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Effect of Maltodextrin Concentration on Anthocyanin Content and Antioxidant Activity of Rukem Fruits Extract Powder

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ABSTRACT

Rukem (Flacourtia rukam Zoll. & Mor.) is an Indonesian tropical fruit with purple peel indicating anthocyanin content; therefore, the fruit can be a potential source of natural colorant. However, anthocyanins are commonly unstable and reactive towards temperature, light, and oxygen. For this reason, encapsulation process is an attempt to improve its stability. The aim of this research was to determine the most efficient concentration of maltodextrin to coat the anthocyanins in rukem fruit, considering the total anthocyanin and antioxidant activity. The fruit was extracted with several concentrations of citric acid 0.5, 1, 2, 3, 4, 5 % (b/v), and the optimal concentration was used to extract the anthocyanin. The extract was then mixed with maltodextrin at following concentrations: 40, 50, 60, 70, and 80% (w/v). The mixture was homogenized, then spray-dried with spray dryer Lab Plant SD-05, Keison, UK. The dried samples were analyzed for chemical (moisture, ash, pH, anthocyanin, antioxidant activity) and color (L, a*, b*) properties. The results showed that 5% citric acid and 40% maltodextrin (w/v) gave the most efficient yield of extraction, and the best effects on anthocyanins powder, resulting in the highest antioxidant activity (74.28± 0.41%), total anthocyanins (3.96±0.08 mg/100 g), encapsulation efficiency (19.26±0.41%) and color values of L* 87.46±0.07; a* 16.21±0.09, and b* -1.60±0.02.*

Keywords: *anthocyanin, antioxidant, maltodextrin, encapsulation, rukem fruit*

INTRODUCTION

Color is an important product attribute for consumers and significantly determines its acceptance. For centuries, natural dyes have been used as coloring agent, but their use is hindered by low stability and complex preparation. This has sparked the idea of synthetic colorant production. Although synthetic color agent is preferable due to its bright and broad variation compared with the natural colorant, its use is linked to deleterious impacts to human health such as carcinogenic and poisoning (Ardila-Leal *et al.,* 2021). Based on this reason, the aim of this research was to develop natural colorant from Indonesian fruit such as rukem, an exotic tropical fruit of Southeast Asia, that contains high antioxidant activity and flavonoids content including anthocyanin.

One hundred gram of rukem (*Flacourtia rukem Zoll. & Moritzi*) contains flavonoids 9.22-11.19 mg and polyphenols 73.31-78.74 mg. Besides, the fruit is reported to contain monogalactosyl-diacylglycerols, *β*-sitosteryl-3*β*-glucopyranoside-6*β*O-fatty acid esters, *β*-sitosterol; triacylglycerols, steroid glycosides, saponin, tanin, alkaloids, and chlorophyll a. The antioxidant activity of rukem was 83.30-84.00% (Barcelo and Chua-Barcelo, 2015; Ragasa *et al.,* 2016), determined by DPPH assay.

Antioxidant effects of anthocyanins in food has been well known, inspiring its numerous applications in nutraceutical products and traditional medicine. It has been used as a phytopharmaceutical and treatments of cardiovascular disease, anticancer effect, diabetic disease, visual health, anti-obesity and antimicrobial (Khoo *et al.,* 2017). Furthermore, previous works explained that anthocyanins showed potential as nutraceutical or pharmaceutical, because of their bioavailability.

Anthocyanin stability is highly susceptible to temperature, oxygen, and light; therefore, the treatment is required to increase its stability. Encapsulation is a common method applied to enhance the stability of active compounds, where they are encapsulated with materials that are able to control the exposure of light, moisture and oxygen (Kandansamy and Somasundaram, 2012; Bojana and Marica, 2016). In this case, maltodextrin is used as a coating agent that can protect anthocyanin. The popularity of maltodextrin for coating agent is associated with its low viscosity in high solid content and good solubility in water (Parikh *et al.,* 2014). Salbi *et al*. (2021) stated that maltodextrin has a range of viscosity around 4–6 PaS which fit with the Indonesian standard SNI. Besides, the low particle size of maltodextrin accounts for low density, which makes it highly appro-

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priate to accommodate more inter-particle friction, thus exhibiting the lower range of density of fruits powder. The inter-particle bonding of maltodextrin is weak, while the coherent junction due to the moisture content was lowest, resulting in low tapped density.

To prepare encapsulation, spray-drying technology is required, converting the mixture of active ingredients and coating agents into powder. It can be applied for industrial scale especially food industries (Parikh *et al.,* 2014). The aim of this research was to develop natural colorant from rukem, an Indonesian tropical fruit, based on the anthocyanins content and antioxidants activity.

MATERIALS AND METHOD

Material

Rukem fruits (*Flacourtia rukam zoll &. morr*) were picked from the tree in Satya Wacana Christian University, Salatiga. Maltodextrin (*food grade*) was purchased from a grocery store in Salatiga. Other chemicals including citric acid, HCl, H_2SO_4, NaOH, ethanol, buffer pH 1 and buffer pH 4 (Merck, Germany), *1,1-diphenyl-2-pycrylhydrazil* (Sigma, USA), and distilled water were analytical grade.

Sample preparation

Fresh rukem fruits (2.000 g) were washed using tap water to remove dust, soil, twig, and other contaminants. Furthermore, the samples were crushed using mortar and pestle, and the moisture content of the sample was determined by moisture analyzer (OHAUS, MB25, USA).

Ash content

Ash content of rukem fruits was determined by AOAC (2019) with some modifications. Prior to analysis, dishes and lid was dried in oven (105°C) for approximately 15 min and cooled down in a desiccator. One gram of sample was placed on the weighed dish and combusted in a furnace at 560°C for 3 h. The ash was desiccated, while the lid was partially opened. The final weight of dish was recorded to calculate ash content using the following formula:

$$\%\ \text{Ash} = \frac{\text{weight of ash}}{\text{weight of sample}} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Crude fiber determination

Determination of crude fiber in rukem fruits followed procedure of AOAC (2019) with some modifications. The fruit slurry (1 g) in a 300 mL-Erlenmeyer flask was added with 100 mL of H_2SO_4 0.3 N, then left to cool down for about 30 min, and filtered using filter papers. The mixture was filtered again after added with 50 mL of 1.5 N NaOH. Afterwards, the filter paper containing residue was washed with 50 mL of hot water until the pH of the water was neutral (determined by pH paper test strips). The residue of H_2SO_4 and NaOH was removed from the paper. The paper was washed again with 25 mL of acetone, and dried in oven at 100°C for h, desiccated and weighed. The crude fiber content was calculated using the following formula:

$$\%\ \text{Crude Fiber} = \frac{\text{weight of residue and filter paper - weight of filter paper (g)}}{\text{weight of sample (g)}} \times 100\% \quad \ldots\ldots\ldots\ldots (2)$$

Total anthocyanin content

Total anthocyanin content was determined by pH differential method, referring to Fitriyani *et al.* (2018) with some modifications. Rukem fruit slurry (1.00 g) was macerated with 60 mL of methanol-HCL 1% in a beaker glass in 10°C (cool room) for overnight, then filtered with Whatman (no 1). The filtrate was collected in a 100 mL-volumetric flask, while the residue was re-extracted with same solvents at volumes (20, 20, and 10 mL, respectively). During re-extraction, the beaker glass was shaked for approximately 1 h in an orbital shaker (IKA-KS 501 digital, speed 125, Germany). The filtrate from each extraction process was collected in the volumetric flask. Finally, the volume was adjusted to 100 mL-mark by adding the same solution. Afterwards, the extract was mixed with buffer (pH 1 and 4.5). The absorbance was measured at 510 and 700 nm, and calculated with the following formula:f

$$A = (A_{510}-A_{700})_{ph1}-(A_{510}-A_{700})_{ph4,5} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Lambert Beer Law was used to calculate the total anthocyanin content, with molar extinction coefficient for cyanidin 3- glucoside = 29.600 and molecular weight = 44.8.

Determination of antioxidant activity

The antioxidant activity was determined using DPPH as free radical following the procedure of Amarowicz *et al.* (2000); Mokbel and Hashinaga (2005); Lestario *et al*. (2008); and Lestario *et al*. (2009) with modification. 2 mL DPPH 0.1 mM (dilluted in methanol) was added with 0.1 mL fruit extract, followed by methanol up to 3 mL. The mixture was kept stand at room temperature for 30 min, and the absorbance was measured at λ = 517 nm. Control (Ao) was made with the same procedure with no fruit extract. The antioxidant activity was calculated by comparing the control's and sample's absorbances, as follows:

$$\text{Antioxidant Activity (\%)}=\left(\frac{\text{Ao - A}}{\text{Ao}}\right)\times 100\% \quad \text{……..…. (4)}$$

Ao = Absorbance of control (contains methanol and DPPH); A = Absorbance of sampel (contains methanol, fruit extract, and DPPH).

Optimization of extracted anthocyanin

The determination of anthocyanin was measured by the pH differential method based on Cisilya *et al.* (2017), with some modifications. Rukem fruit (5 g) was macerated in 30 mL of 0.5, 1, 2, 3, 4, and 5% citric acid solution (w/v) for overnight at 10±0.5°C. The extracts were filtered and transferred into a 50 mL volumetric flask. Subsequently, the residue was re-extracted with 20 mL of same concentration of citric acid, using *orbital shaker* (IKA-KS 501 digital, speed 125, Germany) for 30 min. The extracts were filtered again, and collected together in the same volumetric flask. The volume was adjusted to 50 mL. The pH of all extracts were measured using pH meter (Hanna Instruments H198115, Malaysia) and the anthocyanin content were analyzed with pH differential method Fitriyani *et al.* (2018). The highest extracted anthocyanin among various concentration of citric acid was used for anthocyanin extraction from rukem fruit.

Extraction anthocyanin of rukem fruit

The anthocyanin in rukem fruit was extracted by using a method of Cisilya *et al.* (2017), with some modifications. Fresh rukem fruit (100 g) was crushed with mortar and pestle, then macerated with 600 mL of citric acid solution 5% (w/v) in a 1000 mL-beaker glass at 4°C for overnight. The filtrate was filtered with Whatman no 1, then the residue was re-extracted with 200, 100, and 100 mL (w/v) of 5% citric acid solution (w/v). Each sequence of maceration was conducted for 30 min. The filtrate was collected, while the volume was adjusted to 1000 mL by adding citric acid solution 5% (w/v).

Preparation and spray drying

The sample preparation and spray-drying process conformed to a method of Cisilya *et al.* (2017) with some modifications. Maltodextrin (40, 50, 60, 70, and 80 g) was mixed with anthocyanin from rukem extract (100 mL), which produced encapsulation with 40, 50, 60, 70, and 80% w/v, and then homogenized with a shaker for 30 min. The mixtures were spray-dried in the Laboratory of Bioindustry, Faculty of Agricultural Technology, Gadjah Mada University using Keison LabPlant SD-05 spray dryer, United Kingdom. The drier was operated as follows: inlet air temperature (T in) 120°C, outlet air temperature (T out) 81°C, and flow rate 300 mL/min.

Chemical and color characterization of rukem powder

The chemical properties of Rukem powder included ash content (AOAC, 2019), moisture content (AOAC, 2019), crude fiber content (AOAC, 2019), anthocyanin content (Fitriyani *et al.*, 2018) with some modifications and antioxidant activity (Lestario *et al.*, 2009). Color of rukem powders was expressed by L^*, a^*, b^* using Chroma-meter (Konica Minolta, CR-400, Japan). L^* value ranged 0 – 100 (brightness at L^* = 100; and darkness at L^* = 0); a^* value with range 0 until -80 represent green color and range 0 until +100 represent red color; b^* value with range 0 until -70 represent blue color and range 0 until +70 represent yellow color (Milovanovic *et al.,* 2020).

Data analysis

Data were analyzed statistically by One-Way ANOVA, and Duncan's Multiple Range test (DMRT) was used to determine differences between concentrations with significance level of $p \leq 0.05$ using SPSS v16 (Rahardjo *et al*., 2020). All measurements were made at triplo, except crude fiber, moisture, and ash content of rukem powder (duplo) due to the limitation of sample.

RESULTS AND DISCUSSION

Chemical profile of rukem fruit

Table 1 exhibits chemical profile and antioxidant activity of rukem fruit. Moisture content of the fruit was lower in comparison with *Flacourtia jangomas* reaching 66.86±1.81%, guava 85.30±2.2%, and mango 85.75±1.24% (Sajib *et al.,* 2014). The high moisture content in these fruits may indicate high perishability (Omolola *et al.*, 2017). Ash content was quite high in comparison with *Flacourtia jangomas* 0.72±0.02%, guava 0.57±0.06%, and mango 85.75± 1.24% (Sajib *et al.,* 2014). The ash content reflects the amount of minerals in sample, as the higher ash content indicated higher mineral content (Lestari *et al.,* 2018). Crude fiber was higher compared to *Flacourtia jangomas* 0.92±0.10%, guava 3.21±0.18%, and mango 2.72±0.09 % (Sajib *et al.,* 2014). Fiber is important source for health since the sufficient intake of this component may cause good effects on human health including laxative control function and lower risk of colon disease (Madhu *et al.,* 2018).

Total anthocyanin of rukem fruits in this research was 120.78±2.19 mg/100 g (Table 1), higher than *Flacourtia inermis,* Roxb, the same family plant. Alakolanga *et al.* (2014) reported that total anthocyanin of *Flacourtia inermis,* Roxb. reached 107.54 mg/100 g. Total anthocyanin of rukem fruit was much higher compared to tomi tomi fruit (*Flacourtia inermis,* Roxb), which might be indicated by the brighter peel. Planting location, soil condition, and light intensity were key variables that markedly affect the chemical properties (Lestario, 2017). The antioxidant activity of rukem fruit was higher compared to dragon fruit 51.35±0.87%, goji berry 65.03±7.79%, and persimmon 66.31±8.97% (Shan *et al.,* 2019). The higher antioxidant activity could correlate with higher anthocyanin content. Platzer *et al.* (2022) reported that the antioxidant activity of anthocyanin strongly correlated with their chemical structure, especially the number of hydroxyl groups, the oxonium ion in the C ring, the hydroxylation, methylation, acylation and glycosylation pattern among others.

Table 1. Chemical characterization of rukem (*Flacourtia rukam Zoll. & Mor*.) fruits

Parameters	Results
Moisture (%)	63.99±1.30
Ash (%)	0.99±0.01
Crude fiber (%)	43.70±1.13
Total anthocyanin (mg/100 g)	120.78±5.98
Antioxidant activity (%)	81.31±0.14

Note: The value is the mean of five replications (with standard deviations)

Rana *et al.* (2018) reported the total anthocyanin content of rukem fruit was 23.18±0.20 mg/100 g (wet basis) and 88.89±1.37 mg/100 g (dry basis). In this research, total anthocyanin content was 120 mg/100 g, higher than Rana *et al.* (2018). This can be caused by several factors, such as the condition of the plants, soil humidity, or weather. Cuesta-Riaño *et al.* (2022) supported this result reporting the content of anthocyanin extracted from different plants in another region. Besides, soil quality and weather conditions (e.g. air temperature, wind, and humidity) may alter the characteristics of the fruit.

Moreover, Liu *et al.* (2020) reported the variation of anthocyanin content in wild and cultivated *Lycium ruthenicum* (LR) in China and Mongolia. The research revealed that environmental factors, such as sun light intensity and humidity, markedly altered anthocyanin content. Anthocyanin content of LR *Lycium ruthenicum* (LR) fruit increased with higher altitude, which provided a proper condition for production of seconddary metabolites. Like geographic position, other factors, *i.e.*, temperature and humidity, also had a special influence on the germination momentum of LR, which further explained the natural distribution of LR plants and the adaptability of these species to alpine cold and arid situations. Furthermore, the anthocyanin content of LR fruit was affected by the intensity of sun light. The more sun exposure is responsible for higher anthocyanin content in the fruit.

Extracted anthocyanin

The extracted anthocyanin of rukem fruit using 5% citric acid reached 34.40 mg/100 g, much higher compared to Rana *et al.* (2018) using 3% tartaric acid reaching 8.19 mg/100 g. In addition, citric acid improved the stability of anthocyanin in rukem fruit. Citric acid is a weak acid, meaning that its use could minimize degradation of anthocyanin (Amalia *et al.,* 2013). Table 2 and Figure 1 showed the higher concentration of citric acid, the higher the extracted anthocyanin, from 5.06 mg/100 g on 0.5% citric acid to 34.40 mg/100 g on 5% citric acid. The higher concentration of citric acid, the lower the pH, from 3.1 on 0.5% citric acid to 2.5 on 5% citric acid. Thus, the highest citric acid concentration yielded the highest extracted anthocyanin content and the lowest pH.

Table 2. The effect of citric acid concentrations on the extracted anthocyanin and pH of rukem fruit extracts (*Flacourtia rukam Zoll. & Mor*.)

Citric Acid Concentration (%)	Extracted Anthocyanin (mg/100 g dry weight)	pH
0.5	5.06±0.057[a]	3.1±0.000[a]
1	6.10±0.097[b]	3.1±0.000[a]
2	16.48±0.167[c]	2.7±0.000[a]
3	17.26±0.053[d]	2.6±0.000[a]
4	20.72±0.110[e]	2.6±0.000[a]
5	34.30±0.098[f]	2.5±0.000[a]

Note: The value is the mean of five replications with standard deviation. Mean with different alphabets in the same column indicate significant differences (p<0.05)

Anthocyanins are soluble in water and more stable at low pH, because the flavylium cation can be formed easily (Mattioli *et al.,* 2020). At a low pH (pH <3.0), anthocyanidins became red due to flavylium cations formation at low pH (Mattioli *et al.,* 2020; Khoo *et al.,* 2017). The effect of the citric acid concentration on the color of extracted of rukem fruit could be seen in Figure 2. The result showed that the higher concentration of citric acid, the extract become more pink, because of the higher the formation of flavylium cations. The concentration of citric acid solution influenced the anthocyanin content of the rukem extract, that lowered the pH and increased the total antho-cyanin content of the extract (Table 2).

The higher citric acid concentration rose total anthocyanin content and declined pH level. These could be explained by the fact that in acid condition (pH <3.0), anthocyanin of rukem fruit formed red extract due to form flavylium cations. When the pH was above 3, water concentration decreased, and subsequently increased the rate of deprotonation of the flavylium cation. As a consequence, color stability was declined.

At higher pH, chalcone structures are formed, contributing to pale yellow color (Khoo *et al.,* 2017). As depicted in Figure 2, the extract from citric acid 0.5% had pale yellow color. The pH of citric acid solution was 3.1, remarkably affecting the anthocyanin stability. Hence, the extract appeared yellow pale due to the formation of chalcone which could produce red color at pH 2.5.

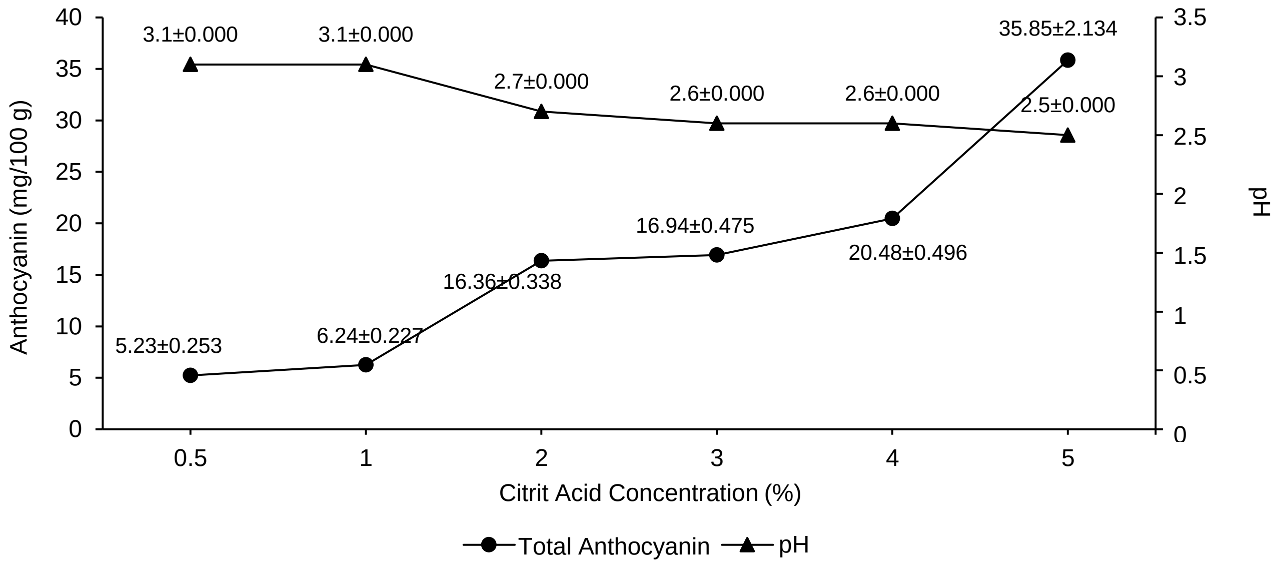
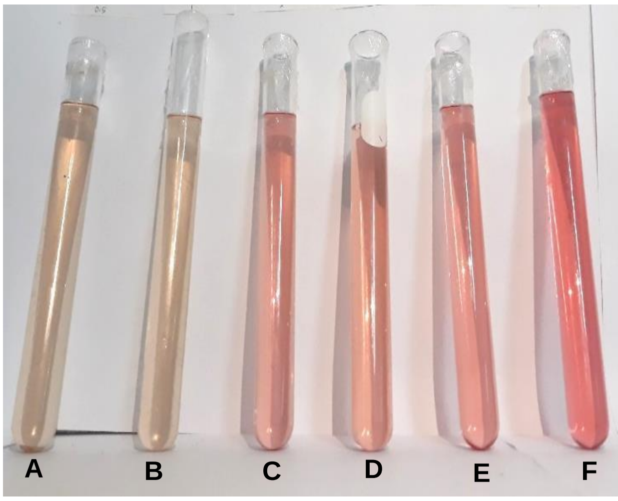


Figure 1. Effect of several concentrations of citric acid on extracted anthocyanin and their pH



Note: Citric acid concentration A= 0.5%; B= 1%; C= 2%; D= 3%; E= 4%; and F= 5%

Figure 2. Influence of citric acid concentration on the the color of rukem fruit extract

This is in line with the result of Mattioli *et al*. (2020), revealing that color of anthocyanin was affected by pH. At pH <3, anthocyanin represented by flavylium cations occurred as red–orange color. Furthermore, at pH 6-7, the extract color shifted from pale yellow to violet. In the case of cyanidin, extra hydroxyl groups in rings A and C can provide facilitate oxidant scavenging and radical delocalization. Positions 3, 5, and 7 of cyanidin oxidized and formed pseudosemiquinone, delocalizing electrons by chromenylium (rings A, C) and stabilizing the formed radicals. These species can be oxidized to give rise to 3.5 or 3.7 pseudoquinonic structures, subsequently isomerizing via keto-enol tautomerism.

Proximate composition of rukem powder

Table 3 exhibits the content of ash, moisture, and crude fiber in rukem powder. Results showed that the lowest moisture content was achieved in samples with maltodextrin 40%, while the highest was found in samples prepared by maltodextrin 80%. It could be seen that the higher concentration of maltodextrin would have the higher moisture content on rukem powder because maltodextrin was high soluble in water; hence, the rising proportion of maltodextrin would increase moisture content of rukem powder samples.

Saavedra-Leos *et al.* (2015) reported that maltodextrin was soluble and dispersible in water. Furthermore, the low addition of maltodextrin could decrease the moisture content (Caliskan *et al.,* 2016). The results revealed that the treatments significantly affected ash content of rukem powder. It could be seen that higher concentration of maltodextrin would result in lower ash content. The highest ash content was achieved in maltodextrin concentration of 40%. Higher ash content correlated with higher mineral content (Lestari *et al.,* 2018).

It also correlated with DMRT results on the maltodextrin concentration. This could be explained by the fact that the moisture content of rukem powder 40% was the lowest. The low moisture content of rukem powder could indicate low mineral content. Higher maltodextrin concentration on rukem powder could indicate the maltodextrin bonded with wasted solvent. Hence, when the process reached the half-ash stage, the content had been dissolved with water.

Furthermore, higher concentration of maltodextrin resulted in the higher crude fiber content, with the highest achieved at maltodextrin 80%. It could be explained because adding the maltodextrin (considered as resistant maltodextrin) would affect crude fiber content. Notably, maltodextrin is made from starch which is one contributor of high crude fiber content. Starch is a carbohydrate that consist of a large number of glucose units linked by glycosidic bonds (Parikh *et al.,* 2014).

Color, total anthocyanin, encapsulation efficiency (%) and antioxidant activity (%) of rukem powder

The highest total anthocyanin of rukem powder was 3.963±0.083 mg/100 g dry weight with the efficiency reaching up to 19.26±0.41%. In this present work, more maltodextrin declined total anthocyanin content, suggesting that the level of maltodextrin negatively correlated anthocyanin content.

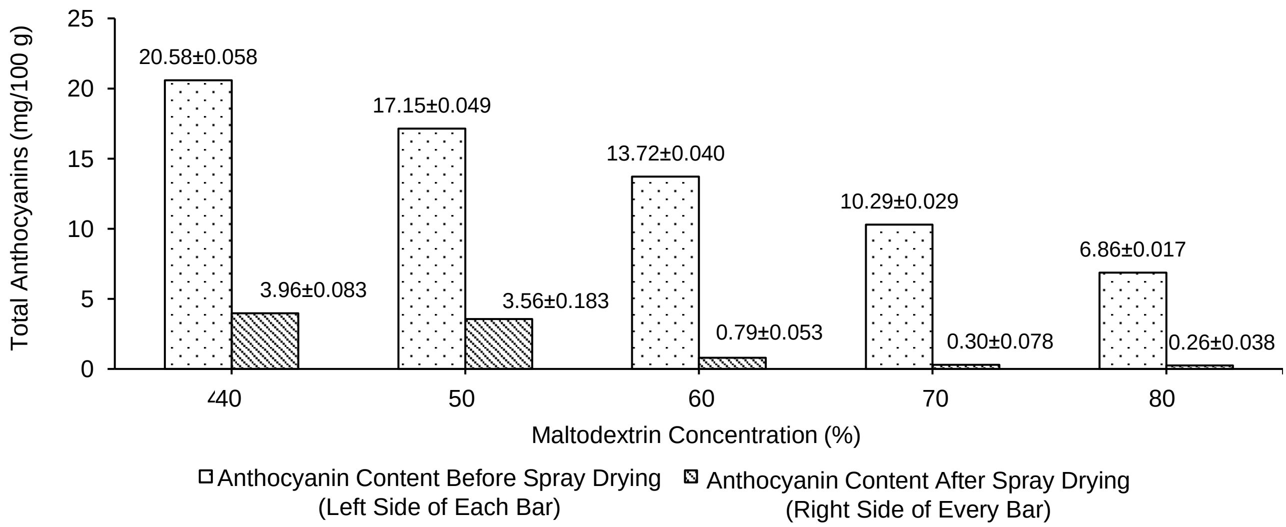
Samples with high level of maltodextrin had thicker wall, which make anthocyanin difficult to overlay. The higher viscosity of wall material led to a denser system in order to insert anthocyanin into the wall material (Mattioli *et al*., 2020). According to Narayanan *et al*. (2018), the higher concentration of maltodextrin decreased the content of anthocyanin powder on the Amaranthus extract. This occurred since Amaranthus extract was not perfectly coated. The coating is insufficient to protect the compound against heating during spray-drying process, leading to significant loss. Based on national standard (BSN, 1995), the moisture content of food colorant powder ranged 4.5 and 5%. This is important to note that moisture content of food is commonly associated with its resilience, grade, and arrangement that could influence the storage, packaging, and processing of the food (Yamashita *et al.,* 2017).

This research showed that the degradation of anthocyanin ranged from 80.76 to 96.21% (Table 4). The loss is caused by improper coating process and over-heating of spray drying. In this work, spray-dryer was operated at 120°C, which was responsible for the massive degradation of rukem powder. The most severe degradation occurred in samples prepared by maltodextrin 80%, corresponding to 96.21% loss; conversely, the lowest was found in samples prepared by maltodextrin 40%, resulting in 80.76% loss. This suggests that optimum level of maltodextrin is a crucial factor as it determines the heat resistance of anthocyanin, with respect to the susceptibility of the colored pigment to heat exposure. According to Mattiolli *et al*. (2020), with the highest temperature, the total anthocyanin was at the lowest level. Under these circumstances, anthocyanin was sensitive to high temperatures (Figure 3). Therefore, slower drying could also cause a bad effect on anthocyanin content because of hydration and other reactions (de Barros Fernandes *et al.*, 2013).

Table 3. The effect of maltodextrin concentration on moisture content, ash content, and crude fiber content of rukem powder (*Flacourtia rukam Zoll. & Mor*.)

Maltodextrins Concentration (%)	Moisture Content (%)	Ash Content (%)	Crude Fiber Content (%)
40	4.585±0.035	0.365±0.098[b]	19.915±3.085
50	5.265±0.715	0.085±0.037[a]	23.885±1.115
60	5.415±0.415	0.060±0.064[a]	24.500±4.500
70	5.440±0.390	0.082±0.006[a]	24.960±0.960
80	6.540±0.060	0.045±0.035[a]	23.265±0.265

Note: The value is the mean of the three replications (triplicate) with standard deviation. Mean with different alphabets in the same column indicated significant differences (p<0.05)



Note: The value is the mean of the three replications, with standard deviations

Figure 3. Total anthocyanin content of rukem powder before and after spray drying (three replications)

Chemically, Priyanti (2018) identified anthocyanin of rukem fruit using Thin Layer Chromatography, including cyanidin 3 glucosides and delphinidin 3-glucosides. The identification of anthocyanin was reinforced with spectrophotometers at λ_{max} 530 nm, confirming the presence of cyanidin 3-glucosides. The anthocyanin color of cyanidin was orange-red, while delphinidin was blue-red, as reported by Mattioli *et al*. (2020).

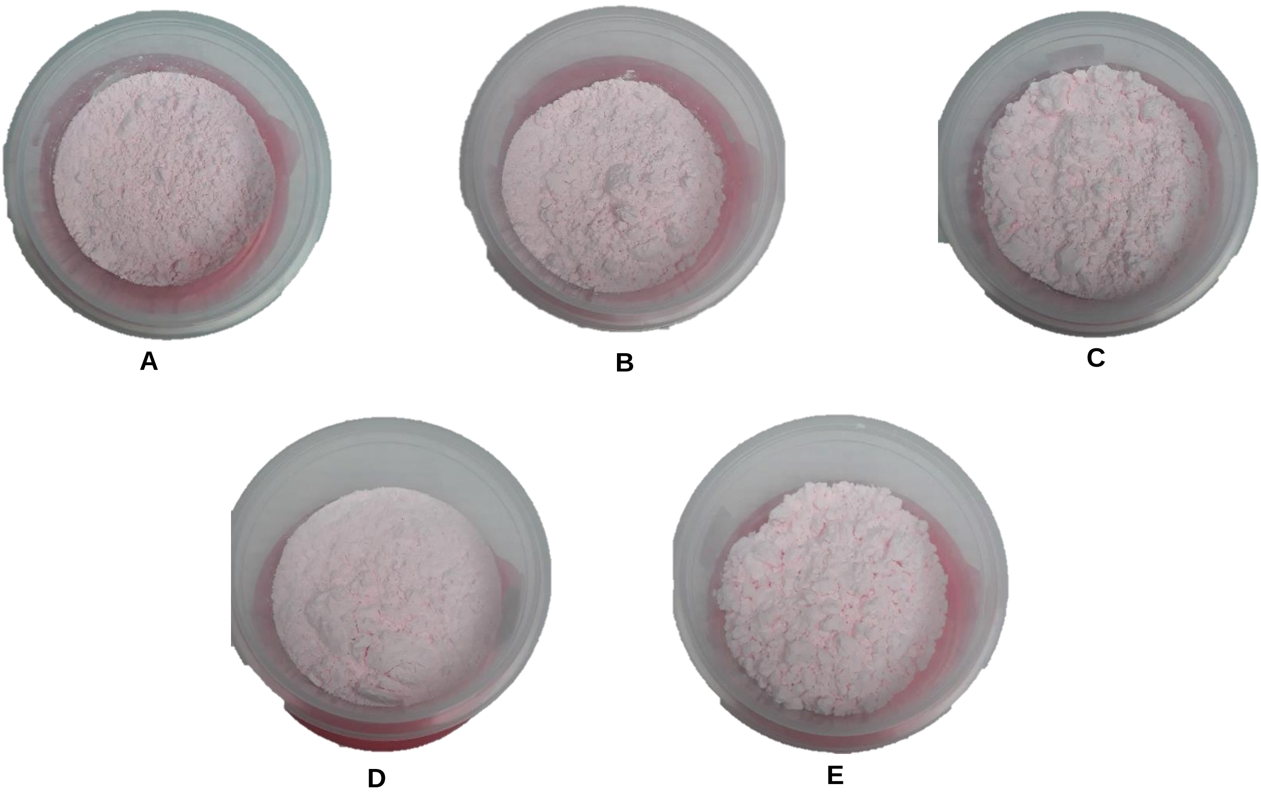
The color of the rukem powder is pink, as seen in Figure 4, indicating that there was cyanidin in the powder. With the low content of total anthocyanin, the red color is less superior to pink. It was associated with the ability of maltodextrin to coat anthocyanin. These results related to the measurement of the chromameter (Table 5).

The higher value of a+ indicates a red level of rukem powder while the lower value of a- indicates the green color was generated. The higher L value indicates the powder has white color. As shown in Table 5, the higher concentration of maltodextrin resulted in the lower value of redness and the higher value of L.

Table 4. Total anthocyanin content before and after spray drying, encapsulation efficiency, and antioxidant activity of rukem fruit (*Flacourtia rukam Zoll. & Mor*.) extracts and powder on various concentrations (40, 50, 60, 70 dan 80% mg/100 g) of maltodextrin

Maltodextrin Concentration (%)	Anthocyanin Before Spray Dry (mg/100 g dry weight ± SD)	Total Anthocyanin After Spray Dry (mg/100 g dw)	Encapsulation Efficiency (%)	Antioxidant Activity (%)
40	20.58±0,058^{e}	3.963±0.083^{d}	19.26±0.41^{d}	74.277±0.410^{d}
50	17.15±0.049^{d}	3.563±0.183^{c}	20.75±1.84^{d}	68.301±2.152^{c}
60	13.72±0.040^{c}	0.790±0.053^{b}	5.76±0.67^{b}	16.716±0.053^{b}
70	10.29±0.029^{b}	0.300±0.078^{a}	2.92±1.30^{a}	14.206±1.079^{b}
80	6.86±0.017^{a}	0.257±0.038^{a}	3.79±0.95^{ab}	5.405±0.573^{a}

Note: The value is mean of three replications (triplicate) with standard deviation. Mean with different alphabets in the same column showed significant differences (p<0.05)



Note: Maltodextrin A= 40%; B= 50%; C= 60%; D= 70%; E= 80%. The higher the concentration of maltodextrin, the lower the color intensity (the pink fades). This occurs due to the decrease of anthocyanin content in higher maltodextrin concentration (Table 4)

Figure 4. Encapsulated f rukem fruit extract on several concentrations of maltodextrin

Table 5. L*, a*, and b* value of rukem powder on several concentrations of maltodextrin (% w/v)

Maltodextrin Concentration (%)	Parameter		
	a*	b*	L*
40	16.21±0.095^{c}	-1.60±0.025^{c}	87.46±0.068^{b}
50	15.84±0.068^{c}	-1.95±0.027^{b}	86.73±0.237^{a}
60	15.16±0.135^{b}	-2.02±0.066^{b}	88.33±0.133^{c}
70	16.16±0.087^{c}	-2.00±0.029^{b}	88.34±0.081^{c}
80	13.16±0.195^{a}	-2.92±0.044^{a}	90.50±0.045^{d}

Note: The value is mean of the two replications (duplicate) with standard deviation. Mean with different alphabets in the same column showed significant differences (p<0.05)

This denotes that the highest total anthocyanin was achieved in samples prepared by maltodextrin 40%, while the lowest corresponded to samples prepared by maltodextrin 80%. The result is in line with a former work (Przybysz *et al.,* 2016), finding that rukem powder with the highest luminescence (L* = 75.13) was attributed to the high proportion of maltodextrin, while the brightest emulsion (L* = 60.39) resulted from the combination of modified starch and maltodextrin. Sample brightness comes from the white color of the carriers, namely modified starch and maltodextrin. Additionally, Yuliawaty and Susanto (2015) reported that maltodextrin tended to be white in color, and when mixed with noni leaf extract (dark green color), the maltodextrin increased sample brightness. In this work, low anthocyanin level contributed to the rise of L value. Regarding b-value, it shows blue color of the rukem powder, which is associated with the delphinidin content. The blue color indicates there was a slight degree of delphinidin resulting from the rukem powder of anthocyanin on rukem fruit.

CONCLUSIONS

Encapsulation efficiency for rukem extract (by citric acid 5%) powder, combined with maltodextrin at 40, 50, 60, 70, and 80% w/v was 19.26±0.41, 20.75±1.84, 5.76±0.67, 2.92±1.30, and 3.79±0.95%, respectively, indicated that the addition of 40% maltodextrin showed the most desirable effects on the quality of rukem capsule with respect to the highest total anthocyanin content and antioxidant activity.

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