Drying of extracted betacyanin from red dragon fruit (
Hylocereus Costaricensis) as natural colorant by using spray
dryer in various operating condition

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Abstract. One of the natural dyes that can be used in food is betacyanin from red dragon fruit. The betacyanin extracted from the red dragon fruit potentially be used for industrial ingredients such as a natural dye that is appropriate and can be applied further for food colouring. The drying process is one of the important stages in producing betacyanin extract from dragon fruit. The objective of this research was to study drying process of extract betacyanin from red dragon fruit using spray dryer in various operation condition. There materials from red dragon fruit: whole fruit, fruit flesh and fruit skin were used for extraction process with water as a solvent. Maltodextrin (30 %) was added as filler to the extracts. The inlet temperature that used in spray dryer condition were: 140 °C, 160 °C, 180 °C. The results showed the highest betacyanin content was found in whole dragon fruit extracts used spray dryer with Inlet temperature 140°C (411.80 mg / kg).

1. Introduction
Fruit is a rich plant in natural colourants resources. More than thousands of plants could be possible used as natural colourant on food. The plant has been used for thousands of years as a source of ingredients to provide attractive colours and appearance to food and drinks. However, in order to introduce in the worldwide market, more advance research should be conducted to study the active compounds that produce natural colour with the extraction techniques on those plants.

One of the potential plants as a source of natural food colourant is Red dragon fruit. Dragon fruit is the fruit of several cactus species that have been classified as white (Hylocereus undatus), red (H. polyrhizus), and yellow (Selenicereus megalanthus) [1][2]. Several studies have mentioned that dragon fruit contains high moisture and rich in fiber, organic acids, protein, phosphorus, vitamin C and other minerals like potassium, magnesium, calcium [3][4]. Furthermore, research investigated dragon fruit identified at least seven betacyanins, namely: betanin, isobetanin, lhylocactin, isophyllocactin, betanidin, isobetanidin and bougainvillein-R-I where all have identical absorption spectra that contribute to the deep purple coloured pulp [5][6][7].

The dragon fruit has been used as a food, natural dye, craft, tribal ceremony and medicine [8][9][10]. Dragon fruit is considered as a heavenly fruit on the earth with high nutritive and medicinal values. Various studies on the potential of red dragon fruit to treat some degenerative diseases such as cervical cancer, breast cancer, colon cancer, antidiabetic, anti-inflammatory has been done in recent years [11][12]. Swarup et al. [13] investigated the antidiabetic of dragon fruit. Results had shown that dragon
fruit extract revealed oxidative damage inhibition activities and decreased the aortic stiffness by pulse wave velocity in streptozotocin-induced diabetes in rats. Widyaningsih et al. [14] investigated that effect of red dragon fruit juice on pregnant women has been able to increase haemoglobin and erythrocyte levels.

Commercialized natural dyes come in two forms, namely concentrate and powder. The concentrate can be obtained by evaporation under vacuum until a 40-60% solid is reached, while the powder dosage form is obtained by drying the extract using a spray dryer. In general, powder forms are preferred over concentrates because they are easier to handle, stable, and have a longer shelf life. The use of dragon fruit as a food colouring simply can be done by blending with the addition of water, and directly used or filtered first then applied to food. However, the colouring produced from this simple method has a short shelf life so that it is only suitable to be applied on a home industry scale where this product is directly used as a mixture of dough. One method that can be used to obtain colouring powder extract from dragon fruit is drying using spray dryer. Drying with a spray dryer will produce a product with a low water content that has a long shelf life and is easily applied on an industrial scale. Therefore, it is necessary to study the effect of drying using a spray dryer on the content of betacyanin in natural dye extracts from dragon fruit. The results of the literature study show that the purplish red colour in plants can also be obtained from the active ingredient of betacyanin substances [15][16][17][18].

2. Materials and methods

2.1 Materials and instruments

Materials used in this research are red dragon fruit (*Hylocereus costaricensis*) that obtained from farmers in Subang West Java, aquades as solvent, maltodextrin as filler. Red dragon fruit will be collected into 3, namely whole dragon fruit (meat and fruit are used), fruit flesh, and fruit skin. The chemical materials for analysis are betacyanin standard, n-butanol, acetic acid was purchased from Sigma Aldrich. The equipment used in this study were spray dryer, UV-Vis Evolution 201 spectrophotometer, blender, filter press.

2.2 Methods

Betacyanin pigments of red dragon fruits (whole dragon fruit, fruit flesh, and fruit skin) were extracted by blending using water as a solvent in a ratio of 1 : 3. Furthermore, the characterization of betacyanin extracts of red dragon fruit included water content analysis with oven method and total Betacyanin analysis (spectrophotometric method). The result of extraction was dried using spray dryer with variations of inlet temperature of 140 °C, 160 °C and 180 °C.

In order to extract the betacyanin pigment of red dragon fruit, the fruits were washed and disinfected, and prickles were removed manually. Red dragon fruit was collected into 3 parts those are whole dragon fruit (meat and fruit), fruit flesh, and fruit skin. The fruit for the extraction was crushed using knife to reduce the size. Extraction was carried out by boiling at a temperature of 98°C for 30 minutes using water as solvent with ratio of red dragon fruit and water was 1:3. The filtrate extracted was filtered using a filter cloth to obtain a liquid extract. Then concentration and concentrated extract were obtained whole dragon fruit (meat and fruit are used), fruit flesh, and fruit skin. The concentrated extract is dried with a spray dryer which aims to produce a product with a low water content that has a long shelf life, maintain the quality and stability of the extract. The drying of betacyanin extract using spray dryer was the drying of extracts stage from whole dragon fruit, fruit flesh, fruit skin using a spray dryer. The extract was added with maltodextrin (30%) and then dried with a spray dryer. Spray Dryer conditions was set as follows:

- Carrier agent /filler : maltodextrin 30%
- Spray nozzle size: 0.5 mm
- Compressed air pressure: 3 bar
- Feed temperature: 30oC
- Feed flow rate: 22.9 ml / min
- Inlet air temperature: 140 °C, 160 °C, 180 °C.

Analysis of total Betacyanin was carried out using Standard of Betacyanin to create a standard curve. Calibration curves was created as follows, a solution stock was prepared by transferring 0.2g of the
Betacyanin standard to a 10 mL volumetric flask and making up to volume with acidified water (1% acetic acid/water v/v). The concentration of betacyanin was calculated by the extinction coefficient for Betacyanin (ε=60,000). The absorption maxima at 538, the equation used was \[\text{[mg/l]} = \frac{A \times DF \times MW \times 1000}{\varepsilon \times L}\], where A is the absorption, DF is the dilution factor, MW and ε are the molecular weight and extinction coefficient and L the pathlength of the 1-cm cuvette [18] [3].

The concentration of betacyanin pigment in extracts from whole fruit, flesh fruit and skin fruit was determined using a calibration curve. The absorbance of the samples was measured at wavelength of 540 nm using UV-Vis Thermo Scientific Evolution 201 spectrophotometer. The linear equation derived from the calibration curve was used to determine the concentration of the pigment extraction from whole dragon fruit, fruit flesh, and fruit skin of red dragon fruit. The absorbance obtained by spectrophotometric measurements was included in the linear equation of the standard curve so that the concentration of the sample solution in mg / 10 ml is obtained.

3. Result and Discussion

3.1. Pigment powder extract appearance of red dragon fruit

The natural dye extraction process has been carried out with water as solvents (aquadest). The treatment consisted whole dragon fruit, fruit flesh, and fruit skin. Each of them was cut into small pieces, then crushed using blender, and added with water (ratio of 1: 3) respectively. Each of treatment were filtered with filter clothes then added with maltodextrin (30%) and dried with spray dryer. Process condition of spray dryer was carried out at varying of inlet temperature: 140°C, 160°C and 180°C. This operating condition was setup to know the effect of the inlet temperature toward the betacyanin content which gave purplish red pigment in red dragon fruit. Pigment powder extract from red dragon fruit dried using spray dryer can be seen in Figure 1.

![Figure 1. Pigment powder extract from red dragon using spray dryer](image)

From Figure 1, it can be seen that the results of the extraction of whole fruit and flesh of the dragon fruit were more concentrated (more purple visually) compared to the fruit skin (pink). It indicated that the betacyanin contained in whole fruit and fruit flesh are more than fruit skin.
3.2. Total betacyanin in pigment extract from red dragon fruit using spray dryer

Freshly extracted and concentrated of pigmen from red dragon fruit was dried using spray dryer. Due to the nature of food which was sticky and formless, drying techniques to increase the active compound of pigment producing plant become a challenge for researcher [19]. Besides the inlet temperature, the others important parameter of spray dryer was spray angle, outlet temperature, air humidity, residence time, etc [20]. Because the inlet temperature gives significant impact to atomized feed droplets to their wet-bulb temperature [21], this has a direct correlation to the wet-bulb temperature of the surrounding hot air which cause different concentration of pigment recovered.

In this research, there is a variation of inlet temperature treatment in 3 temperature conditions, namely 140, 160 and 180 so that it can be seen the effect of inlet temperature on the content of betacyanin in natural dye extracts from dragon fruit. Total betacyanin in Powder pigment extract from red dragon fruit were calculated and presented in in Figure 2.

![Figure 2. Total betacyanin in powder pigment extract from whole fruit (BU), fruit flesh (DB), skin fruit (KB) of red dragon fruit](image)

The highest betacyanin concentration is in whole fruit with inlet temperature of 140 °C amounting to 411.80 mg/kg. Betacyanin is water-soluble and therefore suitable when extracted with water. Some studies investigated that the increasing inlet-air temperature more than 200°C caused less pigment recovery [22]. The other studies investigated that the addition of maltodextrin can maintain the anthocyanin and betacyanin [23][24]. The degradation of active compounds during spray drying become main concern in production of natural pigment therefore the inlet temperature must be set at the lower temperature if the wet-bulb temperature surrounding hot air to be reduced [25][26][27]. The trade-off between the aforementioned circumstances is important in deciding an optimal inlet temperature for the spray drying process.
3.3. pH Value at pigment extract from red dragon fruit using spray dryer
The pH value of the red dragon fruit colour pigment powder can also be used as a distinguishing parameter between anthocyanin and betacyanin. According to Harborne [26], Betacyanin also functions as a natural colouring agent in plants, and has properties not susceptible to changes in pH. The results of the pH analysis of dragon fruit natural colouring powder can be seen in Figure 3.

![Figure 3. pH value of whole fruit (BU), fruit flesh (DB), skin fruit (KB) natural colouring powder](image)

From Figure 3 shows that the range of the pH value of the red dragon fruit dye powder is 4.3 to 4.7. This is in line with the optimum pH of betacyanin, which is around 4.6 to 4.7 [27][28][29].

3.4 Effect of pH changes on colour stability
The stability against pH is one of differentiation indicators between betacyanin and anthocyanin. Betacyanin is more stable to pH (the colour does not differ much in a certain pH range) and the red purple will turn yellow when the pH gets higher (base). The results of stability testing for changes in pH can be seen in Figure 4.

![Figure 4. The stability of red dragon fruit colouring extract to changes in pH (pH 1 - 13)](image)
From Figure 4 it can be seen that at pH 1-9, the colour of the solution is relatively the same, namely purplish red, but when the pH reaches 10 the colour of the solution turns yellow. This is in accordance with one of the distinguishing characteristics of anthocyanins and betacyanin is the higher the pH (base), the red colour will turn yellow [26][27][28]. Betacyanin pigments produce pink / pink to red in the pH range of 4-8. These results provide important information for the application of dyes from red dragon fruit in food products and others in the future.

3.5 Water content of dragon fruit natural colouring powder

Water content is a parameter that shows the drying conditions of the colouring powder. The lower the water content, the longer the shelf life will be. The range of water content of the colouring powder of red dragon fruit is 4.3% to 5.1% (Figure 5). The water content is low, so it is expected that with good storage conditions, the shelf life of the colouring powder will be long.

![Water content of dragon fruit natural colouring powder](image)

**Figure 5.** Water content of dragon fruit natural colouring powder

The results showed that the higher the inlet temperature used when drying, the lower the water content obtained both whole fruit, fruit flesh and skin fruit of red dragon fruit pigment extract (figure 5). The others studies observe that maltodextrin in high quantity can result better stability of powder [30][31][32]. Reducing reactant mobility and moisture content might be the reason of these. Other research show that higher inlet temperature results low water content and hygroscopicity, and high solubility and stable colour [33].

4. Conclusion

According to this research, inlet temperature of the spray dryer has an effect on the content of betacyanin, pH and water content of the natural dyes of the red dragon fruit. The highest concentration of betacyanin in whole fruit with an inlet temperature amount of 140° C.
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