Effect Of Coating Material Ratio And Spray Dryer Inlet Temperature On The Characteristics Of Butterfly Pea Flower (*Clitoria ternatea* L.) Extract Microcapsules

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Abstract. *Clitoria ternatea* L. commonly known as butterfly pea contain a great variety of bioactive compounds and its flower petals containing anthocyanins thus it has a potential to be a natural food colorant. Butterfly pea flower is still rarely used in food products because the anthocyanins and the other bioactive compounds are unstable and sensitive to pH, temperature, or light. The aim of this research is to retain the anthocyanin compounds of butterfly pea flower extract using microencapsulation. This research is divided into two stages. In the preliminary stage, butterfly pea flower were extracted using ethanol. In the main stage, the butterfly pea flower extract was encapsulated by using different coating material ratio (maltodextrin and Whey Protein Isolate (WPI) with ratio 1:0, 1:1, 0:1) and spray dryer inlet temperature (130, 150, 170°C). The microcapsules were analyzed for its moisture content, powder recovery, anthocyanins content, encapsulation efficiency, phenolics content, solubility, particle size, and color measurement. The result showed that the yield of butterfly pea extract was 17.09%, moisture content 22.58%, anthocyanins content 939.31 mg/L, phenolics content 44.28 mg GAE/g sample, and antioxidant activity IC_{50} 853.74 ppm. From this research, it was found that coating material ratio and spray dryer inlet temperature affect on the characteristics of butterfly pea extract microcapsule. Butterfly pea extract microcapsules which encapsulated using WPI at 150°C gave the greatest result with moisture content 4.65%, powder recovery 50.75%, anthocyanins content 50.10 mg/L, encapsulation efficiency 97.30%, phenolics content 10.65 mg GAE/g sample, solubility 83.67%, particle size 1.22 µm, lightness L* 63.40, hue 211.25°, and antioxidant activity IC_{50} 10058.21 ppm.

Keywords: Anthocyanin, microencapsulation, spray drying.

1 Introduction

Color is one of the factors that has important roles in deciding food product quality and consumer acceptance. Butterfly pea flower (*Clitoria ternatea* L.) is one of the alternatives that can be used as natural colorant. Beside giving an attractive color,

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butterfly pea flower is good for health. The butterfly pea flower has compounds which can be used as antidepressant, antistress, anxiolytic, anticonvulsant, and antioxidant [1]. Anthocyanin, phenolic, and flavonoid content of *Clitoria ternatea* extract were 1.46 mg /g dry extract, 54±0.34 mg GAE/g dry extract, and 11.2±0.33 mg catechin equivalent/g dry extract [2].

Most of the pigments in *Clitoria ternatea* are produced by delphinidin that give lilac-blue color. One of the methods that can be used to extract the anthocyanin from *Clitoria ternatea* is by maceration. Anthocyanin could be usually macerated by using ethanol as a solvent.

Anthocyanin and other bioactive compounds in *Clitoria ternatea* are sensitive to temperature, pH, and light. In order to make the natural colorant become more stable, the interaction between pigments and environment can be reduced by using microencapsulation. The main purpose of microencapsulation is to protect the material core, enhance the stability, prolong the shelf life, and improve the solubility of the product [3]. Coating material that can be used in microencapsulation are maltodextrin, protein, fat, selulose, and gum [4]. Spray drying is the most used method for microencapsulation. Mahdavi *et al.* [3] said that the use of inlet temperature in spray dryer can affect the characteristic of microcapsules.

In this research there will be *Clitoria ternatea* extraction with maceration method that used ethanol 96% as the solvent. The process then continues with microencapsulation to maintain the stability of bioactive compounds in *Clitoria ternatea* extract. Coating material that used for the microencapsulation of *Clitoria ternatea* extract are maltodextrin and Whey Protein Isolate (WPI). The treatment of this research are different coating material ratios and various spray dryer inlet temperature. The best treatment will be determined based on the characteristic of obtained microcapsules.

2 Method

The extraction of *Clitoria ternatea used* Choiriyah (2017) method with some modifications [5]. The butterfly pea flower extraction process begins with taking and sorting fresh petal flowers. After that, the flower was reduced in size by using a blender using ethanol 96% and citric acid 2.5%. Butterfly pea flowers were macerated at room temperature for 24 hours using a shaker. After maceration, the extract was filtered with a vacuum pump then the filtrate was concentrated using a rotary evaporator at 55°C to obtain *Clitoria ternatea* extract.

The microencapsulation used the method of Hamzah *et al.* [6] with some modifications. The coating material (maltodextrin and Whey Protein Isolate (WPI) with 1:0, 1:1 and 0:1 ratio) was dissolved in water. After that, *Clitoria ternatea* extract was mixed with coating material with a ratio of 1:20 which can be seen in Table 1. The mixture was then ultrasonified and then the spray drying is carried out with different spray dryer inlet temperature (130, 150, and 170°C).

The experimental design that used in the main stage is completely randomized design with two factors. The factors are coating material (maltodextrin and WPI with 1:0, 1:1 and 0:1 ratio) and spray dryer inlet temperature (130, 150, and 170°C).

The repetition used is twice. Data which collected will be analyzed statistically with ANOVA using SPSS.

Table 1. Formulation of the solution before microencapsulation

Maltodextrin:WPI	Clitoria ternatea extract (g)	Coating Material		Distilled Water (mL)
		Maltodextrin (g)	WPI (g)	
1:0	0.2	4	0	350
1:1	0.2	2	2	350
0:1	0.2	0	4	350

Analysis used in this research are powder recovery [7], moisture content [8], solubility [9], antioxidant activity [10], color measurement [9], anthocyanin 11], encapsulation efficiency [12], total phenolics [13].

3 Results and Discussion

Characteristic of *Clitoria ternatea* Extract

The result of *Clitoria ternatea* extract analysis was shown in Table 2.

Table 2. Characteristic of *Clitoria ternatea* extract

Parameter	Result
Yield (%)	17.09 ± 0.25
Moisture content (%)	22.58 ± 0.027
Anthocyanin (mg/L)	939.31 ± 5.90
Total phenolics (mg GAE/g sampel)	44.28 ± 0.50
Antioxidant activity (IC_{50}) (ppm)	853.74 ± 50.26

The results showed that the yield extraction of *Clitoria ternatea* was 17.09%. This is in accordance with Suzery *et al*. [14] that stated the yield of roselle flowers ethanolic extract was 17.70%. The moisture content of *Clitoria ternatea* extract obtained in this study was 22.58%. According to Haryani *et al*. [15], the moisture content for thick extract is less than 30%. Therefore, in this study the obtained extract still met the requirements of thick extract.

The anthocyanin content of the *Clitoria ternatea* extract obtained was 939.31 mg/L. Vankar and Srivastava [16] stated that the anthocyanin content of *Clitoria ternatea* methanolic extract with maceration for 2-3 hours was 227.42 mg/kg. This difference in anthocyanin content can be caused by different methods and solvents used.

The total phenolic content of *Clitoria ternatea* extract was 44.28 mg/L. According to Rufino *et al*. [17], samples with phenolic content between 10-50 mg GAE/g are included in the moderate category. According to Chayaratanasin *et al*. [2], *Clitoria ternatea* aqueous extract at 95 °C for 2 hours had a phenolic content of 53 mg GAE/g dry extract. The antioxidant activity of *Clitoria ternatea* extract has an

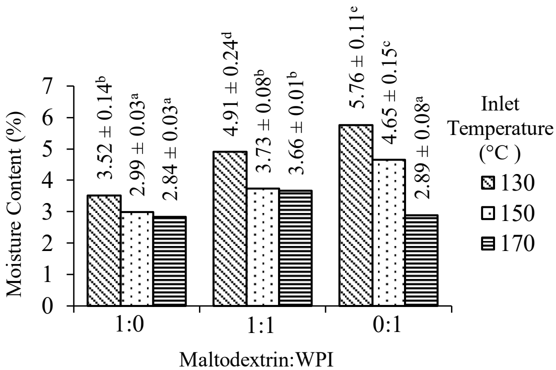
IC_{50} value of 853.74 mg/L. According to Molyneux [18], IC_{50} values of 200-1000 mg/L are included in antioxidants that are less active but still have the potential as antioxidants. Chayaratanasin *et al.* [2] reported that *Clitoria ternatea* extract had an IC_{50} value of 470 mg/L.

Effect Of Coating Material Ratio And Spray Dryer Inlet Temperature On The Characteristics Of Butterfly Pea Flower Extract Microcapsule

In the microencapsulation process, spray drying was carried out from the feed solution containing extracts and coating material. The spray drying process from the feed solution will be operated with 100% aspirator, 35% pump, noozle cleaner 4, and 40 mm flow rate.

Moisture Content

The result of the statistical analysis of the moisture content indicated an interaction between coating material ratio and spray dryer inlet temperature. The result of the moisture content analysis was shown in Figure 1.



Annotation: Different superscript letter shows significance difference ($p \le 0.05$)

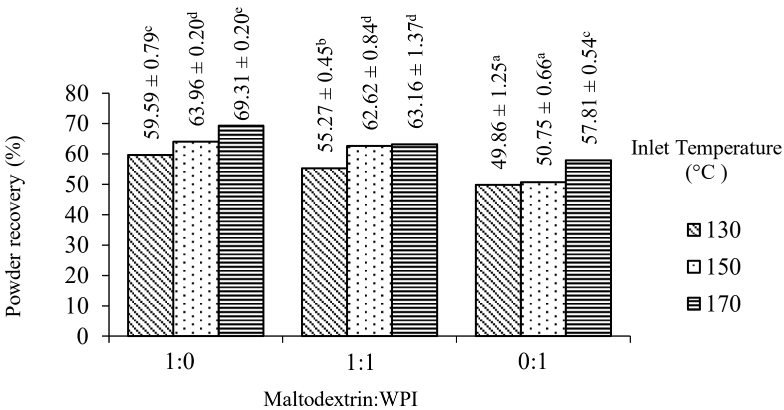
FIGURE 1. The effect of coating material ratio and spray dryer inlet temperature on the moisture content of microcapsules

Based on the results of statistical analysis, it can indicate that coating material ratio and spray dryer inlet temperature have a significant effect on the moisture content of the microcapsules ($p \le 0.05$). Microcapsules with WPI coating material have the highest moisture content while the microcapsules with maltodextrin coating have the lowest moisture content. This result is in accordance with Shi *et al.* [19] that reported microcapsules with maltodextrin coating have lower moisture content than microcapsules with the addition of WPI. This can be caused by maltodextrin that generally has low hygroscopicity so that the obtained microcapsules had occured decreasing of hygroscopicity and produced microcapsules with lower water content.

In addition, it can indicate that the moisture content become lower with the increasing of spray dryer inlet temperature. The microcapsules produced from the spray drying treatment with inlet temperature 130 °C had a higher moisture content than the microcapsules produced from the inlet temperature 170 °C. These results are in accordance with Tonon *et al*. [20] which stated that higher inlet temperature will lower the moisture content. When the inlet temperature is higher, the heat transfer between the product and dry air will be faster so that the evaporation will be even greater.

Powder Recovery

Powder recovery is the ratio of dry weight of microcapsules obtained after spray drying and dry weight of the feed solution before spray drying. Statistical test resulted from powder recovery analysis indicate an interaction between coating material ratio and spray dryer inlet temperature.



Annotation: Different superscript letter shows significance difference ($p \leq 0.05$)

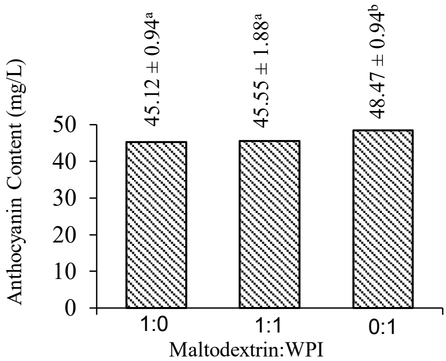
FIGURE 2. The effect of coating material ratio and spray dryer inlet temperature on the powder recovery of microcapsules

Based on the results of statistical tests, it can indicate that coating material ratio and spray dryer inlet temperature have a significant effect on powder recovery ($p \leq 0.05$). Microcapsules with maltodextrin coating material produced higher powder recovery than the microcapsules coated by WPI. This is in accordance with Goula *et al*. [21] who stated that using a certain amount of maltodextrin can prevent the product sticking to the drying chamber therefore can produce a higher recovery in the product.

In addition, it can indicate that the higher the spray dryer inlet temperature the greater the recovery of the powder produced. This result is consistent with Jobbehdar *et al.* [22] who stated that the results of spray drying can be maximized at high inlet temperatures. Suzihaque *et al.* [23] reported that the use of high inlet temperatures can produce more effective heat transfer so that can improve the results obtained.

Total Anthocyanin Content

Based on statistical tests it can indicate that the coating material ratio and spray dryer inlet temperature have a significant effect on the anthocyanin content of the microcapsules ($p \leq 0.05$). The effect of coating material ratio on the anthocyanin content of microcapsule was presented in Figure 3.

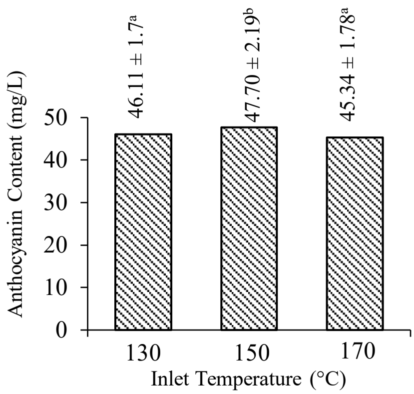


Annotation: Different superscript letter shows significance difference ($p \leq 0.05$)

FIGURE 3. The effect of coating material ratio on the anthocyanin content of microcapsules

Microcapsules with WPI coating material have higher anthocyanin content than microcapsules with a combination of maltodextrin-WPI coatings and single maltodextrin coating. Robert *et al.* [24] stated that pomegranate juice microcapsules with Soy Protein Isolate coating material had a higher anthocyanin content than microcapsules with maltodextrin coating. WPI as coating material has good emulsifying and thermoprotectant properties so that it can protect functional compounds from heat [25]. WPI as coating material has functional properties that can form film layers, form gels, emulsification, and can efficiently bind volatile and nonvolatile components in the matrix [26] while according to Bylaite and Venskutonis [27], one of disadvantages of using carbohydrates as coating material is its small ability to bind volatile components.

The effect of spray dryer inlet temperature on the anthocyanin content of the microcapsules can be shown in Figure 4.



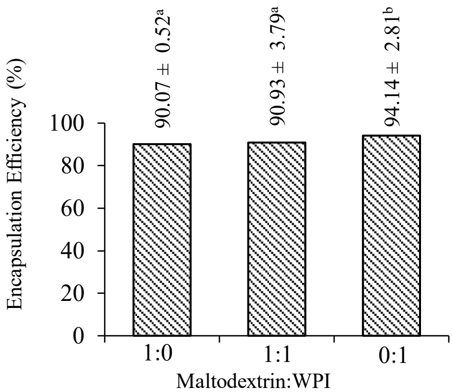
Annotation: Different superscript letter shows significance difference ($p \leq 0.05$)

FIGURE 4. The effect of spray dryer inlet temperature on the anthocyanin content of microcapsules

The results showed that the treatment with spray dryer inlet temperature 150 °C had the highest anthocyanin content and the microcapsules produced from inlet temperature 170 °C had the lowest anthocyanin content. Tonon *et al*. [20] stated that the increase of spray dryer inlet temperature at a certain temperature can degrade the anthocyanin, causing a decrease in the anthocyanin content. In this study, *Clitoria ternatea* extract microcapsules with an inlet temperature 150 °C had a higher anthocyanin content than microcapsules produced by inlet temperature 130 °C. Study of Jimenez *et al*. [28], Ersus and Yurdagel [29] reported that the optimum inlet temperature in anthocyanin microencapsulation which can provide the smallest decrease in anthocyanin degradation is at 140 and 160 °C.

Encapsulation Efficiency

Based on the results of statistical tests regarding the encapsulation efficiency, it can indicate that coating material ratio and spray dryer inlet temperature have a significant effect on the encapsulation efficiency of microcapsules (($p \leq 0.05$).

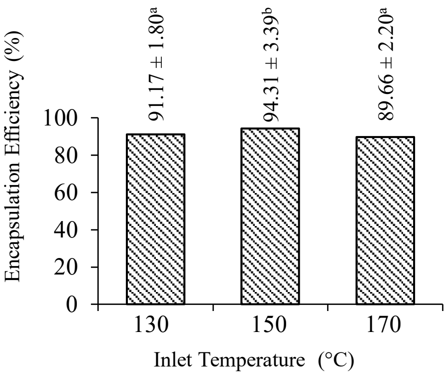


Annotation: Different superscript letter shows significance difference (p≤0.05)

FIGURE 5. The effect of coating material ratio on the encapsulation efficiency of microcapsules

Figure 5 shows that microcapsules with WPI coating material have the highest encapsulation efficiency. The result of encapsulation efficiency is related to the anthocyanin content of microcapsules. The high encapsulation efficiency in the microcapsules coated with WPI showed that WPI can greatly bind anthocyanin. In accordance with Robert *et al.* [24] regarding microencapsulation of anthocyanins from pomegranates, it was stated that pomegranate extract microcapsules coated with Soy Protein Isolate (SPI) had higher encapsulation efficiency than pomegranate extracts coated with maltodextrin. WPI as coating material will migrate to the surface of the particles and will quickly form a thin layer that is rich in protein during the spray drying process [30].

The effect of spray dryer inlet temperature on the encapsulation efficiency of microcapsules can be shown in Figure 6.



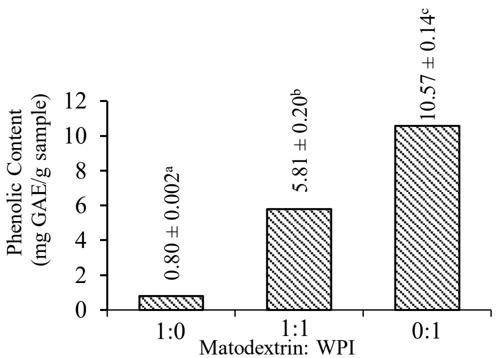
Annotation: Different superscript letter shows significance difference (p≤0.05)

FIGURE 6. The effect of spray dryer inlet temperature on the encapsulation efficiency of microcapsules

The result in Figure 6 showed that the treatment with inlet temperature 150°C has the highest encapsulation efficiency, followed by microcapsules produced with inlet temperature 130°C, and microcapsules with inlet temperature 170 °C have the lowest encapsulation efficiency. This showed that the use of inlet temperatures that are too high can decrease the encapsulation efficiency of the microencapsulation process. Ersus and Yurdagel [29] stated that the use of spray dryer inlet temperature 160°C can bind anthocyanin higher than microcapsules resulting from inlet temperature more than 160 °C. High inlet temperatures can cause excessive evaporation and rifts in the membrane, thereby triggering the release and degradation of core encapsulated material [31].

Total Phenolic Content

The statistical test results of the phenolic content of microcapsules showed that coating material ratio and spray dryer inlet temperature had a significant effect on the phenolic content of the microcapsules ($p \leq 0.05$).

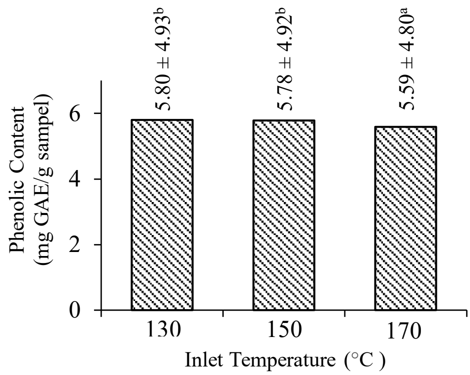


Annotation: Different superscript letter shows significance difference ($p \leq 0.05$)

FIGURE 7. The effect of coating material ratio on the phenolic content of microcapsules

The result in Figure 7 showed that microcapsules with WPI coating material had the highest phenolic content. WPI can interact with phenolic compounds and bind the compounds in the matrix. Robert *et al.* [24] reported that the microcapsules with Soy Protein Isolate (SPI) coatings had a greater total polyphenol than the microcapsules coated with a combination of SPI-maltodextrin. According to Busic *et al.* [32], a good affinity bond between polyphenols and proteins cause the potential for complex formation of polyphenols in order to form a good binding of polyphenols in the system.

The effect of spray dryer inlet temperature on the total phenolic content was shown in Figure 8.



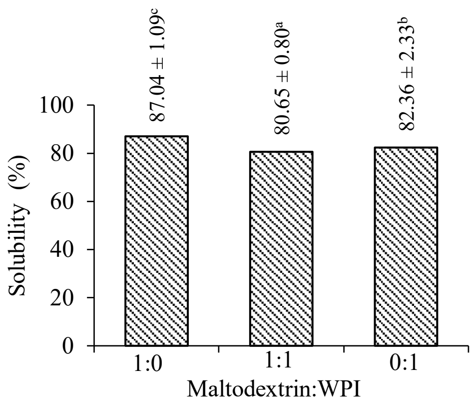
Annotation: Different superscript letter shows significance difference ($p \leq 0.05$)

FIGURE 8. The effect of spray dryer inlet temperature on the phenolic content of microcapsules

Figure 8 showed that the microcapsules produced by inlet temperature 130 °C had a higher phenolic content than microcapsules with inlet temperatures 150 and 170 °C. This showed that an increase in spray dryer inlet temperature can degrade the phenolic content of microcapsules. This result is in accordance with Mishra *et al*. [33] that reported about the encapsulation of amla fruit extract powder where it was found that an increase in spray dryer inlet temperature from 125-175 °C would reduce the phenolic content of microcapsules. The phenolic compounds can be degraded at high temperatures [34].

Solubility

Solubility is a parameter to measure the solubility of microcapsules when dissolved in a solution (water). *Clitoria ternatea* extract microcapsules in this study had solubility ranging from 79.79 to 87.78%. The results obtained are not much different compared to Begum and Deka [9] regarding the anthocyanin microencapsulation of banana bract in which microcapsules coated with maltodextrin have solubility ranging from 82.79 to 87.42%. Based on the results of statistical analysis, it can be shown that coating material ratio and spray dryer inlet temperature have a significant effect on the solubility of microcapsules ($p \leq 0.05$).

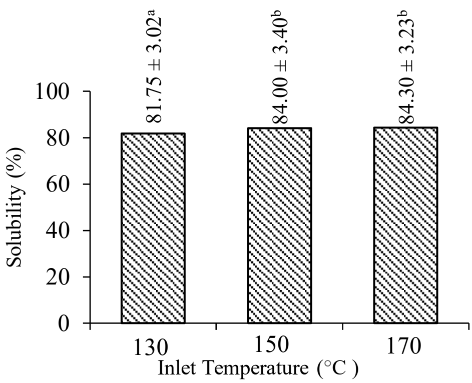


Annotation: Different superscript letter shows significance difference (p≤0.05)

FIGURE 9. The effect of coating material ratio on the solubility of microcapsules

It can be shown in Figure 9 that the microcapsules with maltodextrin coating material have the highest solubility, followed by microcapsules coated with WPI, and the lowest is microcapsules with Maltodextrin-WPI combination coatings. Cano-Chauca *et al.* [35] reported that mango powder coated with maltodextrin had a high solubility which is above 90%. Maltodextrin can increase the solubility of the powder due to its ability to disperse easily in a solution that caused by the presence of hydroxyl group which tends to bind water in the granule [36]. Nevertheless, the use of a combination of coating material between maltodextrin and WPI can reduce the solubility of microcapsules due to microstructural differences that can affect the soluble ability of microcapsules.

The effect of spray dryer inlet temperature on the solubility of microcapsules was shown in Figure 10.



Annotation:Different superscript letter shows significance difference (p≤0.05)

FIGURE 10. The effect of spray dryer inlet temperature on the solubility of microcapsules

It can be seen in Figure 10 that microcapsules with an inlet temperature 130 °C have a lower solubility than microcapsules with an inlet temperature of 150 or 170 °C.

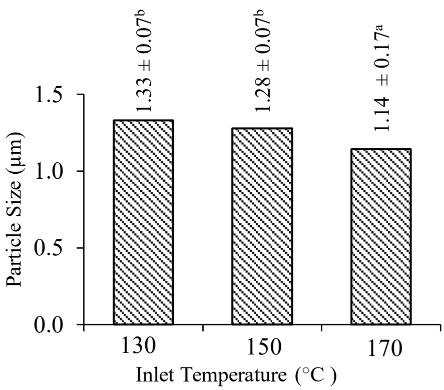
Based on these results it can indicate that the higher the spray dryer inlet temperature, the higher the solubility of the microcapsules. The microcapsules produced from low inlet temperatures have a tendency to clot compared to microcapsules produced from high inlet temperatures [37]. The presence of powder that clots cause the powder to be more difficult to dissolve in water.

Particle Size

The average particle size of microcapsules from this study is around 0.1389 µm. Generally, the powder produced by spray dry has a small particle size (<50 µm) [38]. Based on this theory, it can indicate that the microcapsules produced in this study have particle with micrometer dimensions that match with the size of the powder resulted from spray drying.

The results of the statistical test of particle size indicate that coating material ratio did not have a significant effect on particle size (p> 0.05). Microcapsules with maltodextrin coating material had an average particle size of 1.34 µm, microcapsules coated with a combination of maltodexrin-WPI had an average particle size of 1.21 µm, whereas microcapsules with WPI coating material had an average particle size of 1.20 µm. It can indicate that the treatment of the coating material ratio does not cause a change on the size of the microcapsule particles produced.

The effect of the spray dryer inlet temperature on particle size of microcapsules can be shown in Figure 11.



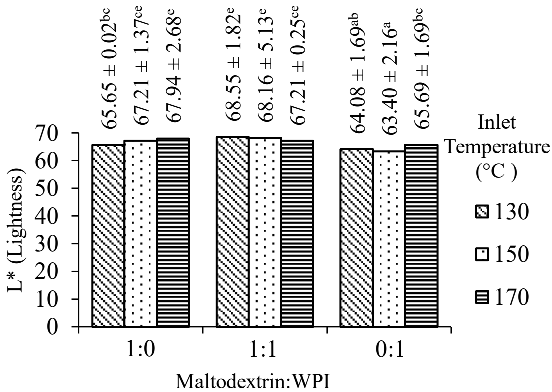
Annotation: Different superscript letter shows significance difference ($p \leq 0.05$)

FIGURE 11. The effect of spray dryer inlet temperature on the particle size of microcapsules

Based on the results of the particle size statistical test it can indicate that the spray dryer inlet temperature has a significant effect on the particle size of microcapsules ($p \leq 0.05$). It can be shown in Figure 11 that the higher the inlet temperature used, the smaller the particle size of the microcapsules. This result is in accordance with Mishra *et al*. (2014) regarding the encapsulation of amla fruit juice in which the particle size of microcapsules will be smaller when the spray dryer inlet temperature increases [33]. The particle size has a tendency to increase when there is a lot of water in the microcapsules. The high temperature of the spray dryer results in a high drying rate will decrease the characteristic of microcapsules such as water content and particle size.

Color Measurement of Microcapsules (L*)

Color measurement L* is used to determine the brightness of the microcapsules. Based on the results of color measurement L* statistical test, it can indicate that coating material ratio has a significant effect on the value of L* microcapsules ($p \leq 0.05$), spray dryer inlet temperature has no significant effect on the value of L* microcapsules ($p > 0.05$), but the interaction between coating material ratio and spray dryer inlet temperature has a significant effect on the L* value.



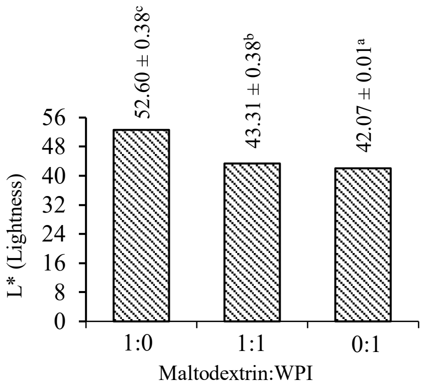
Annotation: Different superscript letter shows significance difference ($p \leq 0.05$)

FIGURE 12. The effect of coating material ratio and spray dryer inlet temperature on the L* of microcapsules

In Figure 12 it can be shown that the microcapsules coated with WPI have a L* value that is lower than the value of L* microcapsules with maltodextrin or maltodextrin-WPI coating material. The greater pigment content would show higher absorbance and lower total reflectance so that it could produce lower L* values [39]. Therefore, it can be stated that the results of L* are related to the content of anthocyanin pigments in which microcapsules with WPI coating material have higher anthocyanin content so that they can produce microcapsules with lower L* values. In addition, based on Figure 12, it can be shown that the value of L* microcapsules with maltodextrin or WPI coating material tends to increase when the spray dryer inlet temperature increases. According to Mishra *et al.* [33], the high value of L* at high inlet temperatures can be caused of the pigment undergoes oxidation resulting in color degradation in the powder produced.

Color Measurement of Microcapsules Dispersion Solution (L*)

The dispersion solution of microcapsules is microcapsule powder dissolved in water. The color measurement of the L* value is used to see the brightness of microcapsules that have been dissolved into the water. The effect of coating material ratio on the L* value of microcapsule dispersion solution can be shown in Figure 13.



Annotation: Different superscript letter shows significance difference ($p \le 0.05$)

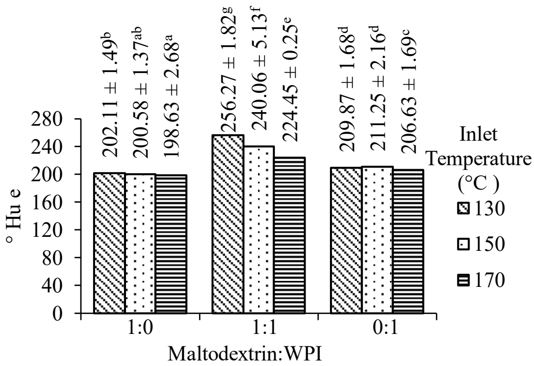
FIGURE 13. The effect of coating material ratio on the L* value of microcapsules dispersion solution

Based on the statistical test of the L* value of microcapsule dispersion solutions, it can indicate that coating material ratio has a significant effect on the value of L* microcapsules ($p \le 0.05$). The microcapsule dispersion solution with WPI coatings has the lowest L* value. Garcia-Estevez *et al.* [40] reported that the low L* value indicates a higher anthocyanin content, while an increase in the L* value indicates a decreasing in anthocyanin content. In accordance with these results, this study found higher anthocyanin content in microcapsules with WPI coating material. Therefore, along with the high anthocyanin content in microcapsules coated with WPI, the anthocyanin content in WPI coating microcapsules dispersion solutions was also higher so that it had a lower L* value.

Color measurement statistical analysis of L* value indicates that spray dryer inlet temperature does not significantly influence the value of L* microcapsule dispersion solution ($p > 0.05$).

Color Measurement of Microcapsules (°Hue)

Based on the statistical test of the hue value of microcapsules, it can be shown that coating material ratio and spray dryer inlet temperature have a significant effect on the value of hue microcapsules ($p \le 0.05$). There is an interaction between the treatment of the coating material ratio and the spray dryer inlet temperature.



Annotation: Different superscript letter shows significance difference ($p \leq 0.05$)

FIGURE 14. The effect of coating material ratio and spray dryer inlet temperature on the °Hue of microcapsules

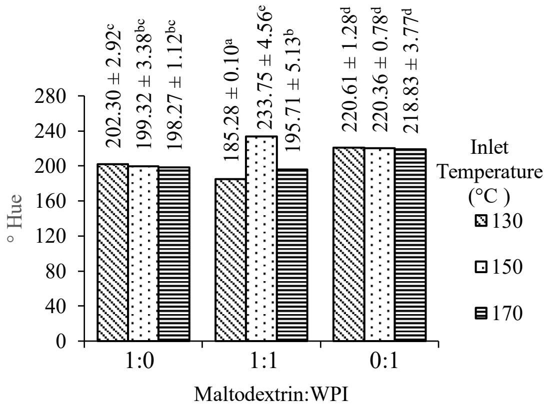
In accordance with the Munsell color system [41], the value of °hue microcapsules produces can be put into two color categories, namely blue green (198-234°), and blue (234-270°). Microcapsules included in the blue green chromatic color range are microcapsules with maltodextrin coating material at inlet temperature 130, 150, and 170 °C, microcapsules with maltodextrin-WPI combination coating at 170 °C, and WPI coating microcapsules at 130, 150 and 170 °C. Microcapsules included in the blue chromatic color range are microcapsules coated with a combination of maltodextrin-WPI at inlet temperatures of 130 °C and 150 °C.

It can be shown in Figure 14 that the use of WPI coating material as a single coating or combination with maltodextrin produces microcapsules with a higher hue value than microcapsules coated with maltodextrin. By applying theory to the research of Quek *et al.* [42], when the hue increases, the color will change to the blue chromatic color range to purple blue. This indicates that the higher the hue there is an increase in blue which indicates more anthocyanin content.

In addition, from Figure 14 it can indicate that the higher the spray dryer inlet temperature, the °hue value decreases. Changes in °hue can occur due to the destruction of pigments at higher temperatures [42].

Color Measurement Microcapsule Dispersion Solution (°Hue)

Based on the statistical analysis of color measurement hue value for the microcapsule dispersion solution, it can be seen that coating material ratio and spray dryer inlet temperature gave a significant effect on the hue value of the microcapsule dispersion solution ($p \leq 0,05$). There is an interaction between the treatment of the coating material ratio and the spray dryer inlet temperature.



Annotation: Different superscript letter shows significance difference (p≤0.05)

FIGURE 15. The effect of coating material ratio and spray dryer inlet temperature on the °Hue of microcapsules dispersion solution

Based on the value of °hue obtained, the colors of microcapsule dispersion solutions can be divided into two categories, namely green and (162-198°), blue green (198-234°). The microcapsule dispersion solution which is included in the green chromatic color range is microcapsules with a combination of Maltodextrin-WPI coating material at 130 °C and 170 ° C, while the microcapsule dispersion solution by coating maltodextrin and WPI at inlet temperatures 130, 150, and 170 °C included in blue green chromatic colors. In Figure 15 it can also be seen that the microcapsule dispersion solution with Whey Protein Isolate coating material has a greater value of hue. Increasing the hue value indicates that the chromatic color will go to blue and purple blue. Anthocyanin from *Clitoria ternatea* has purplish blue so that it can be said that the hue value indicates a higher anthocyanin content.

In addition, in Figure 15 it can indicate that the higher the spray dryer inlet temperature, the hue value tends to decrease. The high inlet temperature of spray dryer can reduce the blue color of the microcapsule dispersion solution. This result can be related to anthocyanin content where anthocyanin degradation can occur at high inlet temperatures. Samber *et al*. [43] stated that temperature can affect the stability of anthocyanins. High temperatures can cause damage to the structure of anthocyanins so that anthocyanin degradation can occur.

Antioxidant Activity

The measurement of antioxidant activity in this study was used as data to determine the functional properties of the microcapsules and statistical analyzes were not carried out. Antioxidant measurements were only carried out on the best microcapsules, which is the microcapsules coated with WPI and inlet temperature 150 °C. Antioxidant activity in *Clitoria ternatea* extract microcapsules produced from WPI coating material and spray dryer inlet temperature 150 °C had an IC_{50} of 10058.21 ppm. According to Xu and Chang [44], environmental conditions such as temperature and light can affect antioxidant activity.

Morphology of Microcapsules

The results of SEM analysis of morphology of microcapsules can be shown in Figure 16

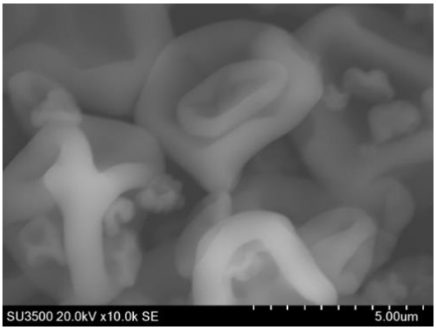


FIGURE 16. Morphology of Microcapsules

Based on Figure 16, it can indicate that the best microcapsules with WPI coating material and inlet temperature of 150°C has a smooth surface and no cracks appear. It can also be shown that there is dents formation on the surface of *Clitoria ternatea* extract microcapsules with WPI coating material. The formation of dents on the surface of microcapsules can be caused by the loss of water in microcapsules due to the high drying rate in the spray drying process [20]. The drying rate will affect the evaporation of water which causes the microcapsules to shrink, causing a dent on the surface of the microcapsules particles produced.

4 Conclusion

Based on the high encapsulation efficiency of the microcapsules produced in this study, it can be concluded that the microencapsulation method can protect the anthocyanin content of *Clitoria ternatea* extract. The treatment of coating material ratio and spray dryer inlet temperature affected the characteristics of *Clitoria ternatea* extract microcapsules, such as moisture content, powder recovery, anthocyanin content, encapsulation efficiency, phenolic content, solubility, particle size and color measurement. The use of maltodextrin coating material can increase the powder recovery and solubility of microcapsules, while the use of WPI can increase the anthocyanin content, encapsulation efficiency, and phenolic content of microcapsules. Increased spray dryer inlet temperature tend to increase powder recovery and solubility, and reduce water content, anthocyanin content, encapsulation efficiency, phenolic content, and particle size of microcapsules. Based on the results, the greatest *Clitoria ternatea* extract microcapsules are microcapsules with WPI coating material and spray dryer inlet temperature 150 °C which has a moisture content of 4.65%, powder recovery of 50.75%, anthocyanin content 50.10 mg/L, efficiency encapsulation 97.30%, phenolic content 10.65 mg GAE/g sample, solubility 83.67%, particle size 1.22 μm, L * 63.40, hue 211.25°, and antioxidant activity IC_{50} 10058.21 ppm.

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