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The Effect of Maltodextrin and Acacia Gum on Encapsulation of Fig Powder Physicochemical Properties

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ABSTRACT

In this study, the effect of coating material composition on the encapsulation of physical and chemical properties of fig powder was investigated. As coating material maltodextrin and acacia gum at different ratios were chosen (100% and 75%:25%). The core to coating ratio was 1:1. The microcapsules were prepared with high-speed homogenizer at 10000 rpm for 10 min. The vacuum dried microcapsules were analyzed in terms of moisture, total soluble solid, bulk and tapped density, Carr's index, Hausher ratio, total flavonoid content, and antioxidant activity. The antioxidant activity was mostly higher when coating ratio was 100% acacia gum in the core and coating ratio of 1:1 as compared to others. There was positive correlation between total flavonoid content and antioxidant activity. Combination of coating agent in ratio 75%: 25% vice versa significantly improve the physical properties of fig powder. The ratio of maltodextrin and gum arabic had significant effect on all physical and chemical properties analyzed.

Keywords:
Encapsulation, maltodextrin, acacia gum, fig powder

1. Introduction

Fig have been known since ancient times for its phytochemical that relates to its curative properties which have been utilized for the treatment of various ailment [17]. In general, polyphenol is a powerful antioxidant which classified in three main classes; phenolic acids, flavonoids, and stilbenoids. Flavonoid is the most natural biological response modifiers among others [4]. In biological systems, oxidative damage results from an imbalance in free radicals and antioxidants. As a result, oxidative stress will lead to cell membrane disintegration, protein damage, and DNA mutation. Furthermore, it will initiate or propagate aging and several diseases, such as neurodegenerative disorders, cancer, liver cirrhosis, cardiovascular diseases, atherosclerosis, cataracts, diabetes, and inflammation. Phenolic compounds, such as phenols, phenolic acids, flavonoids, tannins, and anthocyanins, have received considerable attention for their high

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antioxidant activity [16]. Antioxidant activity can act in various ways, such as inhibiting free radical oxidation reactions by preventing the formation of free lipid radicals; acting as singlet oxygen quenchers; reducing agents which produce stable compounds from hydroperoxide; acting as metal chelators and acting as inhibitors of pro-oxidative enzymes [15].

Encapsulation is a process in which one material is entrapped or coated with another material in order to protect the coated material against adverse conditions and the nutritional deterioration. The coated one is named as core or active material and the surrounding one is coating material [13]. In addition to protection, by encapsulation process, controlling the release of core material and masking the undesired properties of core material can be achieved [5]. Coating materials have significant role in stability of the encapsulation process. Different kinds of coating materials are used for encapsulation process such as polysaccharides, proteins and lipids [13]. Maltodextrin has good solubility in water and low viscosity values even at high concentrations. These properties make maltodextrin useful for coating material. On the other hand, maltodextrins are deficient in terms of emulsification property and surface-active features. For this reason, combining other coating materials with maltodextrin is required to form stable capsules [21]. Acacia gum is composed of branched arrangement of simple sugars like galactose, glucuronic acid, arabinose and rhamnose and small amount of covalently bonded protein. This protein gives functional properties to acacia [13]. It has high water solubility and low viscosity than other gum types [12]. In addition, it can create a protective film around core material and acts like emulsifier. In other words, it prevents aggregation by forming a thick layer [26].

As stated by Farhangi et al. [8], figs can remove the kidney and urinary bladder stone, release intestinal pain, pile, dyspepsia, and anorexia. Fruit contains pentose, amino acid, tyrosine, enzyme, cravin, lipase, protease, and sugar. The most phytochemical content of figs is flavonoids which are quercetin and luteolin [18]. The investigation by Soni *et al*. [22] deals with the nutritional, phytochemical, antioxidant and antibacterial activity of dried fruit of fig (Ficus carica) indicates that its polyphenols contribute to its high antioxidant activity. The rich content of flavonoids in fig contribute to anti-cancer, antioxidant, anti-inflammation, anti-acne, anti-bacterial [14]. The objective of this study was to encapsulate fig juice. Moreover, the effects of coating materials with different type and ratio were investigated in terms of physical and chemical properties.

2. Material and Methods

2.1 Material

Figs was taken from the local market in Johor, Malaysia. Maltodextrin and acacia gum were the coating materials and purchased from VIS Foodtech Ingredient Supply Sdn. Bhd. (Kuala Lumpur, Malaysia). The reagents used in the experiments, which were aluminium chloride ($AlCl_3$), methanol (CH_3OH), potassium acetate (CH_3CO_2K), quercetin ($C_{15}H_{10}O_7$), and DPPH (2,2-diphenyl-1-picrylhydrazyl) were all bought from Merck Germany.

2.2 Encapsulation

The fig juice was prepared by laboratory juice maker (KEA0236, Alpha, China). Coating materials were prepared in 4 different compositions (100% maltodextrin, 100% acacia gum, 25% acacia gum with 75% maltodextrin and 25% maltodextrin with 75% acacia gum). In addition, the mixture of coating materials was homogenized at 6000 rpm for 2 min. Then, the 50g juice and coating material were separately weighted for encapsulation with 1:1 core to coating ratio. In order, to get capsules, the mixtures were homogenized by high-speed homogenizer (IKA T18 digital Ultra-Turrax, Selangor, Malaysia) at 1000 rpm for 10 min. Then, capsules were vacuum dried at 35ºC for 24 hours.

2.3 Physical Properties

The physical properties of fig powder were evaluated by moisture content, total soluble solid (ºBrix), angle of repose value, bulk density, tapped density, Hausner ratio and Carr's index. The moisture content of powder was determined by placing 5g of powder in moisture analyzer (Precisa XM 66, Switzerland). ºBrix was determined by first preparing a blend of 1 g of fig powder with 10 ml of distilled water. This blend could stand for 1hour at room temperature and stirring manually sporadically. Determination of °Brix was carried out using a hand refractometer (Atago PAL-BX/RI, Japan). The refractometer prism surface was cleaned with distilled water and tissue paper, followed by placing a drop of the sample on the prism of the refractometer. The reading was taken by looking through the eyepiece of the refractometer and the soluble sugar was expressed in °Brix. The Carr's index were identified by determining the bulk density (Db) and tapped density (Dt) of powder. Bulk density was obtained by collecting 50 cm^3 sieved powder (sieve no.20) and introduce into a 100ml graduated cylinder. Then, cylinder was dropped three times from height 1 inch at 2 seconds intervals. The density was calculated by dividing the weight of sample in grams by the final tapped volume in cm^3 of the sample in cylinder. The method was repeated for tapped density with different tapped times (100 times). The Carr's index then were calculated as Eq (1):

$$\text{Carr's index (\%)} = [(Db - Dt)/ Dt] \times 100 \quad (1)$$

3. Material and Methods

3.1 Chemical Properties

Both total flavonoid content (TFC) and antioxidant activity were performed to evaluate the chemical properties of fig powder. TFC was determined spectrophotometrically according to the Dowd method describe by Ramamoorthy and Bono [20] with slight modification. The 1 ml of sample solution (1 mg/ml) are taken and mixed well with 3 ml of methanol. Then, 0.2 ml of 10 % $AlCl_3$ and 0.2 ml of CH_3CO_2K in 1M are added to the mixture. The solution is held at the dark condition for 30 minutes before absorption readings taken at 420 nm using a UV-Visible spectrophotometer (T60 U, PerkinElmer, U.S.) against the blank sample. The total flavonoid content is determined using a standard curve with quercetin (0, 10, 50, 100 and 200 µg/ml) as the standard. TFC is express as mg of quercetin equivalents (QE) / mg of sample. Antioxidant activity was determined by DPPH radical scavenging activity spectrophotometrically, according to Xu et al. (2008), with slight modification. The 0.1mM DPPH solution had been formulated just before the start of the experiment. Mixtures of reaction; 2 ml of sample, 4 ml of 0.1 mM DPPH solution and 2 ml of methanol were incubated for 30 minutes. The blank solution has also been tested (4 ml 0.1 mM DPPH solution and 2 ml methanol). Following incubation, the absorption reduction was measured with a UV-Vis spectrophotometer at 517 nm as compared to blank. The following formulation calculated the activity of radical scavenging (percentage of inhibition) by Eq (2):

$$\% \text{ Inhibition} = [(AB-AA)/AB] \times 100 \quad (2)$$

where: AB is the absorption of blank sample and AA is the absorption of the tested sample

3.2 Statistical Analysis

All the tests were performed in triplicate. The analysis of variance (ANOVA) was applied by IBM SPSS Statistics 21 to determine if there is significant difference between coating material composition. Tukey's Multiple Comparison Test was used for comparisons ($p \leq 0.05$).

4. Result and Discussion

4.1 Physical Properties

The moisture contents of the fig powder ranged between 4.07% and 4.78. The values different significantly ($p < 0.05$) with different composition of coating materials. The low moisture contents of the powders indicated that the samples would have good keeping qualities. Moisture content is the amount of water held in a unit volume of bulk powder as percentage by volume. Fig powder with 100% of maltodextrin exhibit the lowest moisture content compared to others as shown in Table 1. According to Barbosa-Canovas et al. [19], the requirement of moisture content in food powder is between 4% and 6%. Moisture content below 10% is desirable for food powder to ward off mold growth (Hagan, 2007). The total soluble solids (TSS) ranged between 0.75 and 0.81°Brix. The values different significantly ($p < 0.05$) as the composition of coating materials different. The powder with acacia gum had high ºBrix compared to powder with maltodextrin. This could be attributed to higher soluble solids in acacia gum than maltodextrin.

Table 1
Physical Properties of Fig Powder

Properties	Coating material %			
	100% Maltodextrin	100% Acacia Gum	75% Maltodextrin: 25% Acacia Gum	75% Acacia gum: 25% Maltodextrin
Moisture content	4.07±0.06	4.78±0.01	4.36±0.01	4.68±0.01
Total Soluble Solid (ºBrix)	0.76±0.01	0.80±0.01	0.76±0.01	0.81±0.01
Bulk density	0.39±0.03	0.42±0.04	0.42±0.02	0.45±0.07
Tapped density	0.47±0.06	0.50±0.09	0.52±0.06	0.56±0.02
Hausher ratio	1.14±0.01	1.27±0.01	1.15±0.06	1.37±0.06
Carr's Index	12.51±0.03	21.41±0.02	18.12±0.05	24.97±0.07

Different letters within the same column shows significant difference ($p \leq 0.05$)

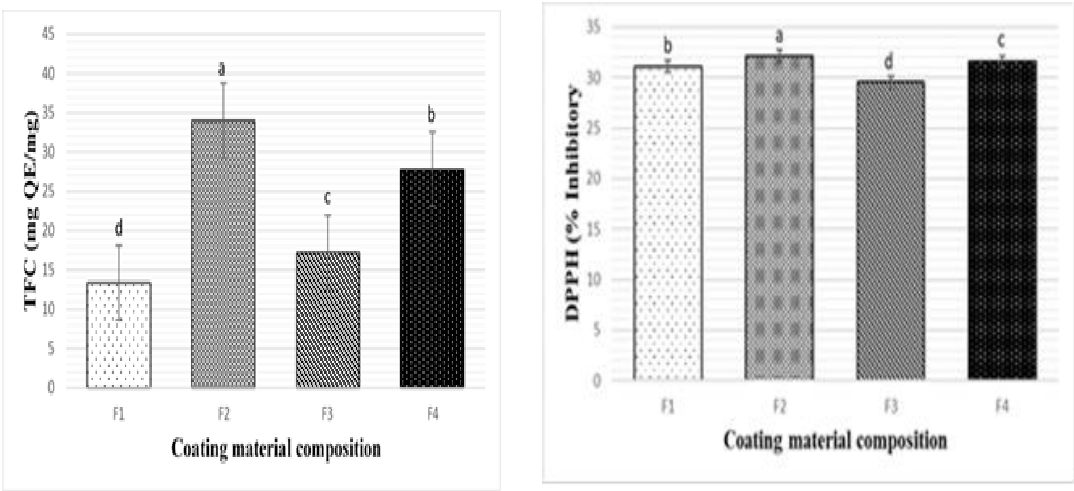
The bulk density of fig powder, as shown in Table 1, were between 0.39±0.03 g/cm^3 and 0.45±0.07 g/cm^3. The results of the bulk density were significantly different as the $p \leq 0.05$. The values of fig powder with acacia gum in bulk density was higher compared to fig powder with maltodextrin because of the moisture content in fig powder with acacia gum was higher than the fig powder maltodextrin. The results of tapped density showed a significant difference at $p \leq 0.05$. The values of tapped density of fig powder were between 0.47± 0.06 g/cm^3 and 0.56 ± 0.02 g/cm^3. The inter-particle bonding of acacia gum is strong, coherent junction as the water content was higher compared to the maltodextrin particle, resulting in high tapped density. According to Zea *et al*. [25], due to the low particle size, it was able to accommodate more inter-particle friction and thus exhibit the lower range of density of fruits powder. It was clear that a change in coating material composition may result in a significant change in the powder density, since the tapped density and bulk density of food powders depends on the combined values between interrelated elements, such as the intensity of attractive inter-particle forces, particle size and number of contact points [19].

Higher Carr's index and Hausner ratio of powder exhibited as 'difficult' to flow. This may be due to the moisture content and hygroscopicity of individual fruit powders. Acacia gum is composed of branched arrangement of simple sugars like galactose, glucuronic acid, arabinose and rhamnose and small amount of covalently bonded protein. Those may be the reason of high Carr's index and Hausner ratio of fig powder with acacia gum compared to fig with maltodextrin (Table 1). Hayes [9] reported that when the Hausner ratio is between 1.0 and 1.1, the powder is considered to be free flowing, the powder with the Hausner ratio between 1.1 and 1.25 is considered to be medium flowing, while the difficult flowing belongs to powder with the Hausner ratio from 1.25 to 1.4; and the powder has very difficult flowing when the Hausner ratio is greater than 1.4. In relation to handling properties, lower Hausner ratio values indicate desirable cohesiveness properties that are correlated to better flowability characteristics. A free-flowing material has a low tendency for further consolidation, which is helpful for preventing production stoppages at industrial scale.

4.2 Chemical Properties

Encapsulation technique has been reported to protect the bioactive compounds' antioxidant activity. For this reason, bioactive compounds were encapsulated into microsystems, so to prevent itself from oxidation/ degradation processes [10]. DPPH assay was reported as a percentage of inhibition against DPPH radical and the percentage were ranged from 29.54 to 32.18% (Figure 2). DPPH assay were performed to evaluate the antioxidant capacity of different coating material composition. The antioxidant activity of coating material was type-concentration dependent. There existed positive correlation between flavonoids content and antioxidant activity in fig powder. Different composition of coating materials results in different flavonoid content. When the composition of coating material is 100% of maltodextrin and 100% acacia gum, the total flavonoids content in fig powder were corresponding to 13.38 mg QE/ mg and 17.21 mg QE/ mg. The antioxidant activity by DPPH percentage of inhibition achieved 29.55% and 30.11%, respectively. The total flavonoid and antioxidant activity slightly improved in fig powder with combination of coating materials. The flavonoids content 27.83 mg QE/ mg and 30.99 mg/ QE/ mg were observed for fig powder contain 75% maltodextrin with 25% acacia gum and 75% acacia gum with 25% maltodextrin, respectively, and the DPPH inhibition percentage reached 31.56% and 32.19%.

These results demonstrated that coating materials preserved the antioxidant activity of the encapsulated nature ingredient, and closely related to flavonoids content. The antioxidant activity of fig powder with acacia gum was higher than that with maltodextrin, most likely because the flavonoids content of acacia gum is higher compared to maltodextrin. Different composition of coating materials significantly affects the antioxidant activity. Anyway, it is certain that coating materials preserved and improved the antioxidant activity of encapsulation of fig phytochemical which is flavonoids. The cooperative adsorption of polysaccharide and protein at emulsion interface could provide excellent physical and oxidative stability then prevent flavonoids from oxidation and degradation. Then free radical scavenging ability was improved [24].



(a) (b)

Fig. 1. The Total Flavonoid Content (a) and Antioxidant Activity (b) Value of Fig Powder; F1 (100% Maltodextrin), F2 (100% Acacia Gum), F3 (75% Maltodextrin: 25% Acacia Gum), and F4 (75% Acacia Gum: 25% Maltodextrin). Different letters show significant different (p≤0.05)

5. Conclusion

In this study, to get the best encapsulation formulation, fig juice was coated with different ratios of maltodextrin and acacia gum combinations. By changing the ratio of maltodextrin and acacia gum as a coating material, statistically different of moisture, total soluble solid, tapped density, bulk density, Carr's index and Hausner ratio could be obtained. Usage of different composition of maltodextrin and acacia gum also affect antioxidant activity significantly. Hence, the best formulation for encapsulation of fig juice is 75% acacia gum with 25% maltodextrin. For the future study, Encapsulation of food material with right coating materials combination will improve physical and chemical properties of food powder. Then the food powder can be used in nutraceutical or functional food development.

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