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Preparation of Banana Puree Powder via Foam Mat Drying Technique

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ABSTRACT

Banana fruit is one of the world's most important crops and plays a key role in food security especially in the developing countries. Regrettably, almost one quarter of the annual banana production is rejected due to not meeting the required dimensions for retail sale. Fortunately, the rejected bananas can be used as a food ingredient for various applications, including as banana puree. Banana puree is the main commercial processed banana product worldwide; however, it is generally deteriorating rapidly. Thus, this study focuses on the dehydration of banana puree through foam mat drying technique to prolong its shelf life. It involves whipping the banana puree to form foam with the usage of a specific foaming agent and foam stabilizer. Based on the obtained findings, the foam mat drying technique managed to produce good quality banana puree powder in terms of its properties.

KEYWORDS

Banana, Banana puree, Foam mat drying, Dehydration, Product development

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INTRODUCTION

Banana, a major global food primary, is the fourth most important crops in the world, after rice, straw, and corn (Daniells, 2003). In Malaysia, banana is usually consumed fresh or processed to produce banana chip or banana puree. Banana puree is one of the main ingredients in many food products such as snacks, desserts, beverages, baby food and traditional food. Besides, the production of banana puree is also a good alternative for the utilization of the overripe bananas which have low commercial value. Unfortunately, banana puree has a short shelf-life and is easily spoiled. The production of banana puree can be further improved by converting this product in a powder form to prolong the shelf-life, for size reduction, convenience of handling and transportation, and easy storage. Converting the puree into powder is expected to improve consumers' acceptance and subsequently improve the product's commercial value.

There are many dehydration techniques available for drying of the banana puree such as sun drying, spray drying, freeze drying, vacuum drying, and conventional oven. Unfortunately, most of the mentioned dehydration methods are either tedious, lengthy, unhygienic, not practical for high throughputs, require high energy consumption or costly. Furthermore, the banana puree itself has a sticky attribute which hinders an effective drying process (Papadakis et al., 2006). The stickiness properties are related to the high content of low molecular weight sugar, such as fructose, glucose, and sucrose in the fruit puree (Muzaffar, 2015).

The application of foam drying technique for the drying of banana puree can be an alternative as to tackle some of the highlighted issues. Through this technique, the puree will be whipped to form stable foams, with the assistance of selected foaming agent and foam stabilizer and dehydrated by any drying methods. The larger surface area of the produced foam will accelerate the drying process for the rapid moisture removal from the high moisture feed (Sangamithra et al., 2014). This technique can be applied to the viscous and high sugar-content foods which normally are difficult to dry and sticky under relatively mild conditions without changes in quality (Sangamithra et al., 2014). Foam mat drying is relatively simple, low cost, rapid and practical to be applied for the removal of water from the banana puree. Accordingly, this study aims to produce banana powder using the foam mat drying method. Besides, the effect of the physical characteristics of the banana powder produced by the foam mat drying method using different amounts of foaming agent will be determined.

MATERIALS AND METHODS

Raw Material Preparation

The banana (Cavendish variety) was supplied from local markets in Sri Serdang, Selangor. As to ensure that the bananas used in this study are in stage 7 of ripeness (overripe), they were left at the room temperature for approximately 3 days. Later, the bananas were peeled by hand and the flesh parts were collected and used as the main ingredient of the banana puree. The whey protein concentrate (WPC) was used as a foaming agent and carboxymethyl cellulose (CMC) as a foam stabilizer, both were also supplied from local markets.

Foam Production

The overripe banana flesh (100g) was mashed by using a meat grinder prior to mixing with whey protein concentrate (WPC) at different percentage of 5, 10 and 15 % (w/w), carboxymethyl cellulose (CMC) of 8% (w/w) and distilled water of 85% (w/w). The mixture was whipped using a kitchen mixer with a maximum speed of 1150 rpm for 50 minutes. The produced foamy-like mixture was removed from the mixer and analysed for its foam density.

Drying Experiment

The produced foam was spread uniformly (thickness of 3.0 ± 0.02 mm) on a metal tray which was covered with a parchment baking paper and then put into the oven. The drying experiment performed at an inlet temperature of 80°C for 7 hours. The drying temperature in the range of 60-80°C had no significant effect on the textural properties and shrinkage of the foams (Sangamithra et al., 2014). Once the drying process completed, the dried foam mat was removed from the oven and ground into powder with a kitchen grinder and sieved (40 μm screen mesh). The produced powder was stored and used for subsequent analyses. The overall preparation of the banana puree powder is shown in Fig. 1. As for a control sample, one batch of banana puree was dried in the oven at 80°C for 20 hours without undergoing the mixing and foaming process.

Foam Analysis

Foam Density

The foamy-like mixture (50 mL) was poured into a 50 ml graduated cylinder at a controlled ambient temperature (22-25 °C) (Bag et al., 2009). The sample was weighed and used to calculate the foam density according to the following equation:

$$\text{Foam density} = \frac{weight\ of\ foam\ (g)}{volume\ of\ foam\ (cm^3)} \quad (1)$$

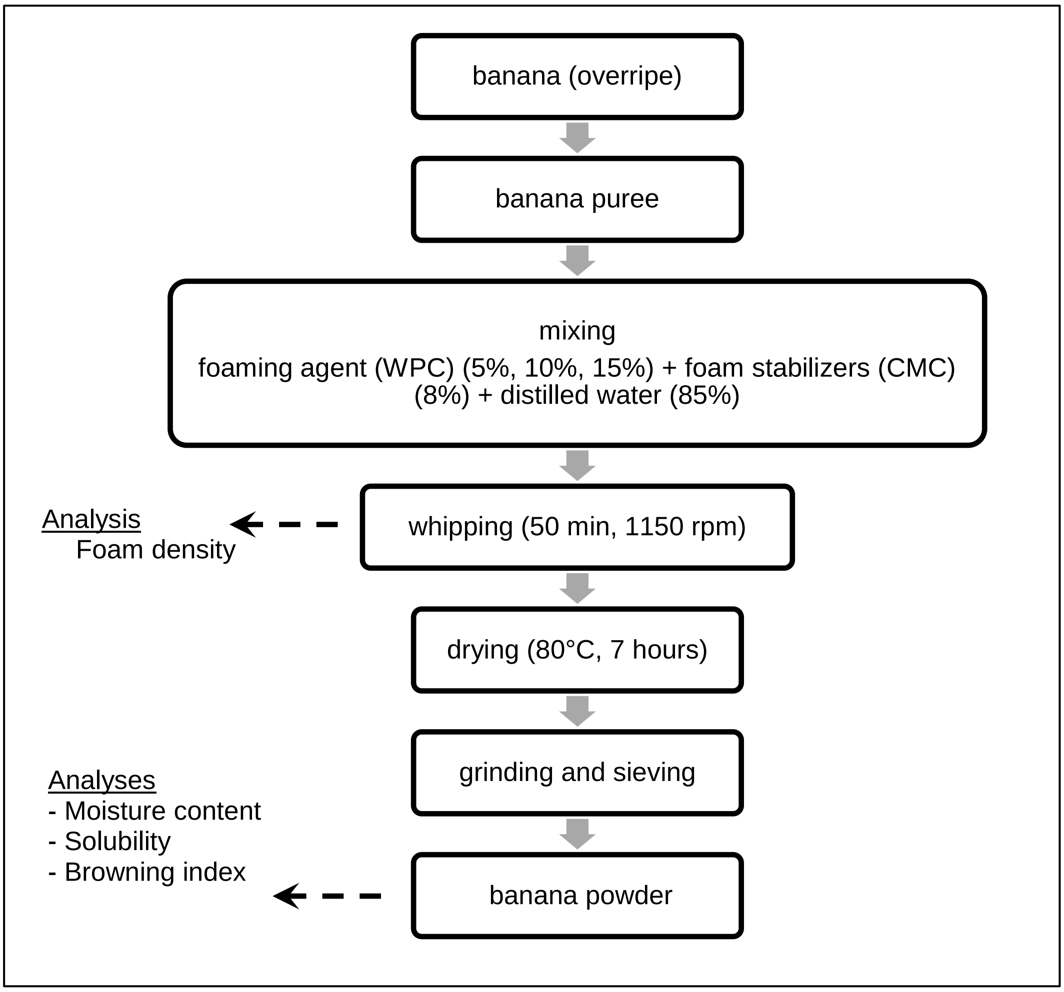

Figure 1: Process flow for the preparation of banana powder

Powder Analysis

Moisture Content

The moisture content of banana powder (3 gram) is determined by using a moisture analyser (MX-50, AND, Japan).

Solubility

Solubility is the dissolving rate of particles in a solution. Time has been evaluated solubility of powder products. Banana powder (3 gram) was inserted into a 500 mL beaker containing 200 mL of distilled water. The mixture was immediately stirred by using a magnetic stirrer and the time for the powder to completely dissolve in the water was recorded (Tinay et al., 1985).

Colour

The colour properties of the banana powder were measured using a spectrophotometer (UltraScan Pro, HunterLab, Germany). The sample was placed on the sensor and the colour values expressed as lightness (L*), redness (a*) and yellowness (b*) values were recorded. The browning index (BI), used to assess the intensity of the brown colour of the samples was then calculated based on the below formulas using the obtained L*a*b* values (Oliveira et al., 2012):

$$BI = \frac{[100\ (x - 0.31)]}{0.17} \quad (2)$$

$$\text{with } x = \frac{(a* + 1.750\ x\ L*)}{(5.645 \times L* + a* - 3.012 \times b*)} \quad (3)$$

RESULTS AND DISCUSSION

Effect of Whey Protein Concentrate on Foam Properties

Density of Foam

Table 1: Effect of whey protein concentrate the density of the banana foam

Sample	Whey Protein Concentrate (%)	Foam Density (g/cm^3)
Control	0	0.99 ± 0.006
S1	5	0.75 ± 0.005
S2	10	0.60 ± 0.002
S3	15	0.37 ± 0.020

The whipping properties of the mixtures can be represented by the foam density values, as lower density of the foam structure can be obtained if more air trapped in the foam structure during the mixing process (Falade et al., 2003). Based on Table 1, the density of the foam decreases with the increment of the WPC concentration. This is due to movement of the foaming agent from the liquid phase to the air with the increases of WPC concentration, reduced the surface tension of the structure and hence, leads to the increment of the entered air into the foam structures which causes the density to reduce (Abbasi & Azizpour, 2016).

Effect of WPC on Powder Properties

Drying Time and Moisture Content

Table 2 exhibits the total drying time for all the samples. The production of banana puree powder by foam mat drying technique has reduced the drying time three times shorter compared to the conventional oven drying method of 20 hours. Shorter drying time means lesser energy required for the production of the powder and subsequently will affect the overall production cost.

Table 2 also presents the moisture content (MC) of all samples. The control sample has a significantly higher moisture content (18.4%) compared to the other samples, indicating that the 20 hours continuous drying was not sufficient to remove the moisture in the sample. For the foam-based powder samples, the findings indicate that the higher concentration of CMC during mixing resulted in the lower MC values. It is expected that by increasing the foaming agent concentration, it may also reduce the hygroscopicity of the powder (Seerangurayar et al., 2017). This is in agreement with some other report on the decrement of MC value with the increment of foaming agent concentration levels (Kha et al., 2010).

Table 2: Effect of whey protein concentrate level on some physicochemical properties of foam mat dried banana powder.

Sample	WPC (%)	Drying Time (hours)	Moisture Content (%)	Solubility (min)	Browning Index
Control	0	20	18.46 ± 0.52	1.44 ± 0.05	59.85 ± 0.15
S1	5	7	11.19 ± 0.04	2.20 ± 0.09	29.17 ± 0.05
S2	10	7	10.44 ± 0.21	2.92 ± 0.30	25.77 ± 0.04
S3	15	7	8.84 ± 0.72	3.29 ± 0.04	24.50 ± 0.03

Solubility

Table 2 exhibits the effect of WPC concentration on the solubility of the banana powders. The solubility decreases with the rise of the concentration of WPC. The porosity of the produced powders can be enhanced by increasing the WPC levels to improve the structural stability of the foam. As a result, a more stable foam structure during the drying process can be produced and leads to a more porous produced powder (Abbasi & Azizpour, 2016; Harmayani et al., 2011).

Colour

As shown in Table 2, by increasing the percentage of WPC, the browning index (BI) of the produced powders was reduced. This finding indicates the increment in the browning rate of the samples which is related to the Maillard reaction. As protein is the major component in WPC, the amino acids existing in its chemical composition start the Maillard reaction with reducing sugar of the system, which leads to browning (Abbasi & Azizpour, 2016).

CONCLUSIONS

Banana puree powder was produced using the foam mat drying technique in this study. The application of foam mat drying method for the banana puree production can reduce almost three times of the drying duration compared to the conventional oven drying method. Higher concentration of WPC resulting powders with lesser moisture content and browning index, and better solubility. Hence, the findings of this study demonstrated that the foam mat drying technique is a good alternative for the production of banana puree powder with better properties.

REFERENCES

1. Abbasi, E., & Azizpour, M. (2016). Evaluation of physicochemical properties of foam mat dried sour cherry powder. LWT - Food Science and Technology, 68, 105–110.
2. Bag, S. K., Srivastav, P. P., & Mishra, H. N. (2009). Optimization of process parameters for foaming of bael (*Aegle marmelos L.)* fruit pulp. Food and Bioprocess Technology, 4(8), 1450-1458.
3. Daniells, J. (2003). Bananas and plantains. Encyclopedia of Food Sciences and Nutrition, 372-378.
4. Falade, K. O., Adeyanju, K. I., & Uzo-Peters, P. I. (2003). Foam-mat drying of cowpea (*Vigna unguiculata*) using glyceryl monostearate and egg albumin as foaming agents. European Food Research and Technology, 217(6), 486-491.
5. Harmayani, E., Winarti, S., & Nurismanto, R. (2011). Preparation of inulin powder from *Dioscorea Esculenta* tuber with foam mat drying method. In The 12th Asian food conference; 16-18 June, 2011, BITEC Bangna, Bangkok, Thailand (pp. P30-P36).
6. Kha, T. C., Nguyen, M. H. & Roach, P. D., 2010. Effects of spray drying conditions on the physicochemical and antioxidant properties of the Gac (*Momordica cochinchinensis*) fruit aril powder. Journal of Food Engineering, 98 (3), 385-392.

7. Muzaffar, K. (2015). Stickiness problem associated with spray drying of sugar and acid rich foods: a mini review. Journal of Nutrition & Food Sciences, s12.
8. Morganigi, A., Graham, R., Ginnette, L. & Williams, G. 1961. Recent developments in foam-mat drying. Food Technology, 15, 37–39.
9. Oliveira, F., Sousa-Gallagher, M.J., Mahajan, P.V., Teixeira, J.A., 2012. Evaluation of MAP engineering design parameters on quality of fresh-sliced mushrooms. Journal of Food Engineering, 108 (4), 507–514.
10. Papadakis, S. E., Gardeli, C., & Tzia, C. (2006). Spray drying of raisin juice concentrate. Drying Technology, 24(2), 173-180.
11. Sangamithra, A., Venkatachalam, S., John, S. G., & Kuppuswamy, K. (2014). Foam mat drying of food materials: a review. Journal of Food Processing and Preservation, 39(6), 3165-3174.
12. Seerangurayar, T., Manickavasagan, A., Al-Ismaili, A. M., & Al-Mulla, Y. A. (2017). Effect of carrier agents on flowability and microstructural properties of foam-mat freeze-dried date powder. Journal of Food Engineering, 215, 33-43.
13. Tinay, A. H & Ismail, J. A (1985). Effect of some additives and processes on the characteristic of agglomeration and granulated spray dried roselled powder. Journal of Food Science; 14 (3) 283-295