Spray Drying of Enzymatic Clarification Red Purple Pitaya (*Hylocereus Polyrhizus)* Pigment Extract

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Abstract: ***Betacyanin pigments obtained form Hylocereus Polyrhizus can be used as a natural food colourant. Enzyme Rohapect B1L (4%, v/w) was used to clarify pigment extract prior spray drying. The 10 DE and 25 DE maltodextrin and its mixtures were used as coating agents to give a total soluble solid (TSS) ranging from 20 % - 30 % with drying temperature at 200 ˚C. The quality attributes and the structure of the pigment powders were characterized. The use of mixtures maltodextrin enhanced the stability during storage compared to the 25 DE and 10 DE powders separately.***

Keywords: maltodextrin, betacyanin, *Hylocereus Polyrhizus*, spray drying, Rohapect B1L

1. Introduction

The consumer acceptance of ‘natural’ foods is increasing and the various regulations which completely ban artificial colours from food. Betalains, are plant pigment classes commercially used for food colouring, are generally considered heat-labile [1]. Betalains are water-soluble pigments, which are synthesised from the amino acid tyrosine into two structural groups; the red-violet betacyanins and the yellow-orange betaxanthins. Betalains are responsible for the red colour and it also has antioxidant capacity, which can be associated with health benefits [2]. The fruits of *Hylocereus* species, known as red pitaya which means “scaly fruit’’, with medium-large berries bearing large green or red scales in Latin America. The peel is usually red, and the pulp varies from purple or red colours of various hues to white. The pulp contains numerous small soft seeds and the texture is delicate and juicy [3]. Red purple pitaya (*H. Polyrhizus*) species belong to the vine cacti. In Israel, some of the cacti are already cultivated in plantation for purpose commercial. According to Wybraniec and Mizrahi [4] reported the colour characteristics of several *Hylocereus* ranged from purple to red. The fruit from the Cactaceae have been proposed as a alternative betalain source [5] [6], offering preparation pigment with a broader colour spectrum and being devoid of the mentioned drawbacks [5]. The stability of betacyanin pigments is influenced by numerous confounding factors (e.g. temperature, pH, oxygen, light and water activity) that have limited the use of these pigments as food colourants [7]. From the previous study, betacyanin pigment obtained from red pitaya fruit and peels have been done by Ee et.al [8], Sri and Aulia. [9] and Ashwini et.al. [10].

Encapsulation is a potential approach to transform liquids into free flowing and stable powders which are easy to incorporate and handle into dry food [7]. Food industry usually used spray drying technique to maintain the stability of the foods. Some wall materials are available for food application, the effective wall materials for spray drying should have functional properties, including good emulsification, high solubility, film forming, low viscosity at higher concentration and low cost properties. Gum Arabic, methyl cellulose, dextrose, starches, sugar, gelatine, and mixtures of these have been used as coating agents for the spray drying of flavours and colorants. Maltodextrin was a good comprise between effectiveness and cost, had low viscosity at high solids ratio, bland in flavour and were available in different molecular weights.

In the present study, clarified pigment extract with the highest betacyanin content obtained after enzyme depectination treatment was subjected to spray drying process to produce pitaya pigment powders using 2 different types maltodextrins (10 DE and 25 DE) and maltodextrin mixtures (10 DE + 25 DE) concentration as coating materials at several of total soluble solid (TSS) concentration. The spray dried pitaya pigment powder obtained was examined for their characteristics and their stability to determine the suitability of the maltodextrin type as coating materials. The objective of this study was to produce spray dried pitaya pigment powder. The effects of maltodextrin used as coating material on the storage stability of the pitaya pigment powders were also investigated. Cactus fruits are an alternative source to provide customized hues for colouring foodstuffs [11].

2. Literature Survey

The consumers concern about side effect of synthetic colourant applied in food system, thus there was increasing demand for natural colourant in food products. In cactus family fruit, the most important fruit pigments are the betacyanin and betaxanthins. The known betacyanin pigments of *Hylocereus polyrhizus* are betanin, phylocactin, and a recently discovered betacyanin, hylocerenin [4]. Wybraniec and Mizrahi [4] reported that red pitaya fruit rich in phenolic content and antioxidant properties. It also reported that betanin effectively inhibited lipid peroxidation and heme decomposition and this pigment may provide protection against certain oxidative stress related disorders.

The stability of natural colorants is less stable than the artificial colorants. Betalain stability is affected by some factors, such as pigment concentration, external factors, the particular betalain structures, pH and a_w values will have considerable impact on betacyanin pigment stability. In order to ensure the optimum pigment and colour retention in betalain foods, the temperature, time conditions during food manufacture, storage temperature, oxygen exposure and light must be considered.

Microencapsulated is the technique by which the sensitive ingredients are packed within a coating or wall material to prevent the loss of volatile ingredient and control release of the ingredient and its potential approach to transform liquid into stable and free flowing powders. Tthe effective wall materials for spray drying should have functional properties, including good emulsification, film forming, high solubility, low viscosity at higher concentration and low cost properties. Gum Arabic, dextrose, sugar, starches, gelatine, methyl cellulose and mixtures of these have been used as a carrier and coating agents for the spray drying of colorants. Maltodextrin was also a good wall material between cost and effectiveness, was bland in flavour, had low viscosity at high solids ratio, and was available in different average molecular weights.

Spray drying has covered the production of powder colourants with high storage stability, easier to handle for some applications, and minimize the weight for transportation, in comparison with liquid concentrates. Some advantages of spray drying include the ability to quickly produce a dry powder (i.e. as compared to lyophilization) and the ability to control the particle size distribution [12]. The powder colourant is expected to have: high colour strength, low moisture and high storage stability.

3. Materials and Methods

3.1 Fruit Samples

Red pitaya fruits (*H.Polyrhizus*) were obtained from plantation in Johor, Malaysia. Fresh fruits samples were cut and peels removed. Samples were kept frozen at -18 ˚C for further analysis.

3.1.1 Carrier agents for spray drying

Maltodextrin M100 (10DE) and M250 (25DE) were kindly provided by Grain Processing Coorporation (USA). Maltodextrin was used as the wall materials for encapsulating betacyanin pigment.

3.1.2 Extraction of Betacyanin pigments

In this study, aqueous extracts of betacyanin pigments were prepared following method described by Cai [13] with slightly modification. After thawing red pitaya fruit, a part of the fruit flesh was shaken with 2 parts of water. Subsequently, enzymatic treatment using 4% Rohapect B1L (AB Enzyme, Darmstadt, Germany) was carried out for 90 minutes at 47 ˚C in a water bath for clarified the mucilaginous contents. The solid part was separated by using centrifugation at 3500 rpm for 15 minutes. The total soluble solid (TSS) of the pigment concentrate was about 5%.

3.1.3 Preparation of feed mixtures

The clarified pigment extract at 5 % TSS (Total Soluble Solid) was used and thoroughly mixed with the coating material using an Ultraturrax IKA Labortechnik and stirred to homogeneity for the feed mixture. Three different mixtures of maltodextrin were formulated as the coating materials, i.e. maltodextrin 10 DE, maltodextrin 25 DE and maltodextrin mixture (10 DE and 25 DE) at 3 ratios. Maltodextrin was added to the clarified pigment extract to obtain a final of TSS content of 20 %, 25 % and 30 % (w/w), feed mixtures according to the formulation given in Table 1. High TSS obtained by increasing amount of maltodextrin. Solid contents were analyzed using a PAL-1 digital refractometer (Atago Co., Ltd., Japan).

Table 1: Formulation of feed mixture

Coating materials (maltodextrin)	% (w/w) maltodextrin added	Total Soluble Solid (TSS)	Sample code
10 DE	13	20 %	10DT20
	18	25 %	10DT25
	22	30 %	10DT30
25 DE	13	20 %	25DT20
	18	25 %	25DT25
	22	30 %	25DT30
Mixture (10 DE + 25 DE) At 3 different ratios			
1 : 1	13	20 %	11DT20
	18	25 %	11DT25
	22	30 %	11DT30
1 : 2	13	20 %	12DT20
	18	25 %	12DT25
	22	30 %	12DT30
1 : 3	13	20 %	13DT20
	18	25 %	13DT25
	22	30 %	13DT30

3.1.4 Spray drying

The feed mixture was spray dried in a Büchi Mini Spray Dryer (B290, Flawil, Switzerland) at 98 ˚C outlet air temperature and 200 ˚C inlet air temperature, feed rate of 0.8 l/h (40 % maximum pump speed). These spray drying conditions were preliminary optimized to produce a stable pitaya pigment powder with higher colour strength and lower water content. Red pitaya pigment powder produced which was pinkish in colour was stored in a 100 ml screw capped amber bottle and placed in a cool place (25 ˚C) until further analysis.

3.1.5 Pigment powder storage

Pigment powders were stored in a 100 ml bottle sealed with screw caps and cover with aluminium foil, placed at 25 ˚C. Characteristic at zero storage time were analyzed within 1 day after drying.

3.2 Quality Attributes Analysis

3.2.1 Yield of betacyanin pigment powder (%)

The percentage yield of pitaya pigment powder obtained after spray drying was determined following method described by Obón [12] and calculated as:

[Total weight of pigment powders (g)/ feed solid content (g)] × 100

3.2.2 Pigment recovery

Pigment content was determined by using spectrophotometric method [13] with absorbance was measured at 532 nm with Shimadzu UV-visible recording spectrophotometer (Tokyo, Japan).

Pigment recovery (%) was calculated as:
[betacyanin content after spray drying/ betacyanin content before spray drying] × 100

3.2.3 Moisture content
Moisture content of pitaya pigment powder (5 g) was determined using a moisture analyzer (Denver Instrument IR-30). Triplicate samples were analyzed and the mean value was recorded.

3.2.4 Solubility
The following method by Singh and Singh [14] was used to analyse cold water solubility of spray dried pitaya pigment powders. One gram of pitaya pigment powder was mixed with 100 ml of water using a magnetic stirrer at room temperature for 30 min. A 30-ml aliquot of solution was transferred to a 50-ml centrifuge tube and centrifuged (Kubota 2100, Japan) at speed 430 *g*. A 10-ml aliquot of the supernatant was dried in an oven at 110 ˚C for overnight.

3.2.5 Hygroscopic of powder
Moisture gain of pitaya pigment powder samples (2 g) were measured under saturated solution of Na_2SO_4 [10]. After 1 week, hygroscopicity was expressed as g of moisture per 100 g dry solids (g/ 100 g).

3.2.6 Colour measurement
The colour of aqueous pigment extract was determined using Minolta Spectrophotometer CM-3500d (Osaka, Japan), followed method by Ashwini et.al. [10]. Results were given on Commission Internationale de I'Eclairage *L**, *a**, and *b** (CIELAB) colour space coordinates. Triplicate samples were done for each measurement.

3.2.7 Scanning electron microscopy (SEM)
Scanning electron microscopy (SEM) images were obtained for all the pitaya pigment powders to examine pigment powder were using a Scanning electron microscopy Leo Supra 50vp (Oberkokhen, Germany). Samples were fixed onto SEM stubs using a two aside adhesive tape. The surface was sputtered for 120 seconds and coated with a thin layer of gold. Representative photographs were taken at 3000 x magnification and operated at 5 kV.

3.2.8 Statistical analysis
The mean values, standard deviations and analyses of variance (ANOVA) were calculated with SPSS software, version 15. Mean comparisons were performed using Duncan's test (p<0.05). All experiments were done in triplicate.

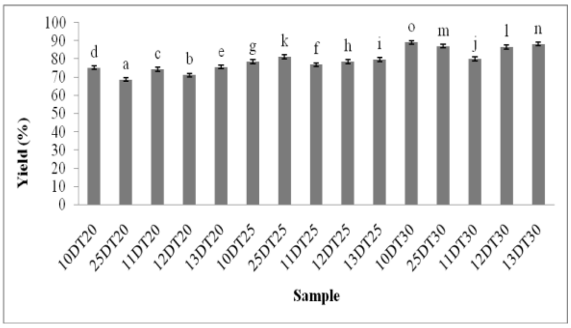
4. Result and Discussion

4.1 Yield and pigment recovery of betacyanin pigment powder

The results shown in Figure 1, demonstrated that the yield of spray dried pitaya pigment powder increased with an increase in total soluble solid (TSS) of the feed mixtures. The influence of feed flow rate, inlet air temperature and maltodextrin concentrations on the spray drying process influenced the yield of pitaya pigment powder produced. In general, the results given in Figure 1 show that the higher % TSS the higher the % yield of pitaya pigment powder was obtained for all types of maltodextrin used. From the result, indicated that the samples with maltodextrin of lower DE value gave higher % yield with the exception samples at 25 % TSS. The samples with 10DE matodextrin at 30% TSS gave the highest % yield (89.1 ± 0.10 %). Quek [15] reported that addition of 5 % maltodextrin to the feed appeared to have greater yield than addition of 3 % maltodextrin. The process yield ranged from 34.39 % to 55.66 % for spray dried açai powder with 10 % to 30 % maltodextrin at air inlet temperature of between 138 ˚C and 202 ˚C [16]. The yield is affected by the amount of spray dried powder adhering to the wall of the drying chamber due samples not dried efficiently [17].

Pigment recovery in spray dryers is a major challenge in utilizing the spray drying technology for food production, due to the amorphous nature of food which displays high tendency to become rubbery and sticky [18]. In this study, the results have shown that with a higher concentration of maltodextirn as coating materials, the percent pigment yield also increased. However, with feed mxiture with solid content of more than 30 % TSS is not suitable and the feed mixtures became too viscous that spray drying was not possible. It was also observed from the results in Table 1 that increase in TSS content in the feed mixtures, also resulted in higher pigment recovery (Table 2). Higher solid content in the feed material can reduced the production cost and caused lower loss in betacyanin pigment during spray drying. However, with higher solid content of more than 30 % TSS the viscosity of feed will increase and thus will create problems in the spray drying process. Samples with 10 DE maltodextrin at 20 %, 25 % and 30 % TSS gave pigment recovery of 58.84 ± 0.28 %, 69.06 ± 0.11 % and 72.86 ± 0.48 %, respectively which were higher (P<0.05) compared to samples with 25 DE. Sample with maltodextrin mixtures (10 DE + 25 DE) at all ratios show higher pigment recoveries than samples with single maltodextrin.

Saénz [19] reported 100 % of betacyanin recovery of the *Opuntia ficus-indica* spray-dried powder by using 20 % maltodextrin. This fact supported the results on higher TSS in the feed material can increased the betacyanin pigment recovery during spray drying. Higher inlet-air temperature i.e >200 ˚C caused less pigment recovery. An increase in air inlet temperature causing moisture of droplet to decrease and droplet size to increase and these would lead to lower pigment loss [20]. On the other hand, Tonon [16] investigated that using maltodextrin ranging from 10 % to 30 % could retain the anthocyanin of açai fruit resulting in yields from 77.21 % to 86.01 % with spray drying condition at inlet temperature between 138 ˚C and 202 ˚C. In addition, Goula [21] reported that large droplet size would have smaller surface to volume ratio, reducing oxygen exposure of the droplet mass and lower pigment loss. The result obtained in this study suggested that air inlet temperature at 200 ˚C and high TSS (>25 %) can be used to produce betacyanin pigment extract with reasonable and good yield and pigment recovery.



Means ± S.D (n=3) value with same letter within the bar are not significantly different from each other at P<0.05.Vertical bar represent one standard deviation of samples in triplicate. Pitaya pigment powder samples: at 20 %, 25 % and 30 % TSS with maltodextrin 10 DE (10DT20, 10DT25 and 10DT30); at 20 %, 25 % and 30 % TSS with maltodextrin 25 DE (25DT20, 25DT25 and 25DT30) and maltodextrin mixtures (10 DE + 25 DE) at ratio 1:1 (11DT20, 11DT25 and 11DT30); 1:2 (12DT20, 12DT25 and 12DT30) and1:3 (13DT20, 13DT25 and 13DT30).

Figure 1: Yield of spray dried pitaya pigment powder

Table 2: Pigment recovery (%) of spray dried pitaya pigment powders

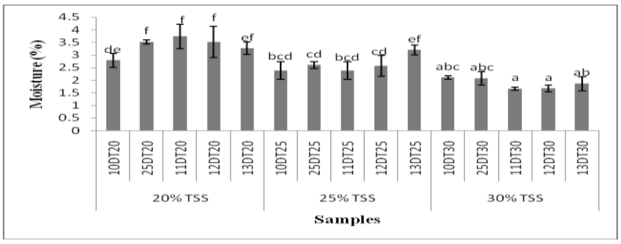
Coating materials (maltodextrin)	Total Soluble Solid (TSS)	Sample code	Pigment recovery (%)
10 DE	20 %	10DT20	58.84 ± 0.28^a
	25 %	10DT25	69.06 ± 0.11^b
	30 %	10DT30	72.86 ± 0.48^b
25 DE	20 %	25DT20	51.78 ± 0.77^b
	25 %	25DT25	60.18 ± 0.10^a
	30 %	25DT30	62.93 ± 0.32^a
Mixture (10 DE + 25 DE) ratio			
1 : 1	20 %	11DT20	64.17 ± 0.64^c
	25 %	11DT25	77.27 ± 0.28^c
	30 %	11DT30	80.43 ± 0.10^c
1 : 2	20 %	12DT20	66.58 ± 0.55^d
	25 %	12DT25	80.46 ± 0.50^d
	30 %	12DT30	85.22 ± 0.10^d

Means ± S.D (n=3) value with different letters within the same TSS are significantly different from each other at P<0.05. Pitaya pigment powder samples: at 20 % TSS; 25 % TSS and 30 % TSS with maltodextrin 10 DE; 25 DE and maltodextrin mixtures (10 DE + 25 DE) at ratio 1:1; 1:2 and 1:3.

4.2 Moisture content

From Figure 2, moisture contents of spray dried pitaya pigment powder varied from 1.7 % to 3.7 %. The moisture content results were in the range with other researchers such as Loksuwan [22] on microencapsulated *β*-carotene (2.1 % – 6.0 %) and Quek [15] on watermelon powders (1.5 % - 2.8 %). The samples with lower DE maltodextrin had lower moisture content than all samples with the exception of sample 10 DE at 30% TSS. This was explained by Tonon [23], that maltodextrin 10 DE has less hydrophilic groups and adsorbing less water compared to higher DE maltodextrin. However, at 25 % TSS content, all samples showed no significant different (P>0.05) with the exception of sample mixture at ratio 1:3 at 25% TSS having the higher moisture content. At 30 % TSS content, there was also no significant different (P>0.05) for all samples in moisture content.

In general, it was observed that as the percentage of TSS increased, the moisture content of samples decreased for all samples with different maltodextrin type. Thankitsunthorn [24] reported that higher water content in the feed, final product will also have higher moisture content. It showed that with high amount of maltodextrin, reduced the water content and TSS content increased in the feed. Moisture content is also influenced by feed flow rate and inlet temperature as reported by Koul [25] which studied on spray dried red beetroot; by Tonon [16] on spray dried açai and by Grabowski [26] on spray dried sweetpotato puree. Higher amount of maltodextrins resulted in a better stability of powder. This might be due to the ability of maltodextrins to reduce reactant mobility. Grabowski [26] agreed that moisture content decreased with increasing maltodextrin. The results obtained indicated that addition of maltodextrins could increase TSS in the feed and reduced the water for evaporation thus, decreased the moisture content of the product. It was suggested that maltodextrins could alter the surface stickiness of low molecular weight sugars [15].



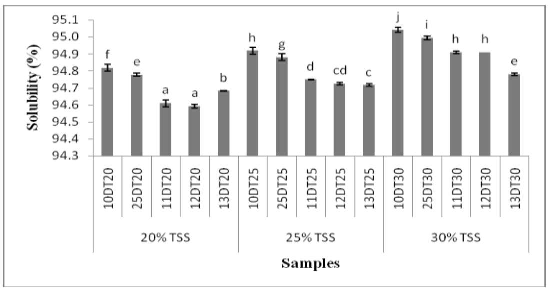
Means ± S.D (n=3) value with same letter within the bar are not significantly different from each other at P<0.05.Vertical bar represent one standard deviation of samples in triplicate. Pitaya pigment powder samples: at 20 %, 25 % and 30 % TSS with maltodextrin 10 DE (10DT20, 10DT25 and 10DT30); at 20 %, 25 % and 30 % TSS with maltodextrin 25 DE (25DT20, 25DT25 and 25DT30) and maltodextrin mixtures (10 DE + 25 DE) at ratio 1:1 (11DT20, 11DT25 and 11DT30); 1:2 (12DT20, 12DT25 and 12DT30) and 1:3 (13DT20, 13DT25 and 13DT30).

Figure 2: Moisture content of spray dried pitaya pigment powder

4.3 Solubility

From Figure 3, it can be observed that cold water solubility is affected significantly by the percentage Total Soluble Solid (TSS) content. Higher solubility was obtained with increasing % TSS in sample feed mixtures. Solubility of pitaya pigment powder obtained ranged from 94.59 % to 94.99 %. Lower DE (10 DE) had higher solubility than 25 DE at all % TSS (20 %, 25 % and 30 % TSS). However, there is no particular trend was showed in samples with mixtures 10 DE and 25 DE. At 20 % TSS, solubility in samples mixtures (10 DE + 25 DE) was lower compared to sample with 25 DE. It was also found that there is no significant different (P>0.05) between the mixtures (10 DE + 25 DE) with the exception of sample mixture at ratio 1:3 having high (94.7 ± 0.003 %) solubility. However, at 25 % TSS content, there was no significant different (P>0.05) between all samples mixtures (10 DE + 25 DE). At 30 % TSS content, there is no significant different (P>0.05) between the mixtures (10 DE + 25 DE) with the exception of sample mixtures at ratio 1:3 having lower solubility. The lowest (94.60 ± 0.02 % and 94.59 ± 0.02 %) solubility was found in samples mixture at ratio 1:1 and ratio 1:2. Goula and Adamopoulos [27] reported that the lower moisture content which obtained in high TSS the more soluble the powder on spray drying tomato pulp. The solubility of powder increased as a result of adding maltodextrin since it can formed outer layers on the droplets in the spray drying chamber and alter the stickiness of the particles surface due to transformation into glassy state [26]. Maltodextrin was normally used as the coating material in the spray drying of fruit juices, due to their high solubility and low viscosity which are important conditions for the spray drying process [28] [29] [15]. The effects of drying air flow rate effected on powder moisture, solubility, as low moisture content and associated with fast dissolution [27].

The addition of maltodextrin caused increase in solubility index more than 20 units in spray dried sweetpotaotes as reported by Grabowski [26]. The effect of maltodextrin can be attributed to the inverse relationship of maltodextrin concentration and the mean diameter of the particles [26]. Al-Asheh [30] reported that increase inlet air temperature resulted in an increase of product solid, solubility and particle size and exhibited decreased in bulk density. The better powder properties include lower water activity and moisture content, but higher solubility.

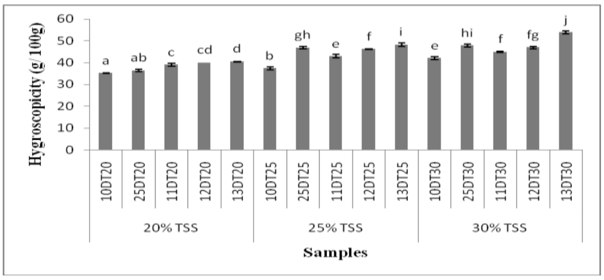


Means ± S.D (n=3) value with same letter within the bar are not significantly different from each other at P<0.05. Vertical bar represent one standard deviation of samples in triplicate.
Pitaya pigment powder samples: at 20 %, 25 % and 30 % TSS with maltodextrin 10 DE (10DT20, 10DT25 and 10DT30); at 20 %, 25 % and 30 % TSS with maltodextrin 25 DE (25DT20, 25DT25 and 25DT30) and maltodextrin mixtures (10 DE + 25 DE) at ratio 1:1 (11DT20, 11DT25 and 11DT30); 1:2 (12DT20, 12DT25 and 12DT30) and 1:3 (13DT20, 13DT25 and 13DT30).

Figure 3: Moisture content of spray dried pitaya pigment powder.

4.4 Hygroscopic of powder

The results of hygroscopicity analysis of the microencapsulated powders are shown in Figure 4. The mixtures (10 DE + 25 DE) maltodextrin affected to the hygroscopicity of the powder. At the higher % TSS (25 % and 30 %) no particular trend can be observed. However, at 25 % TSS content, all samples mixtures (10 DE + 25 DE) showed significant (P<0.05) lower hygroscopicity compared to 25 DE with the exception of sample mixtures at ratio 1:3 having the higher (48.23 ± 0.95 g/ 100g) hygroscopicity. Same trend was observed at 30 % TSS content, there was also significant different (P<0.05) for mixtures (10 DE + 25 DE) compared to 25 DE in hygroscopicity. Samples mixture at ratio 1:3 at 30% TSS gave the highest higroscopicity (53.85 ± 0.72 mg/ 100g). The hygroscopic moisture of spray dried powders was increased with increasing DE value of maltodextrin [31]. Moisture and hygroscopicity are important properties determining the storage stability of products and shelf life of the product. Al-Kahtani & Hassan [32] pointed out that hygroscopicity was one of the major problems related to stability of spray-dried betacyanin pigment red pitaya powder. Betacyanins pigment powders has many hydrophilic groups, thus easily absorbed moisture. Nevertheless, decreased of molecular weights of carrier agents resulted increasing hygroscopic properties of betacyanin powders [33]. From the results, various carrier agents for spray drying gave effect for the properties of the betacyanin powder.



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Pitaya pigment powder samples: at 20 %, 25 % and 30 % TSS with maltodextrin 10 DE (10DT20, 10DT25 and 10DT30), at 20 %, 25 % and 30 % TSS with maltodextrin 25 DE (25DT20, 25DT25 and 25DT30) and maltodextrin mixtures (10 DE + 25 DE) at ratio 1:1 (11DT20, 11DT25 and 11DT30); 1:2 (12DT20, 12DT25 and 12DT30) and 1:3 (13DT20, 13DT25 and 13DT30).

Figure 4: Hygroscopicity of spray dried pitaya pigment powder

4.5 Colour measurement

The result showed that addition of maltodextrins affected the colour of pitaya pigment powder. Samples at 30 % TSS showed higher L^* values (lightness) compared to those at 20 % and 25 % TSS as shown in Table 3. The feed concentration i.e. TSS content is an important parameter since higher feed concentration could lead to lower values of colour strength as expressed in L^* value and colour yield. The L^* value in samples with 25 DE at 20 % and 25 % TSS were higher (84.82 and 84.43, respectively) compared to those sample with 10 DE (83.86 and 84.41, respectively). Sample with mixtures (10 DE + 25 DE) showed lower L^* value compared to those sample with single type of maltodextrin at all TSS concentrations with the exception sample mixtures at ratio 1:1. This meant that high L^* value are paler in colour. The more positive a^* value means the samples are redder in colour. From the results, it observed that a^* values increased from 10 DE < 25 DE < mixtures (10 DE + 25 DE) at all ratios for all levels of TSS content which indicated that sample with 10 DE are less red compared to the mixtures. Colour change due to maltodextrin concentration can be described by the change in hue values (H°). H° are affected by maltodextrin in both the dry powder and reconstituted solution. H° value of sample 10 DE 20 % TSS was found to be highest (354.50). Higher a^{*} and lower H° indicates purple shade of red colour. It is concluded that the higher TSS content, the paler in colour is the pitaya pigment powder. It was found that sample mixture at ratio 1:3 at 20 % TSS was more reddish to purple colour according to characteristic by colorimeter. According to Duangmal [34], high concentration of maltodextrin contributes to high stability of anthocyanin colour during storage. The colour of pitaya pigment powder was found to be paler and less red-purplish with high amount of maltodextrin added.

Table 3: Means values of colour analysis of spray dried pitaya pigment powder

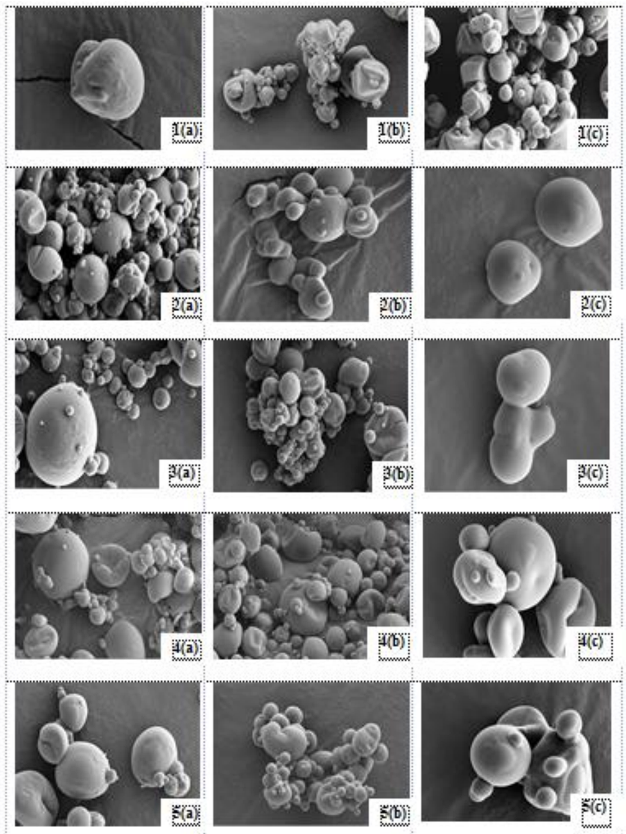
Sample	L^*	a^*	b^*	C^*	H°
10DT20	83.86 ± 0.03^{f}	11.08 ± 0.02^{c}	-1.07 ± 0.05^{a}	11.13 ± 0.02^{c}	354.50 ± 0.20^{j}
25DT20	84.82 ± 0.05^{j}	11.46 ± 0.03^{e}	-3.14 ± 0.01^{i}	11.88 ± 0.03^{j}	344.65 ± 0.02^{c}
11DT20	82.90 ± 0.13^{b}	12.82 ± 0.08^{j}	-2.57 ± 0.07^{e}	13.08 ± 0.09^{j}	348.67 ± 0.27^{h}
12DT20	83.24 ± 0.02^{d}	12.59 ± 0.02^{i}	-2.32 ± 0.14^{c}	12.78 ± 0.05^{h}	349.98 ± 0.66^{i}
13DT20	82.61 ± 0.03^{a}	13.00 ± 0.06^{k}	-2.55 ± 0.12^{e}	13.25 ± 0.04^{k}	348.91 ± 0.56^{h}
10DT25	83.41 ± 0.17^{e}	12.38 ± 0.25^{h}	-3.00 ± 0.08^{h}	12.74 ± 0.23^{g}	346.36 ± 0.58^{ef}
25DT25	84.43 ± 0.03^{h}	11.23 ± 0.03^{d}	-2.51 ± 0.02^{d}	11.50 ± 0.03^{d}	347.41 ± 0.06^{g}
11DT25	83.27 ± 0.04^{d}	12.31 ± 0.09^{h}	-3.20 ± 0.03^{j}	12.72 ± 0.08^{g}	345.42 ± 0.18^{d}
12DT25	83.80 ± 0.03^{f}	12.31 ± 0.03^{h}	-3.53 ± 0.06^{k}	12.81 ± 0.01^{i}	343.98 ± 0.26^{a}
13DT30	83.11 ± 0.02^{c}	13.17 ± 0.04^{l}	-3.90 ± 0.06^{l}	13.74 ± 0.05^{l}	343.49 ± 0.19^{b}
10DT30	85.74 ± 0.12^{k}	10.19 ± 0.08^{a}	-1.99 ± 0.06^{b}	10.38 ± 0.07^{a}	348.92 ± 0.37^{h}
25DT30	84.85 ± 0.05^{j}	11.46 ± 0.03^{e}	-3.14 ± 0.01^{i}	11.88 ± 0.03^{e}	344.65 ± 0.02^{c}
11DT30	85.71 ± 0.04^{k}	10.70 ± 0.05^{b}	-2.53 ± 0.09^{e}	11.01 ± 0.02^{b}	346.68 ± 0.49^{f}
12DT30	84.20 ± 0.03^{g}	11.73 ± 0.01^{f}	-2.96 ± 0.10^{f}	12.10 ± 0.02^{e}	345.86 ± 0.49^{de}
13DT30	84.66 ± 0.07^{i}	11.88 ± 0.14^{g}	-2.77 ± 0.24^{g}	12.20 ± 0.08^{f}	347.40 ± 0.53^{g}

Means ± S.D (n=3) value with different letters within the same column are significantly different from each other at P<0.05.

Pitaya pigment powder samples: at 20 %, 25 % and 30 % TSS with maltodextrin 10 DE (10DT20, 10DT25 and 10DT30); at 20 %, 25 % and 30 % TSS with maltodextrin 25 DE (25DT20, 25DT25 and 25DT30) and maltodextrin mixtures (10 DE + 25 DE) at ratio 1:1 (11DT20, 11DT25 and 11DT30); 1:2 (12DT20, 12DT25 and 12DT30) and 1:3 (13DT20, 13DT25 and 13DT30).

4.6 SEM

Scanning Electron Microscopy (SEM) analyses evaluate the encapsulating ability of various polymers. The spray dried pitaya pigment powder or microcapsules showed spherical shapes with smooth and some shrinkage surfaces (Figure 5). Samples with maltodextrin 25 DE had smoother outer structures when compared to samples with 10 DE. The SEM micrographs showed that 10 DE samples had more surface indentations and cracks in wall system. Low molecular weight sugars preventing shrinkage of the surface during drying [22]. With maltodextrin mixtures (10 DE + 25 DE), smoother surface microcapsules were obtained and the microstructure of microcapsules seemed to improve (Figure 5, (3), (4) and (5)). The smooth outer surfaces of these samples were similar to those samples with 25 DE. Samples with 10 DE especially at 30 % TSS had many deep dents compared to the others. For the samples with mixtures (10 DE + 25 DE) increasing TSS content to 25 % gave better outer structure and the surfaces of microcapsules were smoother and more uniform (Figure 5 – 5a and 5b). It was found that all the pitaya pigment powder with various coating materials at 30 % TSS was irregular in shape and also sticky. The outer surfaces of the microcapsules were characterized by the presence of dents. It is concluded with increasing TSS, the structure of betacyanin powder becomes sticky, more surface indentations and cracks in wall system. Similar morphology was observed in microcapsules of *Opuntia* mucilage pigment [35], the dents formed in the spray dried powder are due to shrinkage of the particles during cooling and drying due to the high concentration of maltodextrin used.



Pitaya pigment powder samples: with (1) 10 DE; (2) 25 DE; (3) the mixture (10 DE + 25 DE) at ratio 1:1; (4) the mixture (10 DE + 25 DE) at ratio 1:2 and (5) the mixture (10 DE + 25 DE) at ratio 1:3. TSS content: (a) 20 % TSS; (b) 25 % TSS and (c) 30 % TSS. The magnification of all micrograph was 3000x (2μm ├──┤).

Figure 5: SEM of spray dried pitaya pigment powder

5. Conclusion

Higher total soluble solid resulted in lower pigment recovery, but caused increase the yield of betacyanin pigment powder. For spray drying of red pitaya betacyanin pigment, there was a positive interaction between lower DE and higher DE maltodextrins as combined carrier agents. The mixture of 10 DE and 25 DE at ratio 1:2 at 25% TSS as a coating agent gave the highest pigment recovery (80.46 ± 0.50 %). Various carrier and coating agents affected the properties and storage stability of the spray-dried betacyanin pigment powders.

6. Future Scope

The results of this study would be helpful in developing red pitaya fruit as food grade, stable and with antioxidant natural red colourant. This research is a preliminary research to get natural food colorant from red pitaya fruit to with high yield and high stability. For the further study, can apply this natural food colorant into food product for children such as yoghurt and jellies. In addition, further research can also be done to study the application of this natural food colorant as food coating.

References

[1] Fernández-López, J., A., Angosto, J., M., Giménez, P., J., & Leon, G. (2013). Thermal Stability of Selected Natural Red Extracts Used as Food Colourants. *Plants and Foods for Human Nutrition*, 68, 11 – 17.

[2] Herbach, K.M., Maier, C., Stintzing, F.C., & Carle, R. (2006). Betalain stability and degradation – structural and chromatic aspects. *Journal of Food Science*,71(4), R41-R50.

[3] Diego A. Moreno Æ Cristina Garcı´a-Viguera Æ., Jose´ I. Gil Æ Angel Gil-Izquierdo. (2008). Betalains in the era of global agri-food science, technology and nutritional health. *Phytochem Rev*, 7, 261–280.

[4] Wybraniec, S., & Mizrahi, Y. (2002). Fruit flesh betacyanin pigments in *Hylocerues Cacti*. *Journal of Agricultural and Food Chemistry*, 50, 6086-6089.

[5] Stintzing, F.C., Scheiber, A., & Carle, R. (2001). Phytochemical and nutritional significance of cactus pear. *European Food Research and Technology*, 212(4), 396-407.

[6] Stintzing, F.C., Scheiber, A., & Carle, R. (2003). Evaluation of colour properties and chemical quality parameters of cactus juices. *European Food Research and Technology*, 216, 303-311.

[7] Lori, A.W., & Joseph, J.W. (1995). Stability of Spray-dried Encapsulated Carrot Carotenes. *Journal of Food Science*, 60(5), 1048-1053.

[8] Ee, S. C., Bakar, J., Kharidah, M., Dzulkifly, M. H., & Noranizan, A. (2014). Physico-chemical properties of spray-dried red pitaya (*Hylocereus polyrhizus*) peel powder during storage. *International Food Research Journal*,21(3), 1213 – 1218.

[9] Sri, P., & Aulia, P. (2015). Stability of Betacyanin Extract from Red Dragon Fruit (*Hylocereus polyhrizus*) Peels. *Procedia Chemistry*, 16, 434 – 444.

[10] Ashwini, G., Gary, A., D., & Wee, S., C. (2016). Stability of betacyanin from red pitaya (*Hylocereus polyrhizus*) and its potential application as a natural colourant in milk. *International Journal of Food Science and Technology*, 51, 427 – 434.

[11] Moßhammer, M.R., Stinzing, F.C., & Carle, R. (2005). Colour studies on fruit juice blends from *Opuntia* and *Hylocereus* cacti and betalain-containing model solutions derived therefrom. *Food Research International*, 38, 975-981.

[12] Obón, J.M., Castellar, M.R., Alacid, M., & Fernández-López, J.A. (2009). Production of a red-purple food colorant from *Opuntia stricta* fruits by spray drying and its application in food model systems. *Journal of Food Engineering*, 90(4), 471-479.

[13] Cai, Y.Z., Sun, M., Wu, H.X., Huang, R.H & Corke, H. (1998). Characterization and quantification of betacyanin pigments from diverse Amaranthus species. *Journal of Agricultural Food Chemistry*, 46, 2063-2070.

[14] Singh, J., & Singh, N. (2003). Studies on the morphological and rheological properties of granular cold water soluble corn and potato starches. *Food Hydrocolloids*, 17(1), 63-71.

[15] Quek, S. Y., Chok, N. K., & Swedlund, P. (2007). The physicochemical properties of spray-dried watermelon powder. *Chemical Engineering and Processing*, 46(5), 386–392.

[16] Tonon, R.V., Brabet, C., & Hubinger, M.D. (2008). Influence of process conditions on the physicochemical properties of açai (*Euterpe oleraceae Mart.*) powder produced by spray drying. *Journal of Food Engineering*, 88, 411-418.

[17] Wang, S., & Langrish, T. (2009). A review of process simulations and the use of additives in spray drying. *Food Research International*, 42, 13-25.

[18] Woo, M.W., Daud, W.R.W, Tasirin, S.M., & Talib, M.Z.M. (2009). Controlling food powder deposition in spray dryers: Wall surface energy manipulation as an alternative. *Journal of Food Engineering*, 94, 192-198.

[19] Saénz, C., Tapia, S., Chávez, & Robert, P. (2009). Microencapsulation by spray drying of bioactive compounds from cactus pear (*Opuntia ficus-indica*). *Food Chemistry*, 114(2), 616-622.

[20] Goula, A.M., & Adamopoulos, K.G. (2005a). Stability of lycopene during spray drying of tomato pulp. *Lebensmittei Wissenschaft and Technologie*, 38, 479-487.

[21] Goula, A.M., Adamopoulos, K.G., & Kazakis, N.A. (2004). Influence of spray drying conditions on tomato powder properties. *Drying Technology*, 22(5), 1129–1151.

[22] Loksuwan, J. (2007). Characteristics of microencapsulated β-carotene formed by spray drying with modified tapioca starch, native tapioca starch and maltodextrin. *Food Hydrocolloids*, 21, 928-935.

[23] Tonon, R.V., Baroni, A.F., Brabet, C., Gibert, O., Pallet, D., & Hubinger, M.D. (2009). Water sorption and glass transition temperature of spray dried açai (*Euterpe oleracea* Mart.) juice. *Journal of Food Engineering*, 94, 215-221.

[24] Thankitsunthorn, S., Thawornphiphatdit, C., Laohaprasit, N., & Srzednicki, G. (2009). Effects of drying temperature on quality of dried Indian Goosberry powder. *International Fiid Research Journal*, 16, 355-361.

[25] Koul, V.K., Jain, M.P., Koul, S., Sharma, V.K., Tikoo, C.L., & Jain, S.M. (2002). Spray drying of beet root juice using different carries. *Industrial Journal Chemistry Technology*, 9, 442–445.

[26] Grabowski, J.A., Truong, V.D., & Daubert, C.R. (2006). Spray drying of amylase hydrolyzed sweetpotato puree and physichochemical properties of powder. *Journal of Food Science*, 71(5), E209-E217.

[27] Goula, A.M., & Adamopoulos, K.G. (2005b). Spray drying of tomato pulp in dehumidified air: II. The effect on powder properties. *Journal of Food Engineering*, 66, 35-42.

[28] Tonon, R.V., Brabet, C., & Hubinger, M.D. (2010). Anthocyanin stability and antioxidant activity of spray-dried açai (*Euterpe oleracea* Mart.) juice produced with different carrier agents. *Food Research International*, 43(3), 907-914.

[29] Gabas, A. L., Telis, V. R. N., Sobral, P. J. A., & Telis-Romero, J. (2007). Effect of maltodextrin and Arabic gum in water vapor sorption thermodynamic properties of vacuum dried pineapple pulp powder. *Journal of Food Engineering*, 82(2), 246–252.

[30] Al-Asheh, S., Jumah, R., Banat, F., & Hammad, S. (2003). The use of experimental factorial design for analyzing the effect of spray dryer operating variables on the production of tomato powder. *Trans IChemE*, *81* (Part C) [online], [Accessed 13th May 2008]. Available from World Wide Web: www.igentaselect.com/titles/09603085.

[31] Ersus, S., & Yurdagel, U. (2007). Microencapsulation of anthocyanin pigments of black carrot (*Daucuscarota* L.) by spray drier. *Journal of Food Engineering*, 80, 805-812.

[32] Al-Kahtani, H.A., & Hasan, B.H. (1990). Spray drying of Roselle (Hibiscus sabdariffa L.) extract. *Journal of Food Science*, 55(4), 1073-1076.

[33] Cai, Y.Z., & Corke, H. (2000). Production and properties of spray-dried Amaranthus betacyanin pigments. *Journal of Food Science*, 65(6), 1248-1252.

[34] Duangmal, K., Saicheua, B., & Sueeprasan, S. (2008). Colour evaluation of freeze-dried roselle extract as a natural food colorant in a model system of a drink. *Lebensmittei Wissenschaft and Technolohgie*, 41, 1437-1445.

[35] León-Martinez, F., M., Méndez-Lagunas, L., L., & Rodriguez-Ramirez, J. (2010). Spray drying of Nopal Mucilage (*Opuntia ficus-indica*): Effects on Powder Properties and Characterization. *Carbohydrate Polymers*, 81, 864–870.

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