Production of bambangan (*Mangifera pajang* Kosterm) juice powder using spray dryer

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ABSTRACT Bambangan fruit juice is a popular beverage in Sabah. However, it has certain limitations, including a relatively short shelf life which is around a week to months depending on the heat treatment processes. Producing bambangan fruit juice in powder form offers an alternative solution to preserve the flavor and ensure its availability throughout the year. Spray drying is a common method for producing fruit juice powder, but it often results in a sticky powder when dealing with concentrated fruit juices. To address this issue, maltodextrin is used as a carrier agent during the spray drying process. This study aimed to identify the optimal conditions for producing bambangan juice powder by examining three key spray drying parameters: maltodextrin concentration (0, 5, 10, 15, 20, and 25%), inlet temperature (150, 160, 170, and 180 °C), and flow rate (20, 30, and 40 rpm). The findings revealed that the best parameters were a maltodextrin concentration of 20%, an inlet temperature of 160 °C, and a flow rate of 20 rpm, yielding a powder recovery rate between 57.0% and 58.8%. These results indicate a high powder yield, exceeding 50% across the parameters studied. The bambangan juice powder produced shows significant potential for applications in various industries, including the food and pharmaceutical sectors.

KEYWORDS: Bambangan fruit; Juice powder; Spray drying; Maltodextrin; Yield
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INTRODUCTION

Mangifera pajang Kosterm commonly known as the bambangan fruit, is a species of mango from the Anacardiaceae family (Al-Sheraji *et al*., 2012). It can be found in the Borneo Island, including Sabah and Sarawak (Malaysia), Brunei, and Kalimantan (Indonesia) (Abdulrahman *et al*., 2011). The bambangan tree is a seasonal fruit that fruits around October to February (Tangah *et al*., 2017). Bambangan fruit is typically consumed fresh. Additionally, its flesh can be used to produce fermented bambangan pickles or bambangan fruit juice. Bambangan juice is a popular beverage among the community in Sabah. However, this juice product has certain drawbacks, such as a relatively short shelf life of about 10 to 15 days when the juice is pasteurized and stored at cold temperatures (<10 °C) (Frangopoulos *et al*., 2024). The shelf life of fruit juice depends on microbiological stability and natural degradation caused by chemical and physical processes. According to Pandraju & Rao (2020), the shelf life of sugarcane juice is limited due to the presence of microbes and high enzymatic activity, which can affect the physicochemical properties of the juice, such as color, taste, and texture (Dziadek *et al*., 2019). Spoilage of fruit juice reduces its acceptability among consumers and can lead to wastage if discarded.

Spray drying techniques can be used to convert bambangan fruit juice into powder. Producing fruit juice powder offers several advantages, including an extended shelf life, the ability to preserve the flavor of bambangan juice, and year-round availability. Moreover, the production of fruit juice powder offers numerous economic benefits, such as improved quality, reduced packaging costs, easier management and handling, more efficient transportation, and longer storage stability (Fazaeli *et al*., 2012). In fruit juice powder production, several operational parameters play a crucial role in ensuring the final product meets the desired standards. Spray drying parameters, such as inlet and outlet air temperature, feed temperature and rate, atomizer speed and type, and the type and concentration of carrier agents, influence the particle size, bulk density, moisture content, yield, and hygroscopicity in spray-dried food (Phisut, 2012).

However, spray drying concentrated fruit juice presents challenges, as it often results in sticky powders. This issue arises because the glass transition temperature of fruit sugars, such as glucose, fructose, and sucrose, is low. When the glass transition temperature of carbohydrates is exceeded during the drying process, physical changes occur, including increased specific heat and molecular mobility. This leads to reduced viscosity and causes the powder to stick to the dryer walls (Navarrete-Solis, 2020). This problem can be overcome by adding carrier agents, such as maltodextrin, gum arabic, and waxy starch, during the spray drying process. Maltodextrin is the most commonly used carrier agent due to its high solubility, low viscosity, and ability to protect aroma and flavor, thereby reducing oxygen exposure. These properties make maltodextrin an essential component for stabilizing fruit juice powder (Navarrete-Solis, 2020). According to Shishir & Chen (2017), the optimal concentration range of maltodextrin for spray drying fruit juice is within 10–20%. However, this range depends on the targeted compounds and the desired properties of the final product. This study investigated the effects of maltodextrin concentration, inlet temperature, and flow rate of the spray-drying on the yield of bambangan fruit juice powder.

METHODOLOGY

Bambangan Juice Preparation

Bambangan fruits (*Mangifera pajang*) were purchased from the Ranau market in Sabah and transported to the laboratory. Upon arrival, the fruits were washed, and their peels were manually removed to extract the pulp. The maturity of the pulp was assessed based on its total soluble solids (°Brix) using a refractometer (Atago, Germany). Mature bambangan fruits typically have a total soluble solid content of approximately 15°Brix. The pulp (fibrous solid part of the fruit) was then cut into smaller pieces, blended using a food processor (Dito Sama, Italy), and filtered to obtain the slurry. The juice (liquid extract) was prepared by mixing the slurry with water in a 1:1 ratio before being stored in a 500 mL Schott bottle.

Spray Drying

A pilot-scale spray dryer was used to convert the bambangan fruit juice into powder. The study used a one-factor-at-a-time design, where the effect of change in one factor on the output is studied while all the other factors are kept constant (Tontul & Topuz, 2017). First, the effect of the concentration (0, 10, 15, 20, and 25%) of the carrier agent, maltodextrin 10 DE, on the yield was studied while keeping the inlet temperature and flow rate fixed at 150°C and 20 rpm, respectively. Second, after the optimal maltodextrin cencentration was determined, the effect of inlet temperature (150 °C, 160, 170, and 180 °C) on the yield was studied at the optimal maltodextrin concentration and a flow rate of 20 rpm. Last, the effect of flow rate (20, 25, and 30 rpm) on the yield was examined at the optimal values of the maltodextrin concentration and inlet temperature.

Determination of Powder Yield

The yield of powder obtained using the spray drying method was calculated using the following formula (Santhalakshmy *et al*., 2015), with slight modifications:

$$Powder\ yield\ (\%) = \frac{weight\ of\ powder\ obtained\ (g)}{bambangan\ juice\ (g) + carrier\ agent\ (g)} \times 100$$

Statistical Analysis

All data were analyzed with SPSS 27.0 software using one-way ANOVA, followed by Tukey's test. The data obtained are reported as mean ± standard deviation.

RESULT AND DISCUSSION

Powder Yield of Bambangan Fruit Juice at Different Maltodextrin Concentrations

The quality of spray-dried fruit powder depends on various processing factors during spray drying. The important factors of spray drying include drying temperature, drying air flow rate, feed flow rate, speed of atomizer, type of carrier agent and concentration of carrier agent (Fazaeli *et al*., 2012; Murali *et al*., 2015; Phisut, 2012; Tonon *et al*., 2008).

In this study, six concentrations of maltodextrin were selected to determine the yield of bambangan juice powder. Table 1 shows the yield of bambangan juice powder at different maltodextrin concentrations. In the absence of maltodextrin, the yield percentage was found to be 37.91%. As the maltodextrin concentration increased to 5–20%, the yield of bambangan juice powder significantly improved, reaching a maximum of 58.84% at 20% maltodextrin. This result was slightly higher than the findings of Fang & Bhandari, (2012), who reported a 45% powder recovery at 20% maltodextrin. However, 25% maltodextrin resulted in a reduced yield of 54.84%. This indicated that the optimal yield of bambangan juice powder through spray drying was achieved at the maltodextrin concentration of 20%, and this value was used for the subsequent determination of powder yield at different inlet temperatures.

A similar result was reported by Quek *et al*. (2007), who found no watermelon juice powder recovery in the cyclone when the spray drying was performed without a carrier agent. The powdered particles were extremely sticky and adhered to the walls of the drying chamber. This was attributed to the high levels of low molecular weight compounds, such as fructose and organic acids, present in watermelon juice. When the concentration of the carrier agent increased up to 10%, the drying process of sticky products was enhanced, resulting in a higher yield and reduced moisture content of the spray-dried products (Abadio *et al*., 2004; Quek *et al*., 2007). However, adding 25% of maltodextrin to the bambangan fruit juice significantly decreased the powder yield. This effect can be explained by the excessive amounts of maltodextrin (>25%), which slowed the diffusion of water molecules during drying (Goula & Adamopoulos, 2010).

Table 1. Bambangan powder yields at different concentrations of maltodextrin (carrier agent).

Concentration of maltodextrin (%)	Powder yield (%)
0	37.91 ± 0.063^{c}
5	45.71 ± 0.032^{a}
10	47.62 ± 0.012^{b}
15	55.64 ± 0.009^{e}
20	58.84 ± 0.005^{f}
25	54.84 ± 0.005^{d}

*Different lowercase letters (a-c) for mean±standard deviation values in the same column indicate significant differences (p<0.05).

Powder Yield of Bambangan Fruit Juice at Different Inlet Temperatures

The inlet air temperature or drying temperature is a critical factor influencing the physicochemical properties of spray-dried powder (Shishir & Chen, 2017). Higher drying temperatures provide more heat to the drying chamber, accelerating the drying rate and reducing the moisture content of the final product. Table 2 presents the yield of bambangan juice powder at different inlet temperatures. There were four inlet temperatures selected for the study. At an inlet temperature of 150°C, the yield percentage was found to be 57.2%. The yield increased further when the inlet temperature was raised to 160 °C. This result (inlet temperature of 160 °C) showed a positive effect on process yield, which can be attributed to the greater efficiency of heat and mass transfer processes (Fazaeli *et al*., 2012). However, when the inlet temperature was increased to 170 °C and 180 °C, the yield of bambangan juice powder decreased to 43.0% and 37.9%, respectively. This reduction was attributed to the issues of stickiness, indicating that the drying temperature had exceeded the glass transition temperature. According to Sundarajan *et al*. (2023), high inlet temperatures increase the risk of particles becoming sticky by exceeding their "sticky point" or glass transition temperature, which leads to wall deposition and a reduced powder yield.

Table 2. Bambangan powder yields at different inlet temperatures.

Inlet temperature (°C)	Powder yield (%)
150	57.18± 0.008^{c}
160	57.62 ± 0.014^{d}
170	43.02 ± 0.012^{b}
180	37.98 ± 0.008^{a}

*Different lowercase letters (a-c) for mean±standard deviation values in the same column indicates significant differences ($p<0.05$).

Powder Yield of Bambangan Fruit Juice at Different Flow Rates

The feed flow rate primarily depends on the speed of the atomizer. A higher pump speed results in an increased feed flow rate. When the feed flow rate is higher, more energy is required to evaporate the same amount of moisture from the feed droplets (Shishir & Chen, 2017). Based on Table 3, three different flow rates (20, 30 and 40 rpm) were selected for this study. At 20 rpm, the highest yield 57.03%. When the flow rate was increased to 30 rpm and 40 rpm, a significant decrease in powder yield was noted. This is because an increase in flow rate reduces the drying time, resulting in incomplete drying. As a result, the incomplete drying process affects the final product yield, leading to a higher moisture content. This demonstrated that 20 rpm was the optimal flow rate for obtaining the highest yield.

Table 3. Bambangan powder yields at different flow rates.

Flow rate (rpm)	Powder yield (%)
20	57.03±0.014^{c}
30	47.86±0.012^{b}
40	47.18±0.012^{a}

*Different lowercase letters (a-c) for mean±standard deviation values in the same column indicate significant differences ($p<0.05$).

Tonon *et al*. (2008) reported that higher feed flow rates significantly reduced the process yield of spray-dried açaí fruit powder. Increased feed flow rates slowed heat and mass transfer, making it difficult for the droplets to dry adequately. This resulted in wet particles adhering to the walls of the drying chamber. Tonon *et al*. (2008) also observed dripping inside the drying chamber, caused by improper atomization at high feed flow rates. This also reduced the process yield. Similarly, Chegini & Ghobadian (2007) found that higher feed flow rates decreased process yield. Higher feed flow rates also increase the moisture content of spray-dried powder. This occurs because the limited interaction time between the feed droplets and the hot air reduces the effectiveness of heat and mass transfer. As a result, the shorter contact time leads to higher moisture levels in the final product (Hong & Choi, 2007)

CONCLUSION

Bambangan juice powder was successfully produced through spray drying. The most favorable spray drying conditions for achieving the highest bambangan juice powder recovery, between 57% and 59%, were a 20% maltodextrin concentration, an inlet temperature of 160 °C, and a flow rate of 20 rpm. The results showed that operational parameters of spray drying such as maltodextrin concentration, inlet temperature, and flow rate influenced the yield of bambangan juice powder. In conclusion, this study provides valuable insights for producing high-quality bambangan juice powder and can serve as a reference for the fruit juice powder production industry.

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