

Phycocyanin stability in microcapsules processed by spray drying method using different inlet temperature

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Abstract: Phycocyanin is natural blue colorant which easily damages by heat. The inlet temperature of spray dryer is an important parameter representing the feature of the microcapsules. The aim of this study was to investigate the phycocyanin stability of microcapsules made from *Spirulina* sp with maltodextrin and κ-Carrageenan as the coating material, processed by spray drying method in different inlet temperature. Microcapsules were processed in three various inlet temperature i.e. 90°C, 110°C, and 130°C, respectively. The results indicated that phycocyanin microcapsule with 90°C of inlet temperature produced the highest moisture content, phycocyanin concentration and encapsulation efficiency of 3,5%, 1,729% and 29,623%, respectively. On the other hand, the highest encapsulation yield was produced by 130°C of the inlet temperature of 29,48% and not significantly different with 110°C. The results of Scanning Electron Microscopy (SEM) showed that phycocyanin microcapsules with 110°C of inlet temperature produced the most rounded shape. To sum up, 110°C was the best inlet temperature to phycocyanin microencapsulation by the spray dryer.

Keywords: Inlet temperature, Spray Drying, Phycocyanin, Microcapsules

1. Introduction

Food products usually use color to improve their appearance, promotion, and selling. Several food products are known to contain synthetic food coloring and textile dyes which hazardous for health. Brilliant Blue FCF is the most common synthetic colorant used in food, where its use is mixed with tartrazine [1]. One of the efforts to reduce the using of synthetic coloring is by using safer natural coloring.

Spirulina contains phycocyanin blue pigment [2] which known as an antioxidant, able to reduce oxidative stress [3], free radical [4], and trap nitrate oxide [5]. However, phycocyanin will damage during storage as it sensitive to high humidity, light, temperature, and pH [6,7]. Therefore, phycocyanin is processed into microcapsule by microencapsulation technology.

Microencapsulation is a process that turns liquid into the powder with size around 1-1000 µm [8]. Spray drying is one of the methods used in the microencapsulation process because its equipment is easy to find and the cost is quite affordable. Spray drying is used in several microencapsulation processes [9, 10,11]. Spray drying turns the liquid form into solid (powder) through droplet dispersion from the product in the chamber which is in contact with hot air, where the coating material is added as encapsulating agents [12]. Maltodextrin is a coating material that commonly used because of its ability to protect bio-active compounds [13]. Carrageenan able to form viscous gel and stable [14].



The spray drying condition especially the inlet temperature able to affect the physical characteristic of produced microcapsules [15]. Otherwise, it is also expected to affect the bio-active compounds in microcapsules. The aim of this study was to investigate the effect of inlet temperature to the phycocyanin microcapsule stability which coated with maltodextrin and carrageenan.

2. Methods

2.1. Material

Phycocyanin extracted from *Spirulina* sp. powder (PT. Neoalga, Sukoharjo, Indonesia) [16] with modification. Coating materials maltodextrin DE 10 (CV. Multi Kimia Raya, Semarang, Indonesia) and k-Carrageenan (PT. Selalu Lancar Maju Karya, Jakarta, Indonesia).

2.2. Phycocyanin Microencapsulation

Phycocyanin microencapsulation [10] with modification was performed using homogenization of phycocyanin extract with the ratio 9% maltodextrin:1% k-carrageenan (w/v) toward the phycocyanin extract using homogenizer (Ultraturrax T50 Basic Ika Werke, Germany) at 4500 rpm for 2 minutes. The sample then put into spray dryer (Plant Lab, England) with different inlet temperature: 90°C, 110°C, and 130°C. Microcapsule produced then stored in dark glass bottle and coated with aluminum foil.

2.3. Yield

The microcapsule yield was calculated based on obtained phycocyanin microcapsule divided by total dissolved solid from phycocyanin microparticle solution multiplied by 100% [17,18].

2.4. Moisture Content (%)

Moisture content was measured using the gravimetric method by heating the sample at 105°C for 24 hours. The moisture content percentage was obtained after reaching the constant weight [19].

2.5. Phycocyanin Concentration

Around 40 mg of phycocyanin microcapsule was diluted in 10 ml buffer phosphate pH 7, then homogenized and spectrophotometrically measured at 620 nm.

$$\% \text{ Phycocyanin} = \frac{A_{620} \times (\text{ml solvent})}{3,39 \times (\text{mg sample}) \times \text{sample's dry weight}} \times 100\%$$

3,39 = C-phycocyanin coefficient at 620nm wavelength [20, 10]

2.6. Encapsulation Efficiency/ EF (%)

Encapsulation efficiency calculated based on percent ratio of phycocyanin level before coated and phycocyanin level after microencapsulation process [6].

2.7. Morphology

Phycocyanin microcapsule was observed its morphology by using Scanning Electron Microscopy [21].

2.8. Statistical Analysis

This study using Completely Randomized Design with one factor which is inlet temperature. The data was obtained from assay triplication and analyzed using SPSS 17. The advanced test was performed using Tukey analysis.

3. Results and Discussions

Table 1. Phycocyanin concentration and phycocyanin microcapsule moisture content

| No | Phycocyanin Microcapsule with inlet temperature | Yield (%) | Moisture Content (%) | Phycocyanin Concentration (%) | Encapsulation Efficiency/ EF (%) |
|----|---|---------------------------|----------------------------|-------------------------------------|--|
| 1 | 90°C | 18,240±1,115 ^a | 3,500±0,361 ^b | 1,729±0,041 ^c | 29,623±0,700 ^c |
| 2 | 110°C | 27,700±0,548 ^b | 3,200±0,200 ^{ab} | 1,458±0,050 ^b | 24,963±0,873 ^b |
| 3 | 130°C | 29,480±1,506 ^b | 2,633±0,153 ^a | 1,078±0,047 ^a | 18,457±0,798 ^a |

Note: The data was average of triplication ± Standard deviation

Different superscript on the same column indicates significant different on level α 0,05

3.1. Yield

Phycocyanin microcapsule with maltodextrin-carrageenan as coating materials processed by spray drying method with different inlet temperature produced microcapsule yield. At 90°C of inlet temperature, the lowest phycocyanin microcapsule was produced for about 18,240% and its result was significantly different with the yield processed at 110°C and 130°C. Moreover, microcapsule produced at 110°C and 130°C was not significantly different 27,700% and 29,480%, respectively. This result was similar with Sarabandi et al. [22] that the higher inlet temperature used, the higher microcapsule yield produced.

Carrageenan as coating materials was easy to form gel [23]. At 90°C of Inlet temperature, phycocyanin microcapsule emulsion can't dry perfectly and partly stuck at the spray dryer chamber wall which results in the lower microcapsule yield. Suzihaque et al. [24] stated that the loss of spray drying result due to it stuck at the chamber wall.

3.2. Moisture Content

Moisture content is an important factor on a food product. Moisture content also an important factor to keep the quality of microcapsule. The higher moisture content on microcapsule depends on drying condition especially temperature [19]. The higher inlet temperature will decrease the moisture content of microcapsule [22]. Table 1 showed that the higher inlet temperature used on spray drying process produced a low moisture content of phycocyanin microcapsule. At 90°C of inlet temperature, the moisture content of phycocyanin microcapsule was 3,500% and it was significantly different with phycocyanin microcapsule produced at 130°C. This result was lower compared to Dewi et al. [10] where phycocyanin microcapsule with 80°C of inlet temperature produced 8,36% of moisture content. Inlet temperature produced hot air which able to evaporate the moisture level on the droplet and turn it into powder [25].

3.3. Phycocyanin Concentration

Table 1 showed the phycocyanin concentration on microcapsule where the higher inlet temperature used, the lower phycocyanin microcapsule concentration produced. The decreasing of phycocyanin content due to phycocyanin was susceptible to temperature, where the increasing of temperature able to decrease the phycocyanin content [7]. Phycocyanin microcapsule concentration with 90°C of inlet temperature was 1,729% and this result was significantly different with phycocyanin concentration on phycocyanin microcapsule with higher inlet temperature. This result was lower compared to Dewi et al. [10] that produced 2,83% of phycocyanin concentration at 80°C of inlet temperature.

3.4. Encapsulation Efficiency/ EF (%)

Total phycocyanin which able to encapsulated was showed with encapsulation efficiency [18]. Table 1 showed that phycocyanin microcapsule with higher inlet temperature produces low encapsulation efficiency. Encapsulation efficiency related to phycocyanin concentration. Phycocyanin microcapsule

produced at 90°C of inlet temperature had the highest encapsulation efficiency about 29,623% and it was significantly different with phycocyanin microcapsule with higher inlet temperature. This result was in line with phycocyanin concentration where microcapsule with 90°C of inlet temperature also produced the highest phycocyanin concentration. This showed that low inlet temperature able to maintain the phycocyanin content.

Encapsulation efficiency produced on this research was higher than Dewi et al. [10] please use onlu number as suggested for IOP format that produced 12,89% of encapsulation efficiency. However, this was lower and inversely proportional with Venil et al. [26] please did the same as suggested which perform pigment microencapsulation with carrageenan as the coating materials with 140°C of inlet temperature and produced 2,054% of encapsulation efficiency and keep increasing along with the increasing of inlet temperature until 180°C.

3.5. Morphology

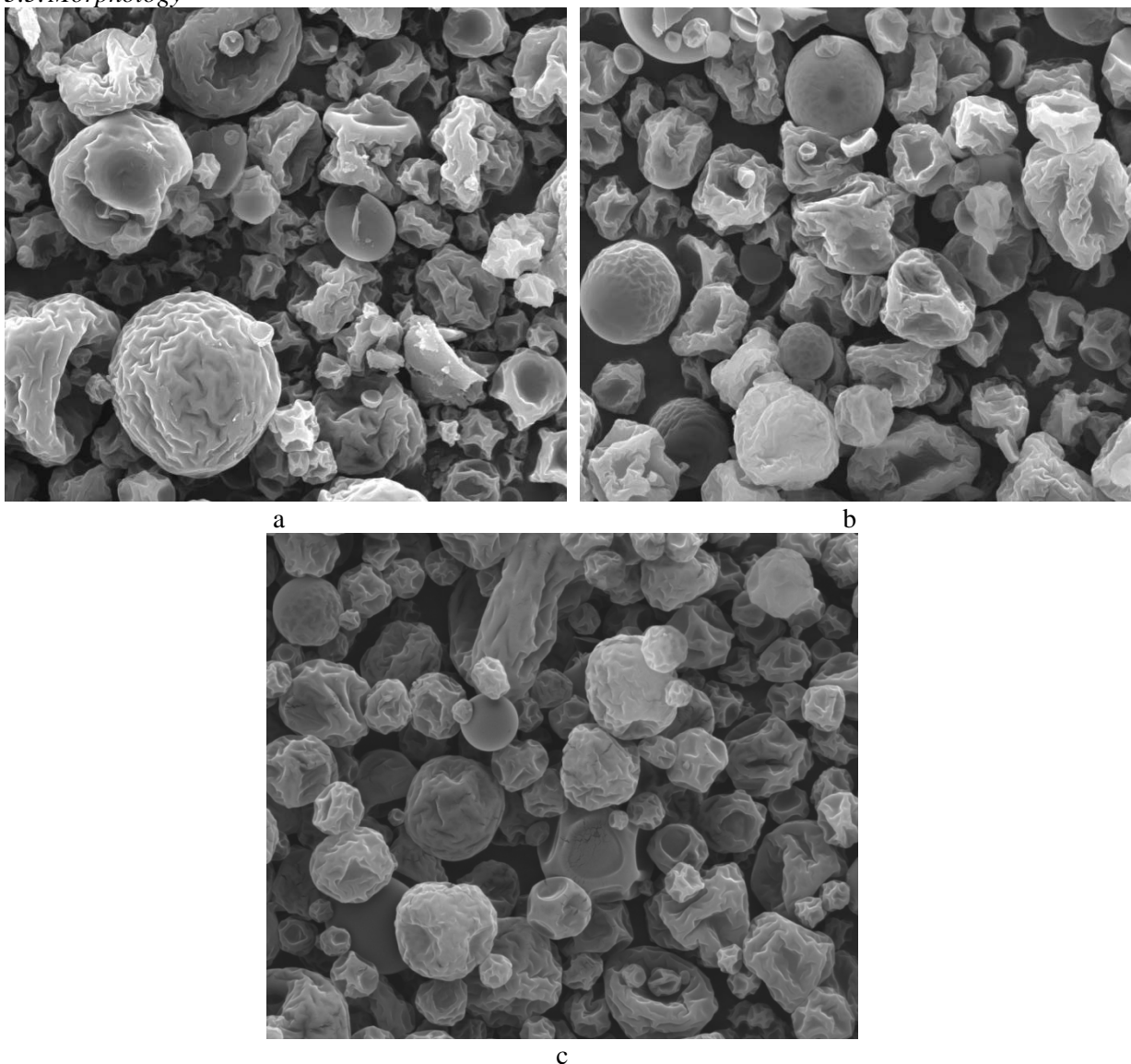


Figure 1. Scanning Electron Microscopy of phycocyanin microcapsule (a) 90°C inlet temperature (b) 110°C inlet temperature (c) 130°C inlet temperature should be mention in main text

Phycocyanin microcapsule was measured using Scanning Electron Microscopy (SEM). Phycocyanin microcapsule SEM images showed in Figure 1. On all SEM images, showed that most of the phycocyanin microcapsule had an irregular shape of microcapsule and cracked. Phycocyanin microcapsule with 110°C and 130°C of inlet temperature, produced more rounded shape than microcapsule with 90°C of inlet temperature. The crack appearance on microcapsule was affected by the liquid evaporation speed on the spray dryer. The similar result also showed by microcapsule produced at 180°C of inlet temperature with different coating materials [26].

4. Conclusion

Phycocyanin microencapsulation with different inlet temperature showed that the higher inlet temperature used, will increase the microcapsule yield, where at 130°C of inlet temperature produced the highest yield about 2,948% and was not significantly different with 110°C of inlet temperature but significantly different with 90°C of inlet temperature. This result was inversely proportional to moisture content, phycocyanin concentration, encapsulation efficiency of 2,633%, 1,078%, and 18,457%, respectively. As can be seen from its morphology, phycocyanin microcapsule at 110°C of inlet temperature produced the most rounded shape. In the end, 110°C was the best inlet temperature to produce phycocyanin microencapsulation by the spray dryer.

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