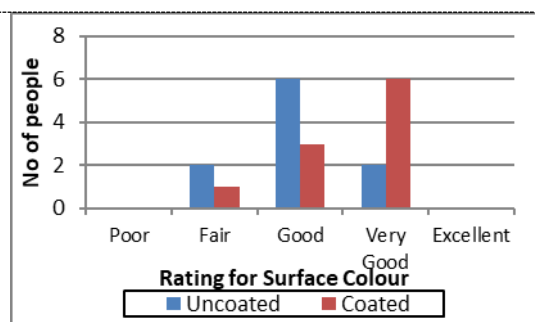
### 3.2. Sensory Evaluation

Sensory evaluation has been done for the coated and uncoated apple cubes that were stored in a chiller for 12 days at 4°C. For the coated apple cubes, apple cubes that were coated with coating solution that contain 15 $\mu$ L turmeric oil were presented as a sample. A total of ten sensory panellists were gathered during the 4<sup>th</sup> of May 2016 to evaluate the sample of apple cubes that were being presented in a coded dish labelled as A and B. The panellists were given a hedonic questionnaire to test the appearance and surface colour of coded samples of apple cubes.

Based on Figure 3 and Figure 4 above, there are variety of ratings given from the sensory panellist. However, the ratings for the coated apple cubes were quite high both for the appearance and the surface colour of the apple cubes. Six panellist rate the appearance to be in very good appearance and one panellist rate the appearance of the apple cubes as excellent. It can be concluded that even from the sensory evaluation, the appearance of the apple cubes that were coated with the turmeric oil seems to be having a great appearance towards the panellist. This proved that the turmeric oil can preserve the apple cubes from the enzymatic browning by using its antioxidant characteristics.



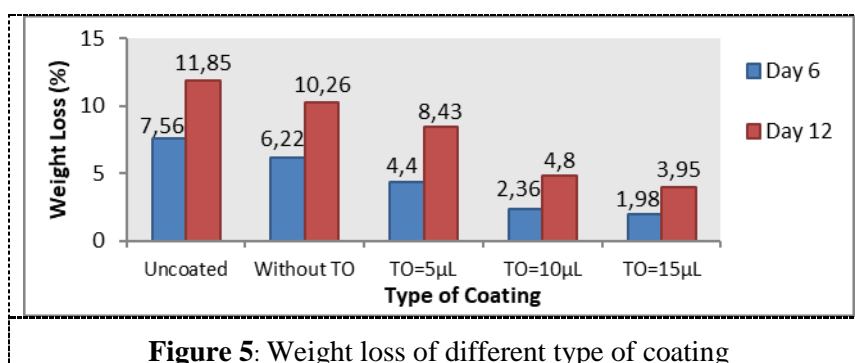
**Figure 3.** Rating for appearance of uncoated and coated apple cubes.



**Figure 4.** Rating for surface colour of uncoated and coated apple cubes

### 3.3. Weight loss

The percentage of weight loss for apple cubes with different types of coating at their sixth day and twelfth day of storage were shown in Figure 5. All apple cubes with different types of coating were being stored inside a chiller at 4 °C. Analysis of divergence showed that apple cubes being coated with 15  $\mu\text{L}$  turmeric oil presented notably the lowest weight loss at their sixth and twelfth day with 1.98 % (sixth day) and 3.95 % (twelfth day) compared to other apple cubes, whereas, apple cubes that were uncoated had no significant effect on the weight loss since the percentage of their weight loss on their twelfth day (11.85 %) is quite high. Moreover, the effect of using the turmeric oil can be seen through the weight loss where apple cubes that were being coated with turmeric oil, even the smallest concentration, showed lesser weight loss compared to the apple cubes that were being uncoated and coated without turmeric oil. At the same time, it can be seen that the higher the concentration of turmeric oil being used in a coating solution, the lower the weight loss occurred to the apple cubes. This shows that coatings that contained even the slightest amount of turmeric oil played an important role in avoiding weight loss of apple cubes, meanwhile coating that does not contain turmeric oil (only contain starch and glycerol) showed poor moisture barrier.



**Figure 5:** Weight loss of different type of coating

### 3.4. Colour Measurement

The apple cubes were stored in a chiller with a mean temperature of 4 °C for a few days. Since the apples were dipped into difference concentrations of turmeric oil, the apple cubes were kept in different containers. As the apple cubes were being observed for a few days, the apple cubes underwent the color changes as there were increased in  $a^*$  and  $b^*$  values and decrease in  $L^*$  value. According to Perez-Gago *et al.* (2006), an increase in colorimetric  $a^*$  and  $b^*$  values and decrease in  $L^*$  value (represent lightness), indicate that the enzymatic browning in the apple cubes were also increased. The lower the value of  $L^*$ , the higher the loss of the lightness of the apple cubes [13].

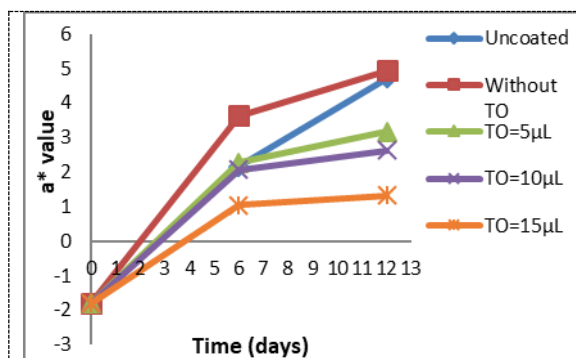
Table 4 shows the result obtained for the value of  $L^*$ ,  $a^*$  and  $b^*$  for apple cubes with different turmeric oil concentrations on their sixth day and twelfth day of storage. Meanwhile, Figure 6, 7 and 8

shows the result being plotted into the graph. From Figure 6, it can be seen that the value of  $a^*$  seems to be increasing from the control value for all apple cubes in their sixth and twelfth day. However, after being observed, the value appeared to start slowing down on their increment with the apple cubes being coated with a solution that contain  $5 \mu\text{L}$  of turmeric oil. The value of  $a^*$  further slowing down with higher concentration of turmeric oil. The same trend can also be implied with  $b^*$  values as shown in Figure 7. An increase in  $a^*$  and  $b^*$  values indicates an increase in overall pigmentation of the apple cubes. However, the pigmentation starts to slow down with the usage of turmeric oil.

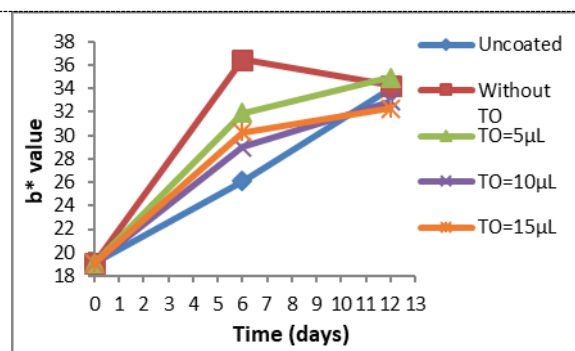
**Table 4:** Value of  $L^*a^*b^*$  for different turmeric oil concentration on their 6<sup>th</sup> and 12<sup>th</sup> day.

	Control		Uncoated		Without TO		TO = $5 \mu\text{L}$		TO = $10 \mu\text{L}$		TO = $15 \mu\text{L}$	
Day	6	12	6	12	6	12	6	12	6	12	6	12
$L^*$	77.38	66.01	54.70	69.24	54.78	72.83	67.91	74.13	70.92	75.53	72.01	
$a^*$	-1.80	2.17	4.72	3.64	4.95	2.28	3.17	2.07	2.63	1.05	1.33	
$b^*$	19.15	26.11	33.94	36.45	34.25	31.91	34.92	29.03	32.93	30.28	32.30	
$\Delta E$		13.91	27.85	19.88	28.01	14.15	19.05	11.10	15.85	11.64	14.54	

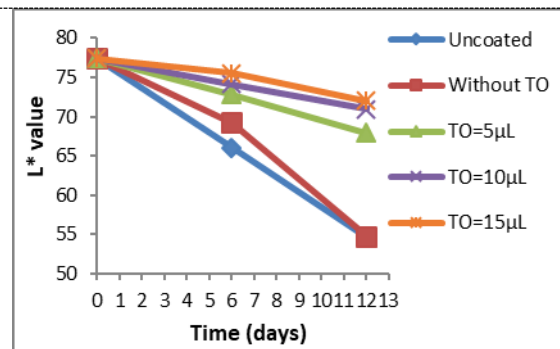
At the same time, the value of  $L^*$  also further proving that the usage of turmeric oil can slow down the enzymatic browning of the apple cubes and also act as an antioxidant agent. In Figure 8, the value of  $L^*$  seems to be decreasing from its control value.  $L^*$  value in the CIE  $L^*a^*b^*$  coordinated represent the lightness of an item and decrease in  $L^*$  value indicate the loss of lightness. In this study, the lower the  $L^*$  value of the apple cubes means the higher the changes in colour happened towards the apple cubes. Hence, the higher the rate of enzymatic browning of the apple cubes. In Figure 8, apple cubes that were uncoated and coated without the turmeric oil are showing the most drastic decrease in their  $L^*$  value. Meanwhile, the apple cubes that are being coated with the turmeric oil but with different concentrations are only showing a little decrease in their  $L^*$  value. This also proved that the use of turmeric oil in coating the fresh cut fruits can help them decrease the rate of the enzymatic browning.



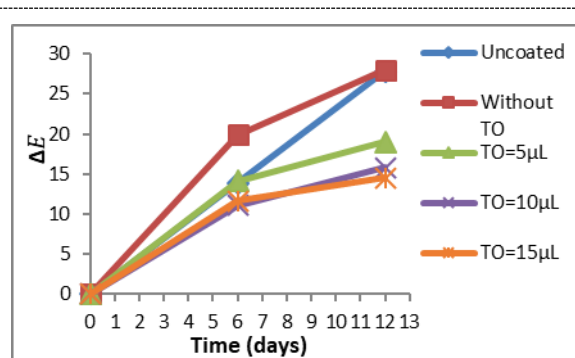
**Figure 6:**  $a^*$  value of apple cubes during storage at  $4\text{ }^{\circ}\text{C}$  in the chiller.



**Figure 7:**  $b^*$  value of apple cubes during storage at  $4\text{ }^{\circ}\text{C}$  in the chiller.



**Figure 8:** L\* value of apple cubes during storage at 4 °C in the chiller.



**Figure 9:** Total colour difference ( $\Delta E$ ) value of apple cubes with different turmeric oil concentration at 4 °C in the chiller.

To further verifying that turmeric oil can act as an antioxidation agent by slowing down the rate of the enzymatic browning, the total colour difference ( $\Delta E$ ) were calculated. Figure 9 shows the result being plotted to a graph. As being shown in Figure 9, the total colour difference for the apple cubes increased significantly between day 0 and 6 of storage. However, for the apple cubes that were coated with the turmeric oil, the colour difference seems to be remained approximately constant thereafter. But, apple cubes that were uncoated and coated without the turmeric oil continue to increase their colour difference on their twelfth day of storage. The increases in the total colour difference suggest an increase in the proportion of oxidized phenols during the storage. This further proving the characteristics of turmeric oil as antioxidation agent by slowing down the enzymatic browning reaction of the apple cubes.

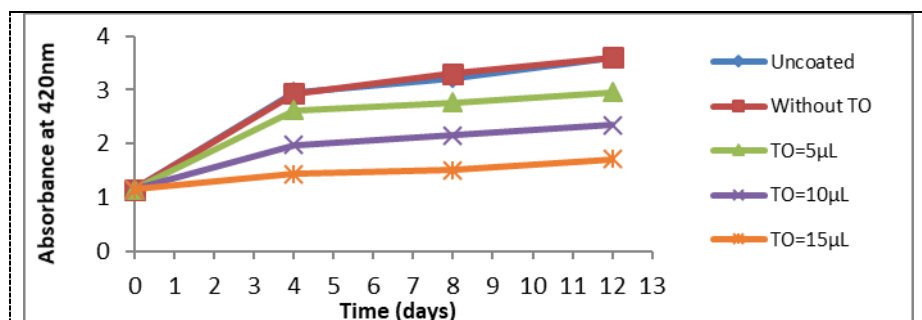
### 3.5. Degree of Oxidation

The changes in absorbance at 420 nm were studied with the time of treatment and also with the type of different coating for apple cubes. Significant differences for the degree of oxidation were observed among the apple cubes as shown in Table 5. Results showed that increasing processing time also increase the absorbance at 420 nm. However, that was not the only factor since it can be seen from Figure 10 that different types of coating also affected the absorbance rate at 420 nm. Apple cubes that were uncoated and coated without the turmeric oil were leading the degree of oxidation followed by coating that contains 5  $\mu\text{L}$ , 10  $\mu\text{L}$  and 15  $\mu\text{L}$  of turmeric oil respectively.

**Table 5:** Value of absorbance at 420 nm during storage at 4 °C in the chiller.

Day	Uncoated	Without TO	TO = 5 $\mu\text{L}$	TO = 10 $\mu\text{L}$	TO = 15 $\mu\text{L}$
4	2.9606	2.9339	2.6242	1.9789	1.4300
8	3.2251	3.3048	2.7694	2.1552	1.5069
12	3.6001	3.5984	2.9537	2.3511	1.7082





**Figure 10:** Change in the degree of oxidation at absorbance at 420 nm during storage at 4°C chiller

As stated before, the degree of oxidation was monitored during cold storage in order to observe relationships with total phenolic or PPO activity. At zero time measurement of the change in absorbance at 420 nm, the PPO activity already registered an initial reading at 1.1413. Similar to what was reported, the result for PPO activity of the apple cubes varied for the next fourth, eight and twelfth days of storage [14]. Apple cubes that were coated with coating contained turmeric oil showed very little change during the storage especially apple cubes that coated with high concentration of turmeric oil. As for the apple cubes that were uncoated and coated without the turmeric oil, there were an enormous increased in their degree of oxidation on the fourth day of storage and it keeps on increasing till the twelfth days of storage.

After comparing the degree of oxidation of the apple cubes with five different types of coating, there was a correlation between the degree of oxidation and PPO activity with the type of the coating used. Apple cubes that were uncoated showed a very high degree of oxidation and rate of enzymatic browning were also very high. However, for the apple cubes that were coated with coating contained 15 µL turmeric oil, it shows a slight increase from the initial reading and it proves that turmeric oil can preserve the apple cubes from the enzymatic browning. Also, the higher the concentration of turmeric oil used in a coating solution, the lower the rate of the enzymatic browning.

#### 4. Conclusion

Based on the findings, it can be concluded that turmeric oil shown its antioxidant characteristics when it incorporated with starch edible coating film for the fresh cut apples. All the apple cubes were stored inside a plastic container at a chiller with a temperature of 4 °C. Apple cubes were divided into categories which were uncoated, coated without turmeric oil and coated with turmeric oil with three different concentrations which were 5 µL, 10 µL and 15 µL. Sensory evaluation has been done and within ten sensory panellist, 6 panellist rate the appearance and the surface color to at a very good rate. Meanwhile for the weight loss, the uncoated apple cubes showed the highest percentage of weight loss during the twelfth day of storage which is 11.85 % whereas apple cubes that were coated with coating that contain 15 µL of turmeric oil showed the lowest percentage of weight loss which is 3.95 %. This proved that the edible coating incorporated with turmeric oil able to preserve the apple cube. Same goes for the colour measurement where the apple cubes that were coated with coating that contain 15 µL of turmeric oil showed the lowest total color difference which is  $\Delta E = 14.54$  at the twelfth day of storage. As for the degree of oxidation, the oxidation activity was measured at absorbance at 420 nm the results showed that increasing usage of turmeric oil decrease the absorbance at 420 nm. Thus, it can be said that the turmeric oil can postponed the enzymatic browning from happening. In conclusion, turmeric oil has been showing its antioxidant activities for the fresh cut apple throughout this entire study and therefore the objectives for this research have been achieved.



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