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Effect of concentration of Curcuma longa L. on chitosan–starch based edible coating

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Abstract. The ability of chitosan-starch based coating to extend shelf life of strawberry were studied. The main objectives of this paper is to study the effects of different concentrations (20, 15, 10 and 5 µL) of *Curcuma longa L.* (CUR) essential oil into chitosan-based edible coating on surface tension in order to increase the effectiveness of the coating. CUR or turmeric is one of the commercially planted herbs in Malaysia for its phytochemical benefits. Application of edible coating using dipping technique has been analysed and evaluated for their effectiveness in extending shelf life of fruits. Surface tension was analysed to investigate the adhesion properties. The best CUR concentration was 15 µL with the optimum surface tension was found to be 31.92 dynes/cm.

1. Introduction

Strawberry is a highly nutritious, juicy and delicious fruit but very perishable with short shelf life due to fungal decay. It is one of the most refreshing, popular and healthy treats indeed. Therefore, it is important to satisfy all demands by developing better methods in extending shelf life of strawberry without any preservatives so that they are all in good quality even after several days. Technologies for food packaging and coating using biopolymers contribute to an interesting alternative in reducing the application of chemical preservatives. Aider (2010) identified that among most polymers, chitosan is one of substance that is extremely reliable as additive for bio-based active film preparation. Thus, edible films and coatings from chitosan seems to be highly promising to extend post-harvest shelf life of strawberry fruit. Edible films and coatings are thin films applied on food products that play an important role to maintain the quality and can be eaten as part of the products (Falguera et al. 2011). It has been used to protect the fruits from any damages include physical, chemical and mechanical as well as microbiological activities. On top of that, edible films and coatings are also applied to many products to control moisture transfer, gas exchange or oxidation process to overcome negative effects on product quality such as browning, off-flavour development, texture breakdown and microorganisms attacks (Rojas-Graü, Soliva-Fortuny, and Martín-Belloso 2009).

Edible chitosan films and coatings can be incorporated with another active compound to ensure that they perform their level best. As reported by Azevedo et al. (2014), edible chitosan coatings enriched with essential oil have been shown a great result as an effective antimicrobial activity against some foodborne pathogens. The effect of antimicrobial activity can protect fruits from microbial spoilage so that the shelf life can be extended. Among all the perishable fruits, strawberry is considered to be the most difficult to maintain the freshness and has therefore been selected to test the efficacy of edible coating (Sallato et al. 2007). Strawberry which is known as *Fragaria x Ananassa Duch* is highly consumed berries worldwide because of its flavour and preferred organoleptic properties (Šamec et al. 2016). It has unique shape, fascinating colour, aromatic and delightful taste.

2. Materials and method

A systematic methodology has been identified to facilitate the research objectives. The experimental works were done in three parts including the preparation of chitosan solution, starch solution and mixture of chitosan and starch solution.

2.1. Materials

Materials involved are cassava starch, *Curcuma longa L.* (CUR) was used as the essential oil from BF1 Sdn. Bhd., 0.1M sodium hydroxide, chitosan with 97% deacetylation, tween 80, acetic acid 99%, and glycerol.

2.2. Edible coating preparation

Chitosan-starch edible coating was developed based on the procedures by Vásconez et al.(2009) with some modifications.

2.2.1. Chitosan solution.

Chitosan with 1% (w/v) was gelatinized in an aqueous solution of 0.5% (w/v) acetic acid at room temperature. 0.1 % (w/v) of tween 80 was added as a surfactant to increase wettability (Santos et al. 2012). In order to ensure that the chitosan is completely dissolved, the solution was stirred for 24 hours at 350 rpm until all the chitosan flake disappear. pH of the solution was adjusted by using 0.1 M NaOH until it reach pH of 5.6 (Guerra et al. 2015) to decrease the acidic condition of chitosan solution. The solution was made up to 100 mL by adding distilled water up to 100mL.

2.2.2. Starch solution.

4% (w/v) of starch solution was gelatinized at 80°C. The solution was stirred for 30 minutes at 350 rpm to overcome the starch from being coagulated. The solution was made up to 100 mL by add up distilled water until reach to 100mL. In order to enhance the application of solution formed by the combining chitosan and CUR essential oil, 2 mL of glycerol was added as a plasticizer.

2.2.3. Chitosan and starch coating solutions.

2% (w/v) of prepared starch solution was added to 100 mL of prepared chitosan solution. The combined solution was stirred at room temperature for 18h to enable the solution well mix. For the combination of EO into chitosan and starch, different concentration of CUR essential oil was used which are 20, 10, 5, and 0 μL. The CUR essential oil was added into the prepared chitosan and stirred at room temperature until complete mixing. The coating solution formulations were added with chitosan concentrations of: 20, 15, 10 and 5 μL; glycerol concentrations of 2.0% and (v/v); Tween 80 concentrations of 0.1% (w/v).

2.3. Characterization of chitosan-starch based coating

The combination of biopolymers give better results compared to only one component (Cao, Shi, and Chen 1998). The importance of surface properties is essential for understanding coating adhesion and to optimize the effectiveness of the coating. In this study, the blending of chitosan and starch coating with different concentration of CUR essential oil has been produced. The coatings were coated on strawberries and then were being evaluated in terms of their surface tension, microstructure and effect to the strawberries.

2.3.1. Surface tension.

In order to examine the adhesion properties of the coating to the strawberry surface, it can be done by measuring the contact angle of a standard liquid on the surface (Moncayo and Buitrago 2015). In this study, analysis of surface tension for all the samples has been done using contact angle meter by the pendant drop method.

2.3.2. Microstructure observation.
The microstructure of coated sample was analysed using a field emission-scanning electron microscopy (FESEM) Zeiss Supra 35VP. The strawberry sample were mounted onto metal stubs and coated with Au using an accelerating voltage of 5kV.

2.3.3. Characterization of strawberries
The laboratory assays were done using fresh strawberries with same the maturity stage, 75% red colour, uniform weight with no sign of mechanical or microbiological injury.

3. Results and discussions

3.1. Surface tension.
Strawberry fruits are very rich in nutrients and have a coarse surface with high moisture conditions which provide a good surface to be coated. The result in Fig.1 shows that surface tension is decreasing as the concentration of the CUR essential oil increased. As reported by Kurek et al. (2013), a monomolecular layer formed by liquid-air interface will reduce the surface tension. Moncayo and Buitrago (2015) in their study have described the meaning of surface tension as the amount of energy needed to increase the surface per area.

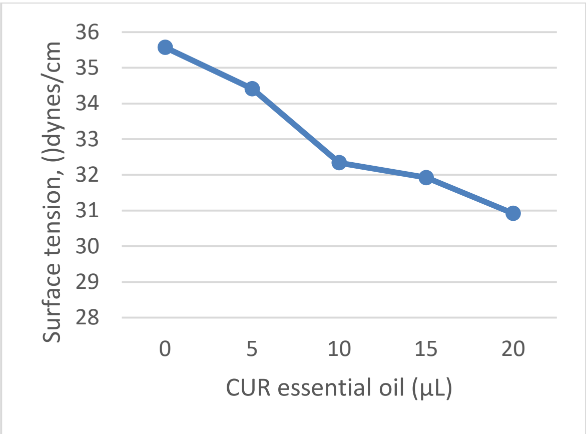

Figure 1. Variation of surface tension of the chitosan-starch based coating with the addition of CUR essential oil

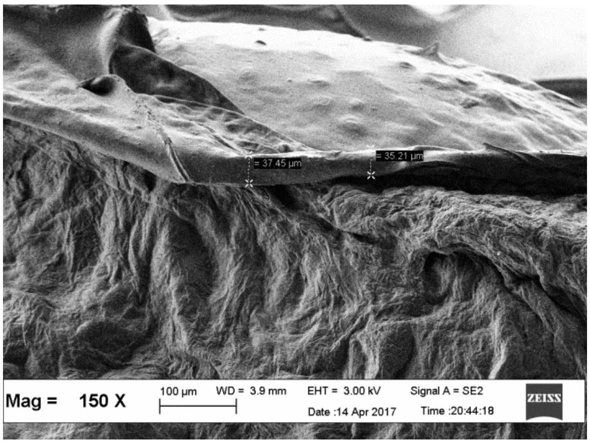

Figure 2. FESEM micrographs of the cross section of the strawberry coated with chitosan-starch based coating containing CUR essential oil

3.2. Microstructure observation.
Field emission scanning electron microscopy (FESEM) was carried out to observe the microstructure and surface characteristics of coating film in order to establish a relationship between coating and strawberry. Fig.2 shows FESEM micrograph of cross section of strawberry coated with chitosan-starch coating plus 15 µL of CUR essential oil. As can be seen the coating had a quite smooth and homogeneous surface with a thickness about 37.45 µm. It suggests that the blending of chitosan and starch with the addition of CUR essential oil are highly miscible and homogeneous.

3.3. Physical appearance

The significance of this study can be seen from results in comparing between coated and uncoated strawberry fruits by qualitative determination through observation. The evolution of infection during the 5th day storage of the coated at different concentration of CUR essential oil and uncoated strawberries is shown in Fig.3 below. On all days of analysis, the strawberries coated with chitosan-starch plus CUR essential oil coatings presented a significantly lower infections than to uncoated.
However, the minimum infections was more evident in the strawberries that were coated with 15 µL CUR essential oil in chitosan-starch coating. This is maybe because of too much of CUR essential oil will interfere the antimicrobial agent to be function. Based on study by (Negi 2012), high concentrations of bioactivity compound at lower pH act in a more hydrophobic way. On the other hand, for some other essential oils, they may give a negative impact even at a very low concentration due to their low breakpoint for perception (Lv et al. 2011).

Figure 3. Effect of CUR essential oil in chitosan-starch based coating with different concentrations: a) uncoated, b) 5 µL, c) 10 µL, d) 15 µL and e) 20 µL on strawberry fruits from day 1 until day 5

4. Conclusions

In this study, it was found that application of chitosan-starch based coatings delayed the ripening process and reduced physicochemical changes of strawberry fruit. Chitosan-starch with 15 µL CUR essential oil coatings inhibited decay incidence and maintained until day 5. This study suggested that combine application of chitosan-starch coatings and CUR essential oil can be used for reducing postharvest deterioration and extending the shelf life of strawberry. In addition, the existence of antimicrobial agent such as CUR essential oil had lower down surface tension of the coating. The optimum values of the coatings were obtained experimentally with the formulation of: 1% chitosan, 2 mL of starch, 2% glycerol, 0.1% tween 80 and 15 µL of turmeric oil with surface tension of 31.92 dyne/cm.

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