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Stability of betanin in pitaya powder and confection as affected by resistant maltodextrin

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ABSTRACT

Physicochemical properties and stability of betanin in pitaya juice spray dried with maltodextrin (MD_p) and resistant maltodextrin (RMD_p), and its stability after incorporation into sugar confection were assessed. MD_p exhibited more favorable powder properties with higher betanin retention, compared to RMD_p. Morphology of MD_p exhibited well defined spheres as compared to RMD_p which displayed agglomerated particles. Storage for 3 months at 4 °C, 25 °C and 40 °C exhibited higher betanin degradation in RMD_p at all temperatures with corresponding lower half-lives compared to MD_p. Exposure of powder to light increased degradation of betanin in RMD_p more so than in MD_p. In sugar confection, RMD_p exhibited higher betanin retention post processing at 78.13% compared to MD_p at 69.06%. However, after storage for 3 months at 25 °C and 40 °C, stability of betanin in candies incorporated with RMD_p reduced below that of candies incorporated with MD_p, signifying higher stability in the latter.

1. Introduction

Natural pigments are currently highly sought after by food producers and consumers, largely due to the scrutiny on synthetic colourants and their adverse effects on health (McCann et al., 2007). Among the major groups of natural pigments, betalains can be considered as the least studied, due to its limited sources. The current commercial betalain crop is red beet root, however many researchers are exploring red dragon fruit or pitaya as a viable alternative (Stintzing, Schieber & Carle, 2002; Naderi, Stintzing, Ghazali, Manap, & Jazayeri, 2010). Betalains consist of water soluble pigments ranging from red purple betacyanins to yellow orange betaxanthins and have been employed in foods such as dairy, confectionary and meats (Castellar, Obón, & Fernández-López, 2006). The major betacyanins which have been studied are betanin, phyllocactin and hylocerenin which are all present in the pitaya fruit, with betanin being in the focus of the present study. Aside from imparting colour, betalains have also been known to possess antioxidative activity (Bazaria & Kumar, 2016). It was reported that antioxidative activity of betalain recorded up to double that of some anthocyanins (Gliszczyńska-Świgło, 2006) and up to 4 times that of ascorbic acid (Cai, Sun, & Corke, 2003).

Encapsulation technology has been extensively utilized within the food industry for the preservation as well as easy handling of substances such as flavours, colours, and aromas (Desai & Park, 2005). Spray drying is by far the most commonly employed encapsulation technique (Gharsallaoui, Roudaut, Chambin, Voilley, & Saurel, 2007). It has been successfully applied for several decades in the production of everyday commodities such as instant drinks, dairy powders as well as sweeteners (Nath & Satpathy, 1998). In addition, it is also regarded as a highly economical method for the preservation of sensitive ingredients (Desai & Park, 2005).

An important variable in the process of spray drying is the use of carrier or wall materials. A proper selection of wall materials is essential due to their effects on functional as well as physical properties of the resultant powders (Barbosa-Cánovas, Ortega-Rivas, Juliano, & Yan, 2005). Wall materials must possess properties such as good emulsifying activity, fine film-formation ability, high solubility and low viscosity (Adem, Gaëlle, Odile, Andrée, & Rémi, 2007). Maltodextrin (MD) is considered as the customary encapsulation material and has been used in the spray drying of a wide variety of food components, especially in the case of fruits and fruit concentrates (Bhandari, Datta, Crooks, Howes, & Rigby, 1997; Quek, Chok, & Swedlund, 2007; Bazaria & Kumar, 2017). Alternatively, resistant maltodextrin (RMD), another category of hydrolysed starch, has a promising potential as a wall material with

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added health value due to high content of soluble fibre (Buck, 2012). It has been reported that resistant maltodextrin can improve bowel regularity (Satouchi, Wakabayashi, Ohkuma, Fujiwara, & Matsuoka, 1993), increase bifidobacterium in the gut (Ohkuma, Matsuda, Katta, & Hanno, 1990), reduce the rise in serum glucose after meals (Nomura, Nakajima, & Abe, 1992), as well as increase satiety when consumed (Ye, Arumugam, Haugabrooks, Williamson, & Hendrich, 2015).

Applications of betalains in food systems along with their corresponding stabilities is quite limited in literature with majority of reports focusing on betalain sources from red beet, cactus pear as well as amaranth (Martínez, Cilla, Beltrán, & Roncalés, 2006; Caldas-Cueva et al., 2015; Cai & Corke, 1999). More than half are specifically focused towards dairy products such as milk, yogurt and ice-cream (Güneşer, 2016; Obón, Castellar, Alacid, & Fernández-López, 2009:; Kumar, Manoj, Shetty, Prakash, & Giridhar, 2015), with sausages being another common medium for incorporation (Martínez et al., 2006: Jin, Choi, Moon, Jeong, & Kim, 2014), all of which are stored under chilled conditions, resulting in a higher pigment stability. There have been scarce reports on the stability of pitaya betalains in food systems, and none in confectionery specifically. Thus, the present work aims to study the powder properties of spray dried pitaya juice with wall materials maltodextrin and resistant maltodextrin as carriers, powder stability as well as stability of these powders incorporated into sugar confection.

2. Materials and methods

2.1. Materials

Pitaya fruits of commercial maturity were obtained from a MultiRich Dragon Fruit Farm in Sepang. Maltodextrin DE 10 (MD) and resistant maltodextrin, Fibersol 2 (RMD) were obtained from San Soon Seng Food Industry Malaysia and ADM Company, USA respectively. Analytical grade solvent, acetone (C_3H_6O), and HPLC grade solvents; acetonitrile (C_2H_3N), and methanol (CH_3OH) were obtained from Sigma Alderich. Formic acid (CH_2O_2), and sodium chloride (NaCl), were purchased from Merck (Darmstadt, Germany).

2.2. Preparation of pitaya powders

Red pitayas were washed, dried, peeled and juiced with a Santos 50 centrifugal juice extractor (*Vaulx*-en-*Velin,* France) to remove seeds. Samples were then centrifuged and pellets were discarded. Pitaya powders were produced through the method described by Muhammad, Amin, and Bakar (2015) with a Niro pilot scale spray dryer (Germany.) Juice was mixed with wall material, MD, RMD, at 1:25 (w/w) ratio. Each mixture was then homogenised with a Heidolph Silent Crusher M (Schwabach, Germany) at 5000 rpm for 10 min. The aqueous feed was then spray dried at inlet and outlet temperatures of 150 °C and 75 °C, respectively, with atomization of 15000 rpm and feed rate of 10 mL/min. Spray dried juice with maltodextrin (MD_p) and spray dried juice with resistant maltodextrin (RMD_p) were collected in opaque aluminium foil pouches with additional polyethylene terephthalate (PET), and polyethylene (PE) layer (140 mm × 100 mm x 10 mm), sealed using a PFS-300 JN impulse sealer, and stored at 4 °C for further analysis.

2.3. Powder properties

2.3.1. Determination of moisture and water activity (a_w)

Moisture content was obtained gravimetrically through a method described by Loksuwan (2007). Water activity was determined using an Aqualab 3TE water activity meter (Pullman, USA) following the method outlined by Fang and Bhandari (2011).

2.3.2. Determination of hygroscopicity

Hygroscopicity determination was based on the method by Nayak and Rastogi (2010) with slight modifications. 2 g of powder was spread evenly in a petri dish inside a container containing saturated NaCl at 79.5% relative humidity. After 1 wk, weight gain of samples was measured, with percentage hygroscopicity calculated according to

$$\text{Hygroscopicity}\ (\%) = \frac{\text{WI} + \text{MC}}{100 + \text{WI}} \times 100 \quad (1)$$

with WI is (mass of sample after one wk − mass of sample)/100, and MC is moisture content of sample.

2.3.3. Determination of solubility

Cold water solubility of powders was determined according to the method described by Cano-Caucha, Strinheta, Ramos & Cal-Vidal (2005). Percentage solubility was calculated according to

$$\%\ \text{Solubility} = \frac{\text{W1} \times 5}{\text{W0}} \times 100 \quad (2)$$

where W_1 is mass of solids in 10 mL and W_0 is mass of powder.

2.3.4. Determination of glass transition temperature

Glass transition temperature (T_g) was determined with a Mettler Toledo Differential Scanning Colorimeter 825e (Germany) according to Fang and Bhandari (2012) with slight modifications. 10 mg of sample was inserted into a DSC pan and hermetically sealed before heated at a temperature range of 30 °C–70 °C with a heating rate of 10 K/min. Results were analysed using the StarE software.

2.3.5. Determination of betanin retention

Pitaya powders were diluted with distilled water before being filtered through 0.45 μm nylon filters. Determination of betalain, specifically betanin was done according to Esquivel, Stintzing, and Carle (2007), employing an Agilent 1200 Series High Performance Liquid Chromatography (HPLC) system (Germany), with Agilent 1200 Series multiple wavelength diode array detector (DAD), and an Agilent Eclipse Plus C18 column (5 μm × 4.6 mm id x 250 mm). Gradient elution was performed with mobile phase A consisting of 0.2 mL/100 mL formic acid with mobile phase B consisting of 80% acetonitrile at a flow rate of 1 mL/min and column temperature maintained at 30 °C. The gradient flow was initiated with 100% mobile phase A for 5 min, followed by a gradual increase of mobile phase B to 10% during the 20th min. Mobile phase B was increased again to 13% by the 40^{th} minute and again to 20% by the 45th minute. Finally mobile phase B was increased all the way to 100% approaching the 50^{th} minute before the gradient was repeated again.

$$\text{Pigment retention}\ (\%) = \frac{Pp \times DMf}{Pf \times DMp} \times 100 \quad (3)$$

where P_p is concentration of betanin in powders, DM_f is dry matter of feed, P_f is concentration of betanin in feed, and DM_p is dry matter in powder.

2.3.6. Powder morphology

Powder morphology was observed with a LEO 1455 VPSEM (United Kingdom) scanning electron microscope equipped with an Oxford INCA 300 energy dispersive X-ray detector (Germany) according to Amin (2009). A small amount of powder was attached to