Spray drying of mangosteen (Garcinia mangostana L.) juice and analysis of antioxidant activity and total phenolic content

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Abstract. Mangosteen contains natural antioxidant compounds such as polyphenolic compounds. It is most fresh consumed and can not be stored for long especially after separated from its pericarp. One alternative to extend the shelf life is by drying the mangosteen fruit. Spray drying was investigated to this study to produce mangosteen juice powder which was examined for antioxidant activity and total phenolic content. Mangosteen juice powder was dried with the addition of maltodextrin in a ratio of mangosteen: maltodextrin of 10:90; 30:70 and 50:50, which mangosteen was based on total solid value. Spray drying was carried out in 2 inlet temperatures condition, 140°C and 160°C, to observe the effect of temperature on antioxidant activity and total phenolic content. These 2 inlet temperatures of spray dryer did not affect the physical appearance, colour, taste, and aroma of mangosteen powder. Increment of spray dryer temperature did not show significant differences in total phenolic content and IC50 of antioxidant activity, except IC50 in the ratio of 50:50. At the ratio 50:50, the increment of spray dryer temperature decreases the antioxidant activity. Therefore, spray drying is a prospective drying option for mangosteen juice at the appropriate addition of maltodextrin and temperature process. It should maintain the physical and chemical properties of mangosteen and finally support ease of storage and shipping.

1. Introduction
Mangosteen (Garcinia mangostana L.) is a tropical fruit and widely cultivated in Indonesia. It contains natural antioxidant compounds such as phenolic acids, anthocyanins, and xanthone derivatives [1] (Xie et al. 2015). Xanthone is largely responsible for its bioactivity. It is a polyphenolic group compound and abundance can be found in mangosteen [2]. Mangosteen pericarp has been used as a medicine against inflammatory and diarrhea and treatment of skin infection and wound. Meanwhile, mangosteen fruit aril was consumed fresh or juice processed [3][4]. Mangosteen juice, combined with other fruit or vegetable which posses antioxidant, is now widely available in the market as a dietary supplement [1].

Drying of juice could extend shelf-life and add the value of mangosteen products. The drying process will remove the water and prevent the growth of fungi and microbial [3]. Powdered juice should be a good alternative for healthy ingredient formulated food [5]. The drying method should be considered so that phenolic contents are maintained. Encapsulation of phenolic content, extracted from fruits or foods, should be a good alternative for maintaining the stability of these compounds. Encapsulation prevents the compounds from light, enzyme, moisture and oxygen exposure [6].

One of the most widely used encapsulation techniques is spray drying, which provides rapid evaporation of water and maintains the low temperature in the particles. Spray drying method suitable
for the drying of heat-sensitive compounds such as polyphenolic compounds [6]. In conclusion, the spray dry method is capable of drying large quantities of liquid rapidly, minimal negative impact on the product, without damaging the surrounding environment, lowest capital and operating costs [7][8]. Drying agent addition such as maltodextrin helps to dry and prevent sticking on the dryer wall. The properties of additives for spray drying in use is critical, as it has an influence on the process parameter and physico-chemical properties of spray drying [9]. Maltodextrin is inexpensive, greater availability, widespread use in foods, possesses low viscosity at high solid content, shown able to reduce product’s hygroscopicity and increases product yield [5][7].

Encapsulation of procyanidins from grape seed extract using spray drying method was carried out by mixing the core substances and wall material (gum arabic and maltodextrin) by the ratio of 30:70. The result showed that spray dry processing did not change the procyanidin [10]. Fang and Bhandari (2011) reported that spray drying using maltodextrin as the carrier could maintain the total phenolic content and anthocyanin in bayberry juice. They also reported that the inlet temperature of 150°C was suitable for spray drying of the heat-sensitive material [11]. Fazaeli et al. (2012) reported that a higher concentration of maltodextrin and increment of spray drying inlet temperature will increase the final yield of black mulberry juice powder [12]. The objective of the present study was to evaluate the effect of maltodextrin addition to mangosteen juice on total phenolic content and antioxidant activity. Evaluation on organoleptic, total phenolic content and antioxidant activity was measured on mangosteen juice powder after spray drying process on inlet temperature of 140°C and 160°C, and mangosteen juice: maltodextrin ratio of 10:90; 30:70 and 50:50.

2. Method

2.1. Materials

Mangosteen fruit is harvested from Purwakarta, West Java. Materials of 2,2-dihenyl picrylhydrazil (DPPH), Folin Ciocalteau reagent, ascorbic acid, gallic acid were purchased from Sigma Co (St. Louis, MO, USA). Sodium carbonate, citric acid, methanol, ethanol were purchased from Merck (Germany). Maltodextrin DE 18-20 was purchased from Zhuceng Dongxiao Biotechnology Co., Ltd. (China). Instruments used for this research were spray drying (Lab Plant, UK Ltd., UK), spectrophotometer (Heλios α, Thermo Spectronic, USA), refractometer pocket (Atago, Atago Co. Ltd., Japan), and magnetic stirrer (Heidolph, Heidolph Instruments GmbH. & Co., Germany).

2.2. Mangosteen juice preparation

Juice preparation was carried out based on Setyawati et al (2019) method by steaming pretreatment. Mangosteen fruit aril was separated from its pericarp and washed with water. Fruit aril was separated from the rotten and yellow ones. Fruit aril was steamed on boiling water for 15 minutes and homogenized in a filtered-blender to obtained mangosteen juice. Mangosteen juice was stored at -20°C (freezer) until the next testing [13].

2.3. Spray drying of mangosteen juice

Production of mangosteen juice powder was carried out using a lab-scale spray dryer instrument (Lab Plant UK Ltd.). Mangosteen juice was mixed with maltodextrin DE 18-20, which ratios of mangosteen juice and maltodextrin were 10:90; 30:70 and 50:50. Mangosteen juice was weighed based on total soluble solid (TS) value, which the parts of 10, 30 and 50 of mangosteen juice were counted as 100% TS value. TS values of mangosteen juice and maltodextrin mixture were measured. The mixture was divided into 2 parts for drying at 2 different inlet temperature of the spray drying process, those were 140°C and 160°C. The flow rate was 3 ml per minute. Sample powder was stored in a desiccator at 25°C for further analysis [3].
2.4. Determination of antioxidant activity by DPPH radical scavenging

Antioxidant activity can be measured by the DPPH radical scavenging activity method based on Ghafar et al. (2010) method with some modification. A 50 µL of sample mixed with 1 mL 0.04 M DPPH in 80% ethanol, shaken and left to stand at room temperature of 25°C for 30 minutes in a dark room. Ascorbic acid was used as a positive control at a concentration of 5, 10, 25, 50 and 75 µg/mL. The negative control contained only DPPH solution, while the blank contained 80% ethanol. DPPH scavenging activity was measured using a spectrophotometer at 517 nm. The scavenging effect was determined by the ratio of DPPH absorption decrease against the absorption of DPPH solution (negative control) using the equation (1).

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\text{Scavenging(\%)} = \frac{\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}}}{\text{Abs}_{\text{control}}} \times 100
\]  

Inhibition concentration 50 (IC\textsubscript{50}) value was obtained from the plotted graph of scavenging against the concentration of the sample (mg/mL) [14].

2.5. Determination of total phenolic content

The total phenolics were determined by using Folin-Ciocalteu method. The sample was prepared by diluted mangosteen aril juice by 10-fold dilution in distilled water. 200 µL of the sample was mixed with 750 µL of Folin Ciocalteu reagent. After 5 minutes, 750 µL of 6% sodium carbonate solution was added to the mixture and stand for 60 minutes at room temperature of 25°C. The absorbance was measured by UV-Vis spectrophotometer at 725 nm. The standard curve of gallic acid was prepared by the same procedure. The maximum concentration of gallic acid of 100 µg/mL was prepared with methanol solvent, from which a serial dilution was made to give concentrations of 70, 50, 30, and 20 µg/mL. Total phenolic content was expressed as µg gallic acid equivalent (GAE) per gram sample [14].

2.6. Statistical analysis

Total phenolic content and antioxidant activity of each spray drying sample powder were compared to each other using Student's t-test.

3. Results and Discussion

Keeping the fruit fresh is the way to maintain its nutritional value but most storage techniques require low temperature (Sagar & Suresh. 2010). Mangosteen can not be stored for a long period and fruit aril will be browning after it is separated from its pericarp. Pretreatment of mangosteen juice preparation by steamed in boiling water for 15 minutes was carried out to prevent the juice from browning and maintain total phenolic content and antioxidant activity (Setyawati et al. 2019). Mangosteen pericarp extract industry will utilize the pericarp and unfortunately, discard the mangosteen fruit aril. Drying of mangosteen fruit aril is a suitable alternative for post-harvest management and to enhance storage stability, minimize packaging requirements and reduce transport weight (Sagar & Suresh. 2010).

Spray drying of mangosteen fruit aril was performed at 2 operating temperatures and mangosteen juice - maltodextrin ratio to determine the effect on physical properties, total phenolic content and antioxidant activity. Maltodextrin is the most commercially available additives used in spray drying. The properties of additives for spray drying in use is critical, as it influences the process parameter and physico-chemical properties of spray drying (Lee, Taip & Abdullah. 2018). Physical quality parameters associated with dried fruit products include colour, visual appeal, the shape of product and flavour should be observed (Sagar & Suresh. 2010).

Physically, mangosteen powder dried by spray drying at inlet temperature 140°C and 160°C had a similar appearance, as well as the taste and smell (Figure 1). While different ratios gave different colours, tastes, and smells. The higher part of mangosteen juice, the browner the colour, the sourer and the more mangosteen typical smell (Table 1). The ratio of 50:50 had better physical characteristics of
powder and better sour taste like fresh consumed mangosteen. Finally, the spray drying technique is able to maintain the sweet and sour taste of mangosteen.

Figure 1. The physical appearance of mangosteen powder at an inlet temperature of spray drying of 140°C and 160°C, and the ratio of mangosteen juice: maltodextrin 10:90; 30:70 and 50:50

Table 1. Physical properties of mangosteen powder

| The ratio of mangosteen juice : maltodextrin | The inlet temperature of spray drying |
|---------------------------------------------|--------------------------------------|
|                                             | 140°C                          | 160°C                          |
| 10:90                                       | Fine powder, slightly brownish-white, slightly sticky, rather sweet, less sour taste | Fine powder, slightly brownish-white, slightly sticky, rather sweet, less sour taste |
| 30:70                                       | Fine powder, brownish-white, slightly sticky, rather sweet, a little sour taste and the typical smell of mangosteen | Fine powder, brownish-white, slightly sticky, rather sweet, a little sour taste and the typical smell of mangosteen |
| 50:50                                       | Fine powder, white brown, slightly sticky, rather sweet, sour taste, the typical smell of mangosteen | Fine powder, white brown, slightly sticky, rather sweet, sour taste, the typical smell of mangosteen |

The hydroxyl groups of phenols or polyphenols in plant extract will react specifically with the yellow Folin-Ciocalteu reagent to form a blue chromophore complex. The more phenolic compounds or polyphenols, the higher the intensity of blue produced [15]. Total phenolic contents of the mangosteen powder ratio of 10:90 between inlet temperature of spray dryer of 140°C and 160°C were not significantly different (significant level P > 0.01), as well as the ratio of 30:70 and 50:50. It showed that the spray dryer inlet temperature between 140°C and 160°C did not affect the total phenolic
content of mangosteen powder (Table 2). The condition of the inlet temperature of the spray dryer should be considered, although a short time process in the spray dryer was applied. The increment of heating temperature decreases total phenolic and antioxidant activity [16], but Fang and Bhandari (2011) reported that spray drying can preserve total phenolic and anthocyanin content higher than 91%. They also suggested that the inlet temperature of 150°C and the outlet temperature of 80°C is suitable for spray drying heat-sensitive material [11].

Total phenolic contents of mangosteen powder ratio of 30:70 after spray-dried at an inlet temperature of 140°C and 160°C were equal to mangosteen juice that is 2.35 mg GAE/g. Mangosteen juice and mangosteen powder in this research contained a higher amount of total phenolic contents than grape (1.58 mg GAE/g), black plum (1.435 mg GAE/g) and cherries (1.054 mg GAE/g) [17].

Table 2. Total phenolic content of mangosteen powder

| The ratio of mangosteen juice : maltodextrin | Total phenolic content (mg GAE/g) |
|---------------------------------------------|----------------------------------|
|                                             | The inlet temperature of spray drying 140°C | The inlet temperature of spray drying 160°C |
| 10:90                                       | 1.02 ± 0.1                        | 0.83 ± 0.07                        |
| 30:70                                       | 2.35 ± 0.13                       | 2.4 ± 0.13                        |
| 50:50                                       | 5.56 ± 0.24                       | 5.41 ± 0.04                       |

Figure 2. Total phenolic content of mangosteen powder at an inlet temperature of spray drying of 140°C and 160°C, and the ratio of mangosteen juice: maltodextrin 10:90; 30:70 and 50:50

DPPH is an oxidizing material which can be reacted with the antioxidant compound. DPPH reduction will occur and change the violet color of DPPH to a pale yellow color. So, high scavenging activity of sample means a high reduction of DPPH [18]. The IC_{50} value of the mangosteen powder ratio of 10:90 between inlet temperature of spray dryer of 140°C and 160°C was not significantly different (significant level P > 0.01), as well as the ratio of 30:70. However, the ratio of 50:50 between the inlet temperature of the spray dryer of 140°C and 160°C was significantly different (significant level P > 0.01). Antioxidant activity at the ratio of 50:50 showed that increment of inlet temperature (160°C) decrease antioxidant capacity (increase IC_{50} antioxidant activity) (Table 3). It is correlated with Chen and Lin (2007), where the increment of heating temperature decreases total phenolic and...
antioxidant activity. But, at the ratio of 10:90 and 30:70, the increment of inlet temperature did not affect the antioxidant capacity. It may be possible due to the higher part of maltodextrin (70% and 90%) can encapsulate heat-sensitive compound better. The higher part of maltodextrin can preserve the antioxidative compound even when exposed to a higher temperature.

### Table 3. Radical scavenging activity of mangosteen powder

| The ratio of mangosteen juice : maltodextrin | Inhibition concentration 50% (IC₅₀) (mg/mL) The inlet temperature of spray drying 140°C | The inlet temperature of spray drying 160°C |
|-------------------------------------------|-----------------------------------------------------------------|-----------------------------------------|
| 10:90                                     | 552.43 ± 32.01                                                  | 529.52 ± 34.17                          |
| 30:70                                     | 146.27 ± 4.23                                                  | 137.43 ± 2.85                           |
| 50:50                                     | 37.50 ± 3.13                                                  | 57.96 ± 2.16                            |

![Figure 3. IC₅₀ of radical scavenging activity of mangosteen powder at an inlet temperature of spray drying of 140°C and 160°C, and the ratio of mangosteen juice: maltodextrin 10:90; 30:70 and 50:50](image)

### 4. Conclusion

Spray drying process and addition of maltodextrin as drying agent were suitable for drying mangosteen juice which contains polyphenolic compounds. Spray drying capable to maintain the original taste and sour of mangosteen fruit and total phenolic content and antioxidant activity. While maltodextrin capable to encapsulate heat-sensitive compounds such as phenolic compounds from heat transfer of spray dryer.

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