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Development of beetroot (*Beta vulgaris*) powder using foam mat drying

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ABSTRACT

Beetroot (*Beta vulgaris*) is normally used as natural food colorants in food industry. The objectives of this research are (1) to determine the effect of types (egg albumen and fish gelatine) and different concentrations of foaming agents on foam properties of foam mat drying beetroot, (2) to evaluate the physicochemical properties (color, pH, Brix, bulk density, water activity, hygroscopicity and moisture content) of foam dried beetroot powder, and (3) to determine the effect of temperature on rehydration ratio and color changes of rehydrated foam mat dried beetroot powder. Beetroot foam was spread at 3 mm thickness and hot air dried at 50 °C for 6 h in cabinet dryer. Beetroot pulp can be successfully foamed using egg albumen and fish gelatine as foaming agents, further hot air dried and grinded into powder. In this experiment, beetroot powder after foam mat drying was considered as hygroscopic food and resulted in lighter and reddish in colour. After rehydrating foam mat dried beetroot powder, L^* value decreased but a^* and b^* values increased. Generally, sample beetroot with fish gelatine (BFG) had good foam expansion, foam density, hygroscopicity, water activity, and red color's powder.

1. Introduction

Beetroot is known as beet or red beet. Besides Europe and Americas, beetroot can also be found at Cameron Highland in Malaysia. Scientific name of beetroot is known as *Beta vulgaris*, from the plant family Chenopodiaceae (Jeffrey, 1982, p. 4).

Betanin or beetroot red is one of the betalains color pigments that is responsible for the purplish red color of the beet. It is used to enhance the red color of tomato paste, sauces, desserts, jam, jellies, ice cream, sweets, and breakfast cereals (Lim, 2016, p. 29). Fresh vegetables and fruits cannot be stored for long term due to its high moisture content (Kowalski & Mierzwa, 2011). Preservation technique like foam mat drying can convert perishable food into stabilised products, enabling storage time and to reduce postharvest losses.

Foam mat drying helps to convert liquid or semi-solid food to stable foam by cooperation with foaming agents or stabilizing agents. This method is relatively easy and can be carried out at low cost than spray drying and freeze drying (Sangamithra, Venkatachalam, John, & Kuppuswamy, 2015). Kandasamy, Varadharaju, Kalemullah, and Maladhi (2014) mentioned that foam mat drying method suitable for samples which are heat sensitive, sticky, and viscous materials that cannot be dried using spray drying. Foam mat drying can be carried out at lower temperatures and shorter drying times which helped to maintain nutrient in vegetable. Foam mat dried powders are easy to make reconstitutable juice powder (Chandrasekar, Gabriela, Kannan, & Sangamithra, 2015). Since beetroot in its fresh form has high water content, it can be processed into powder form in order to enhance its shelf life. Beetroot powder known for its natural red food colorant normally use in dry mixes (soups, Indian curry mixes) for final make up and confectionary (sweets, jam, jellies, icings, decorations) due to its heat instability (Baines & Seal, 2012; Gokhale & Lele, 2011).

Studies have been conducted on drying kinetics and microwave heating of beetroot slices (Kaur & Singh, 2014), dehydration of red beetroot by hot air drying (Gokhale & Lele, 2011) and influence of spray drying conditions on beetroot pigments retention after microencapsulation process (Janiszewska & Wáodarczyk, 2013).

Nowadays, many prefer natural colorants than synthetic colorant due to its health benefits. Thus, it is suggested that beet

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powder can be used to replace synthetic coloring in food products. Beetroot has high nutritional benefits as previous studies have demonstrated potential antioxidant effect of betalains which is heat sensitive compound (Georgiev et al., 2010). Due to limited information on foam mat dried beetroot, this research aimed to develop beetroot powder using foam mat drying technique at lower temperature and determine the effect of foaming agents on the foam mat dried powder properties.

2. Materials and methods

2.1. Preparation of foaming agents

Nutriplus class eggs were purchased from mini market at Sri Serdang (Selangor, Malaysia). Fish gelatine (240–260 Bloom) was purchased from Scienfield Expertise PLT (Selangor, Malaysia). Fish gelatine were in powder form and had to be dissolved and diluted in water to desired concentration before adding into beetroot pulp. Four hundred 50 g of beetroot pulp was mixed with dissolved fish gelatine to final concentration of 5 g/100 g and 10 g/100 g separately. Beetroot samples with 5 g/100 g and 10 g/100 g of egg albumen were labelled as BEA-5 and BEA-10, respectively. Beetroot samples with 5 g/100 g and 10 g/100 g of fish gelatine were labelled as BFG-5 and BFG-10, respectively. Beetroot which acts as control with maltodextrin was labelled as BCMD whereas beetroot without maltodextrin was labelled as BC(W/O)MD.

2.2. Preparation and drying of beetroot foam

Beetroot *(Beta vulgaris)* was purchased from local Pasar Borong at Seri Kembangan (Selangor, Malaysia). Beetroot was washed first then the skin of beetroot was removed with knife and cut into small cubes. Four hundred 50 g of beetroot was weighed and blanched in hot water for enzyme inactivation. Then, it was quickly transferred to cold water 8 ± 1 °C. The sample was grinded for 10 min. BEA-5 was whipped at speed 4 using food processor for 2min into white foam. Then beetroot slurry was added to the bowl and whipped for additional 10min. During whipping, 10 g/100 g of maltodextrin was added into the samples to be whipped. Beetroot thick foam was spread on the stainless steel tray and dried at 3 mm thickness at 50±1 °C for 6 h in cabinet dryer. After drying, beetroot flakes were scrapped and grinded into powder. After sieving with 400US mesh size siever, the powder was quickly kept in polyethylene bag and being sealed off. The experiment was repeated by using 10 g/100 g of egg albumen, 5 g/100 g and 10 g/100 g of fish gelatine.

2.3. The analysis of foam properties

2.3.1. Foam expansion

Beetroot foam expansion indicates the ability of foam to cooperate air into the structure of foam was determined using Eq. (1) as shown by Durian (1995):

$$\text{Foam expansion} = \frac{V_1 - V_0}{V_0} \times 100 \quad (1)$$

where,

V_1 = Final volume of foamed beetroot pulp, cm^3
V_0 = Initial volume of beetroot pulp, cm^3

2.3.2. Foam density

The method used to determine foam density of beetroot is according to Bag, Srivastav, and Mishra (2011). The method was slightly modified. Beetroot foam was poured into a 1 L measuring cup then it was weighed and its volume was taken. The density of beetroot foam was measured in as mass per volume of foam and expressed as g cm^{-3} as shown in Eq. (2).

$$\text{Foam density} = \frac{\textit{Weight of foam } (g)}{\textit{volume of foam } (cm^3)} \quad (2)$$

2.3.3. Foam stability

Foam of the beetroot sample was inserted into 20 mL of measuring cup and left at room temperature (25 ± 1 °C) for 3 h (Marinova et al., 2009). Every 30min, the volume reduction was measured. Beetroot foam stability was estimated using Eq. (3).

$$\text{Foam stability} = \frac{V_{foam}}{V_0} \times 100\% \quad (3)$$

where, V_{foam} occurred during the 30min time interval and V_0 was the volume of the foam at zero min.

2.4. The analysis of foam mat dried powder

2.4.1. Moisture analysis

Moisture content of foam mat beetroot powder in different concentrations and types of foaming agent was determined using oven method. Sample was dried by oven drying at 105 ± 1 °C using standard AOAC method.

2.4.2. Water activity, a_w

The water activity of foam mat dried beetroot powder were measured using digital water activity meter at 25 ± 1 °C (Aqua Lab, model 3T E; Decogon Devices, Pullman, USA).

2.4.3. pH

The pH was recorded using pH meter (Hanna Instrument PH 211 Microprocessor pH Meter, Italy) for foam mat dried powder rehydrated into beetroot juice at 25 ± 1 °C.

2.4.4. Total soluble solid

Total soluble solid levels of rehydrated beetroot juice were measured with refractometer. A drop of rehydrated beetroot juice was placed on refractometer (Atago co., Ltd., Tokyo, Japan) to measure the soluble solid levels in %Brix at 25 ± 1 °C. The refractometer prism was cleaned with distilled water after each analysis.

2.4.5. Bulk density

Bulk density of the foam mat dried beetroot powders was carried out with some modifications (Goula & Adamopoulos, 2008). Five gram of powder was inserted in 25 mL of measuring cylinder. The beaker together with the contents was moved up and down in vertical movement for 15±2 cm for 10 times to get a constant reading of powder volume. Bulk density was calculated as shown in Eq. (4).

$$\text{Bulk Density} \left(\text{gcm}^{-3}\right) = \frac{\textit{Mass of the powder } (g)}{\textit{Volume of powder } (cm^3)} \quad (4)$$

2.4.6. Hygroscopicity

Hygroscopicity of beetroot powder was measured using Cai and Corke (2000) method with modifications. One gram of beetroot powder was put on crucible and placed in an airtight desiccator filled with saturated solution of NaCl (75% RH) and stored at 25 ± 1 °C for one week. After one week, the powder was weighed