Spray Drying Microencapsulation of Kantan Extract (Etlingera Elatior) with Various Wall Materials

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Abstract. The aim of this research was to study the effect of spray drying condition on quality of kantan (Etlingera elatior) powder and their characteristics. Effects of Hanjeli Flour and Modified Cassava Flour (MOCAF) concentration at 5 % (wt/v) and Maltodextrin concentrations at 5 %, 10 %, 15 %, 20 % and 25 % (w/v), on physical properties and antioxidant properties of spray dried kantan powder were investigated. Agridon mini spray dryer, model AG-1-06, was used in this research which an inlet and outlet air temperature, feed flow rate and air spray pressure control range was standardize at 180 ºC, 80 ºC, 3.0 Lh-1 and 0.7-1.4 kg/cm², respectively. The result of this study resulted 5 % MOCAF were showed the higher in physical and antioxidant properties such as process yield (31.82 %), flowability (30 º) and ABTS (50.50 %) of spray-dried kantan powder compared to 5 % Hanjeli flour and 5 % maltodextrin. Next, increased maltodextrin concentrations resulted in increased process yield (31.04 %-36.03 %), bulk density (0.33 g/ml-0.48 g/ml) and flowability (37 º-57 º), while the solubility (50.50-133.30 sec), wettability (14.90-45.20 sec), moisture content (5.24 %-5.83 %) and absorbance (2.44- 0.99) decreased. However, there were no significant changes in the water activity (0.22-0.37) and soluble solid (15.16 %-16.80 %) of the kantan powder at all maltodextrin concentrations. The degradation percentage of antioxidant contents ranged in 36 %-66 % in DPPH, ABTS, TPC and TFC after spray drying process at higher temperature. The results from this study can be used to develop instant beverages, cube production as a ready-cook product and several food formulations such as ice-cream, desserts, bakery products.

1. Introduction

Kantan is a culinary herb that belongs to the Zingiberaceae family [1] and is categorized under the genera of Etlingera [2]. Kantan is also known as ‘pink torch ginger’ in many parts of Southeast Asia [3], are widely cultivated in tropical countries. Its flowers and leaves are used as spices for food flavouring and as ornamentals of many dishes such as asam laksa, fish stew and curry dishes and stir fry gravy [2]. Commonly, flavour of kantan is obtained once it being added into final stage of cooking in fresh form.

However, rather than used in fresh form, it also used dried and stored in dried form. This is because kantan is perishable food and has a short shelf life and currently the spray drying process is one of drying method that used to retain the quality of powder food, to increase shelf life of powder products, to...
decrease the nutrient degradation such as aroma and flavour and can reduce storage and transportation costs [4]. The wall material is used to protect the core material from environments, to increase the stability of the material [5] and to avoid collapse and adherence to the drying chamber wall. The aim of this study to evaluate the effect of different wall materials and concentrations in spray drying microencapsulation on the physical properties and antioxidant properties activity of spray-dried kantan powder.

2. Materials and Methods

2.1. Sample preparation
The grinded kantan was purchased from En. Hamdan, the biggest kantan supplier in Bindu, Batu Pahat, Johor. The grinded kantan was mixed with water in ratio of 4 kg of grinded kantan : 1 L of water before it was squeezed by hand. After squeezing, the samples were poured into 1 L of polyethylene bags and stored in a cooling room at 0-4 °C. For spray drying, kantan extracts were supplemented with 5 % (wt/v) of Hanjeli flour, 5 % (wt/v) of MOCAF and 5 %, 10 %, 15 %, 20 %, 25 % (wt/v) of maltodextrin. The solutions were homogenized for 15 min at 2500 rpm by homogenizer (Motology; model Meaf 71a-2).

2.2. Spray drying process
The spray drying process was performed using a laboratory mini spray dryer (Agridon; model AG-1-06) and it was operated concurrently with a 0.7 mm diameter spray nozzle. The inlet and outlet air temperature were 180 °C and 80 °C respectively for all the solutions investigated. The solution was fed into the drying chamber at room temperature (25 °C) through a peristaltic pump with the feed flow rate and air spray pressure control ranges were kept to 3.0/Lh and 0.7-1.4 kg/cm², respectively.

2.3. Physical properties determination
The yields calculated based on the ratio of powder (dry basis) collected at the spray dryer exit divide by the weight of dry matter in the emulsion taken for drying, using the equation 2.1 adapted from [6].

\[
Py (%) = \frac{\text{Dry mass of microparticles (g)}}{\text{Dry mass of raw materials (g) x 100}} \quad (2.1)
\]

The powder’s moisture content was determined by moisture analyzer (model AND MX-50) while water activity was measured by water activity meter (Decagon; model Aqua Lab). Wettability test was determined by following the method proposed by [7] by measuring the time required for powder to become completely wetted by placed 2 g of powder in 40 mL of distilled water from 10 cm height to surface of water. Solubility testing was determined according to the method of [8] by measuring the time required for powder to dissolve completely by transferring 2 g of powder into a beaker containing 125 mL of distilled water and solution was agitated with magnetic stirrer at speed level 2. Bulk density testing was adapted from [9] by weighting and pouring 2 g of powder into a 10 mL graduated cylinder and tapped by hand 50 times and calculated by using equation 2.2:

\[
\text{Bulk density} = \frac{\text{Mass of powder (g)}}{\text{Volume occupied in cylinder (mL) x 100}} \quad (2.2)
\]

The flowability of powder was determined by following method adapted by [10] by pouring 10 g of powder from 20 cm of height of funnel (diameter 1 cm) to surface plate. The repose angle was measured which powder with angle of repose <35 ° is free flowing material, 35-45 ° is fairly cohesive, 45-55 ° is cohesive and >55 ° is very cohesive material. The soluble solid was determined by refractometer (Atago; model RX-50000-Plus). The absorbance of the kantan powder was analyzed using a UV-Vis spectrophotometer (Hitachi; model 2J2-0034) at wavelengths from 590-750 nm.

2.4 Antioxidant properties
DPPH scavenging activity was measured by slightly modified method by [11]. The absorbance of DPPH
diluted in methanol was measured using the UV-Vis spectrophotometer was considered as control. The decrease in absorbance was measured at 517 nm. The radical-scavenging activity (RSA) was calculated using equation 2.3:

\[
\% \text{ RSA} = \frac{(\text{Absorbance (c)} - \text{Absorbance (s)})}{\text{Absorbance (c)}} \times 100
\]  

(2.3)

ABTS radical cation decolorization assay were conducted according to method by [12] by mixing 1:1 of ABTS solution (7 mM) and potassium persulfate (2.45 mM) in water to make ABTS * radical solution and kept it overnight (12-16 hours) in dark at room temperature to yield a dark green colour solution. For valuation of antioxidant capacity, ABTS * radical solution was diluted with ethanol (96 %) for a initial absorbance of about 0.700 ± 0.02 using UV-Vis. The decrease in absorbance was measured at 734 nm and % of inhibition was calculated using equation 2.4:

\[
\% \text{ ABTS} = \frac{(\text{Absorbance (c)} - \text{Absorbance (s)})}{\text{Absorbance (c)}} \times 100
\]  

(2.4)

TPC was determined by [13] with slight modification by mixing 1 mL aliquots 0.024, 0.075, 0.105 and 0.3 mg/mL gallic acid with 5 mL Folin-Ciocalteu reagent and 4 mL sodium carbonate. The absorption was read after 30 min at 750 nm and calibration curve was drawn. 100 μL of sample was mixed with 2 mL sodium carbonate for 2 min and mixed with Folin-Ciocalteu reagent for 30 min and absorbance values was taken and compared to standard curve. While, TFC was determined by using colorimetric method by [14] with slight modification by mixing 1 mL of sample solution, 4 mL of distilled water and 0.3 mL of 5 % sodium nitrate solution for 6 min. Next, the mixture was mixed with 0.3 mL of 10 % aluminium chloride hexahydrate for 5 min and 2 mL of 1 M sodium hydroxide was added for 5 min. The absorbance of mixture was measured at 510 nm and compared to standard curve.

3. Results and Discussion

3.1 Physical properties of kantan powder

Based on the experimental result shows in Table 1, it was indicated that the increase of maltodextrin concentrations, process yield increased from 31.045 (5 % wt/v) to 36.03 % (25 % wt/v) to prevent the adhesion of kantan extract on the chamber walls [15]. The effect of different wall materials on process yield showed MOCAF (31.82 %) being more effective than maltodextrin (31.04 %) and Hanjeli flour (15.02 %) due to the configuration of powders produced [16]. Next, water activity values of kantan powder were below 0.40, in ranges of 0.22 to 0.37, which was very stable for powder stability due to the less free water available for biochemical reactions and growing microorganisms [17]. While, effect of different wall materials on moisture content resulted the lower moisture content in 5 % of MOCAF (4.21 %) compared to 5 % of maltodextrin (5.83 %) and 5 % of Hanjeli flour (5.99 %) due to MOCAF was less hygroscopic compared to others [18]. However, moisture content of kantan powders decreased with the increase of maltodextrin concentrations (5 %-25 %) (wt/v) due to increase of feed solids and decreased total moisture level for evaporation process [19].

The effect of wall materials and concentrations on the wettability can be observed in Table 1 which kantan powder with 5 % MOCAF recorded the lowest in wettability times which were 3.2 sec compared to 5 % Hanjeli flour (5.4 sec) and 5 % maltodextrin (45.2 sec) due to MOCAF is bigger particles which it has high porosity and large pores [15]. Next, the wettability of powder decreased with increase of maltodextrin concentrations due to maltodextrin acts as a bulking agent that have less porous powder and high bulk density [20]. While, the effect of wall materials on the solubility of the kantan powder showed 5% MOCAF (8.1 sec) was lowest in solubility times compared to 5 % Hanjeli flour (29.0 sec) and 5 % maltodextrin (133.3 sec) due to MOCAF and Hanjeli flour were more stable than maltodextrin in term of crystalline configuration [16]. Next, the solubility of kantan powder decreased which varied from 133.3 sec to 50.5 sec with increase of maltodextrin concentrations due to kantan powder was less porous to reduce solubility of kantan powder at all concentrations
The effect of the various wall materials used in production of kantan powder on bulk density resulted maltodextrin was lowest values of bulk density (0.33 g/ml) compared to MOCAF (0.45 g/ml) and Hanjeli flour (0.71 g/ml) because of Hanjeli flour is a smaller particle size that more easily to fill the space among the particles [21]. Next, the increase of bulk density led to increase in the bulk density of kantan powder (0.33 g/ml - 0.48 g/ml) due to its skin forming ability induced the reduction in the volume of air trapped in the powder particle causing less dense, less porous structure and decrease in particle size [19]. While, the flowability of all kantan powders varied from 30 o to 57 o which it were indicated free flowing materials for 5 % of MOCAF (30º) and 5 % of Hanjeli flour (34º), fairly cohesive materials for 15 %, 20 % and 25 % of maltodextrin in angle of 43 º, 41 º and 37 º respectively. While, 10 % of maltodextrin is a cohesive material (53 º) and 5 % of maltodextrin is a very cohesive material (57 º) [10] due to the increase of cohesion was led to the flowability reduction.

The effect of wall materials and concentrations on the soluble solid (Brixº) recorded the lower soluble solids were 5 % MOCAF and 5 % Hanjeli flour compared to 5 % of maltodextrin due to maltodextrin is a hydrolyzed starch made from corn, rice, potato starch or wheat and it are closely related to corn syrup solids which the maltodextrin has <20 % of sugar content while corn syrup solids are at least 20 % after hydrolysis of starch process [23]. The soluble solids values of kantan powder at all maltodextrin concentrations varied from 15 % to 25 % of maltodextrin in ranges of 15 % to 17 %. Generally, the herbs above 12% are considered acceptable to consumers [24]. The effects of different wall materials used on absorbance values of kantan powder production were obtained the kantan powder with 5 % of Hanjeli flour recorded the highest value of absorbance (3.17) compared to MOCAF (2.49) and Maltodextrin (2.44). This is due to kantan powder with Hanjeli flour have a deeper colour compared to others. While, effects of different concentrations of maltodextrin on absorbance values of kantan powder can concluded that increase of maltodextrin concentrations will lead to decrease of absorbance values due to colour of 5 % of maltodextrin more deepest compared to others.

Table 1. Effects of different wall materials and their concentrations based on physical properties determination of kantan powder

| Concentration of wall materials (%,wt/v) | PY (%) | MC (%) | Physical properties determination |
|----------------------------------------|-------|--------|----------------------------------|
|                                        |       |        | aw (sec)*                        |
|                                        |       |        | Wet (sec)*                       |
|                                        |       |        | Sol (sec)*                       |
|                                        |       |        | BD (g/ml)*                       |
|                                        |       |        | Flow (%)*                        |
|                                        |       |        | SS (%)*                          |
|                                        |       |        | Abs*                             |
| 5% of Hanjeli flour                    | 15.02 | 5.99   | ±0.02                            |
|                                        |       |        | ±0.22                            |
|                                        |       |        | 5.40                             |
|                                        |       |        | 29.00                            |
|                                        |       |        | 0.71                             |
|                                        |       |        | 34.00                            |
|                                        |       |        | 2.86                             |
|                                        |       |        | 3.17                             |
| 5% of MOCAF                            | 31.82 | 4.21   | ±0.03                            |
|                                        |       |        | ±0.02                            |
|                                        |       |        | ±0.21                            |
|                                        |       |        | ±0.74                            |
|                                        |       |        | ±0.02                            |
|                                        |       |        | ±1.00                            |
|                                        |       |        | ±0.05                            |
|                                        |       |        | ±0.00                            |
| 5% of Maltodextrin                     | 31.04 | 5.83   | ±0.08                            |
|                                        |       |        | ±0.02                            |
|                                        |       |        | ±0.87                            |
|                                        |       |        | ±6.18                            |
|                                        |       |        | ±0.01                            |
|                                        |       |        | ±0.58                            |
|                                        |       |        | ±0.05                            |
|                                        |       |        | ±0.00                            |
| 10% of Maltodextrin                    | 32.80 | 5.64   | ±0.03                            |
|                                        |       |        | ±0.01                            |
|                                        |       |        | ±0.32                            |
|                                        |       |        | ±2.42                            |
|                                        |       |        | ±0.01                            |
|                                        |       |        | ±1.53                            |
|                                        |       |        | ±0.03                            |
|                                        |       |        | ±0.01                            |
| 15% of Maltodextrin                    | 34.01 | 5.46   | ±0.04                            |
|                                        |       |        | ±0.08                            |
|                                        |       |        | ±0.44                            |
|                                        |       |        | ±0.56                            |
|                                        |       |        | ±0.01                            |
|                                        |       |        | ±0.58                            |
|                                        |       |        | ±0.01                            |
|                                        |       |        | ±0.02                            |
| 20% of Maltodextrin                    | 35.27 | 5.39   | ±0.02                            |
|                                        |       |        | ±0.07                            |
|                                        |       |        | ±0.50                            |
|                                        |       |        | ±1.79                            |
|                                        |       |        | ±0.02                            |
|                                        |       |        | ±1.26                            |
|                                        |       |        | ±0.03                            |
|                                        |       |        | ±0.02                            |
| 25% of Maltodextrin                    | 36.03 | 5.24   | ±0.05                            |
|                                        |       |        | ±0.06                            |
|                                        |       |        | ±0.52                            |
|                                        |       |        | ±3.50                            |
|                                        |       |        | ±0.01                            |
|                                        |       |        | ±0.76                            |
|                                        |       |        | ±0.05                            |
|                                        |       |        | ±0.07                            |

*Data presented as mean values ± standard error (n = 3). PY (Process yield); MC (Moisture content); aw (Water activity); Wet (Wettability); Sol (Solubility); BD (Bulk density); Flow (Flowability); SS (Soluble solid); Abs (Absorbance).

3.2 Antioxidant properties of kantan powder

Based on results in Table 2, the percentage of degradation of antioxidant contents through DPPH, ABTS, TPC and TFC, which it showed 5 % of MOCAF resulted lowest in degradation of antioxidant contents of ABTS (39.79 %) while 5 % of maltodextrin resulted lowest in DPPH inhibition (38.43 %),
TPC (49.51 %) and TFC (64.07 %) due to maltodextrin and MOCAF as carrier agents was used to protect antioxidant content during spray drying process. While, in terms maltodextrin concentrations were showed the percentage ranges of degradation of antioxidant contents through DPPH (38.14 %-38.79 %), ABTS (36.15 %-41.05 %), TPC (45.07 %-50.57 %) and TFC (64.07 %-65.41 %). The kantan extract powder still showed the high antioxidant activity even after a treatment under operating conditions of spray drying due to used of carrier agents to protect antioxidants content because of spray drying at the high temperature (180 °C) which the kantan extracts are a high sensitivity of antioxidant component towards high temperature [25].

**Table 2.** The degradation percentage of antioxidant contents of kantan samples.

| Concentration of wall materials (% w/v) | DPPH | ABTS | TPC | TFC |
|----------------------------------------|------|------|-----|-----|
| 5% of Hanjeli                          | 39.40| 41.71| 56.27| 64.57|
| 5% of MOCAF                           | 44.39| 39.79| 51.27| 64.93|
| 5% of Maltodextrin                    | 38.43| 41.05| 49.51| 64.07|
| 10% of Maltodextrin                   | 38.75| 40.38| 50.57| 64.58|
| 15% of Maltodextrin                   | 38.14| 37.65| 45.07| 65.41|
| 20% of Maltodextrin                   | 38.51| 37.77| 48.30| 64.39|
| 25% of Maltodextrin                   | 38.79| 36.15| 49.71| 65.01|

Data presented as mean (n=3). TPC: total phenolic content, TFC: total flavonoid contents.

4. Conclusion
As a conclusion, Hanjeli flour and MOCAF used as the alternatives of wall materials which MOCAF showed the higher in process yield and flowability while, Hanjeli flour resulted the higher in moisture content, bulk density, and absorbance. Next, high maltodextrin concentrations lead to increase of process yield, bulk density and flowability, while solubility, wettability, moisture content and absorbance decreased and no significant changes in water activity and soluble solid of kantan powder at all maltodextrin concentrations. Lastly, the degradation percentage of antioxidant contents ranged in 36%-66% in DPPH, ABTS, TPC and TFC after spray drying process at higher temperature. The results from this study can be used in food products development and food formulations.

Acknowledgment
We are thankful to Universiti Tun Hussein Onn, Malaysia through the TIER 1 grant (vote no. H256) and MDR (vote no.H506) and Research Centre for Appropriate Technology-LIPI (ELSA-LIPI), Indonesia for financial and technical support.

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