The effect of steaming time and types of cocoa powder on the characteristics of instantized cocoa powder made using batch-type steam jet agglomerator

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Abstract. Cocoa drink is a beverage product made from cocoa powder. However, more effort is needed in its manufacture to dissolve the cocoa powder because the fat content of cocoa powder is quite high. Agglomeration process with steam is one of the methods to produce cocoa powder that dissolves easily in water. This research aimed to examine the effect of cocoa powder, and steaming duration on cocoa drink powder characteristics. Two types of cocoa powder were used, namely C cocoa powder dan P cocoa powder. Five steaming times, namely 1, 2, 3, 4, and 5 minutes were applied. The results showed that types of cocoa powder and steaming duration as well as their interaction influenced the characteristics of instantized cocoa powder. After the agglomeration and drying process, cocoa drink powder exhibited the following physical characteristics: higher solubility value, lower dispersibility value, lower moisture content, lower L* values, higher a* values, lower b* values.

1. Introduction
Nowadays, cold cocoa / chocolate drink is gaining more interest, especially in the tropics. This is supported by the fact that Indonesia is the 7th biggest cocoa producer in the world [1]. In terms of the production, normally, cold cocoa drink is firstly made by dissolving the cocoa powder and other ingredients with hot water. This case occurs because the surface of cocoa powder is hydrophobic [2]. Afterwards, ice cube is added. This way is impractical.

A method has been developed to make the cocoa powder dissolve easily in water. According to Minife [3], some of the common methods that are usually used were the addition of surfactants such as lecithin. This method increases the solubility of cocoa powder. Another method that can be easily used by producer is the use of hot steam [4]. Hot steam can damage the structure of the cocoa powder and causes an agglomeration process so that it can dissolves easily in water.

Agglomeration is the process of combining several primer particles into secondary particles with a greater level of porosity [5-8]. Steam applications are commonly used to enhance instant properties in products such as chocolate drinks, powdered milk for ice cream, and other beverages such as instant coffee and tea. The aim of this research was to investigate the effect cocoa powder and steaming duration on the characteristics of cocoa drink powder. In this study, batch-type steam jet agglomerator was used. Compared to the continuous one, this type is easily used by small scale producers.
2. Materials and methods
This research was conducted at Laboratory of Food and Postharvest Engineering, Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada. The materials used for this research were cocoa powder with different fat content, namely C Cocoa powder (Chockles, Yogyakarta) and P Cocoa powder (ICCRI, Jember). Cocoa powder C has a fat content of 11% while cocoa powder P has a fat content of 27%.

2.1. Material preparation
Prior to the steaming process, cocoa powder was sieved in order to have uniform particle size of ingredient. This process also aimed to minimize the clumping of the material. The steaming time consisted of 5 variations, namely 1, 2, 3, 4, and 5 minutes. The samples were coded as shown in Table 1.

Table 1. Cocoa powder samples

| Cocoa Powder | Time of steaming (minutes) |
|--------------|----------------------------|
| C            | CT1                        |
|              | CT2                        |
|              | CT3                        |
|              | CT4                        |
|              | CT5                        |
| P            | PT1                        |
|              | PT2                        |
|              | PT3                        |
|              | PT4                        |
|              | PT5                        |

2.2. Steaming process
The steaming process was conducted using batch-type steam jet agglomerator. The first thing to do was to fill the chamber with water to a certain level. Thermocouple sensors were set to record the water and steam temperature during the agglomeration process.

The chamber was then heated to produce hot steam as a medium to trigger the agglomeration process. When the steam was produced, the samples were then subjected to the steam with the sample thickness of 2 cm. After 1, 2, 3, 4 or 5 minutes the samples were then dried at 80°C for 8 hours.

2.3. Analytical methods

2.3.1. Moisture content. Moisture content was determined by thermogravimetric method [9]. The basic principle of this method was based on the evaporation of water that occurs in the material by applying drying temperature of 105 °C for 24 hours. The calculation of moisture content is carried out using Equation 1.

\[
\text{Moisture Content % (wb)} = \frac{\text{mass of water (gr)}}{\text{mass of water} + \text{mass of solid part}} \times 100\%
\]  

2.3.2. Color. Color parameter was determined using a Chromameter (Minolta model CR-400) based on the CIE L* a* b* parameters. The L* component shows the brightness of the sample color with a value range of 0 to 100, a* shows the green to red color parameters, and b* shows blue to yellow colors where the range of each coordinate is between -120 to 120 [10,11].

2.3.3. Solubility. Solubility was measured following a method with slight modification Vissotto et al. [12]. A 1 gram of sample was dissolved in 10 ml of distilled water. This process is carried out in a 50 ml beaker using magnetic stirrer. Stirring was done mechanically at 30°C for 5 minutes. Afterward, the solution was put in tubes for centrifugation at speed of 5000 rpm for 15 minutes. The precipitate was dried for 24 hours at a temperature of 105°C. The solubility was then calculated by Equation 2.

\[
\text{Solubility (\%)} = \frac{\text{solids in supernatant (1 gr – the mass of drying solids)}}{\text{solids in solution (1 gr)}} \times 100\%
\]

2.3.4. Dispersibility. The value of dispersibility was determined following a method made by Jinapong et al. [13]. A 1 gram of cocoa powder was put into 10 ml distilled water in 50 ml beaker glass.
Afterwards, the sample was stirred using magnetic stirrer for 15 seconds. The solution was then quickly filtered using a filter pan with 200 mesh size. The solids stayed in the filter pan was dried for 4 hours at ± 105 °C. The dispersibility value was obtained using Equation 3.

\[
\text{Dispersibility} \ (\%) = \frac{\text{dry solids mass (gr)}}{10 \text{ ml aquades} + \text{wet solids mass (gr)}} \times 100\%
\] (3)

2.3.5. Data Analysis. Data analysis was performed using the IBM SPSS version 25.0 software. The analysis used was one-way and two-way analysis of variance (ANOVA) with a significance level of 5%. Homogeneity test was performed with the Levene's test model. A Principal Component Analysis (PCA) test is carried out to visualize the relationship among parameters and samples.

3. Results and discussion

3.1. Characteristics of the ingredients
The characterization of raw materials was aimed to determine whether there was an effect due to the treatments given to samples. The initial characteristics of the ingredients is shown in Table 2.

| Cocoa powder | Moisture content (%) | L*   | a*   | b*   | Solubility | Dispersibility |
|--------------|----------------------|------|------|------|------------|----------------|
| C            | 2.59±1.01            | 31.97±0.51 | 13.80±0.11 | 20.48±0.32 | 30.05±1.58 | 6.63±0.23     |
| P            | 3.56±0.54            | 43.42±0.47 | 14.88±0.11 | 24.66±0.06 | 24.97±1.07 | 6.68±0.02     |

3.2. Relationship between research variables and the characteristics of cocoa drink powder
It can be seen in Table 3 that the effect of cocoa powder and steaming time was more dominant than the interaction of both of them. The interaction effect between cocoa powder and steaming time was only seen on the moisture content, a*, and dispersibility. Cocoa powder and steaming time almost affected all the parameters except on the dispersibility and b* value. This showed that the treatment given to the raw material highly affected the instantized cocoa drink powder.

| Variable of the research | Moisture Content (%db) | L*   | a*   | b*   | Solubility | Dispersibility |
|--------------------------|------------------------|------|------|------|------------|----------------|
| Cocoa Powder (C)         | *                      | *    | *    | *    | *          |                |
| Steaming Time (T)        | *                      | *    | *    | *    |            |                |
| Interaction C x W        | *                      |      |      | *    |            |                |

*Significant at p<0.05

PCA (Principal Component Analysis) was carried out to provide a broad overview of the relationship among variables and parameters. PCA is divided into two categories, the PCA score plot and the PCA loading plot. The relationship among samples is shown in the PCA score plot (Figure 1), while the relationship among parameters is shown in the PCA loading plot (Figure 2). PCA explained more than 82% of the variance in the first two factors, divided into PC 1: 60.5% and PC 2: 21.7%.

It can be seen in Figure 1 that the influence of cocoa powder was shown along PC 1. Cocoa drink powder made from P cocoa powder exhibited higher dispersibility, L, a*, and b* values than cocoa drink powder made from C cocoa powder (Figure 2). These parameters, which were directly proportional to each other, were located at the same cluster. Aside from this, it can be observed in Figure 1 and 2 that
regardless of the types of the cocoa powder, samples made with a longer steaming duration exhibited a higher solubility.

![Figure 1. PCA score plot of instantized cocoa drink powder](image1)

![Figure 2. PCA loading plot of characteristics of cocoa drink powder](image2)

3.3. Moisture content
The ranges of moisture content in the cocoa drink powder are from 0.8 to 3.6% [14]. The use of steam and drying process changes the initial moisture content of cocoa powder [15]. Figure 3 shows that regardless of the types of cocoa powder, moisture content tended to increase as the steaming time increased. Compared to the moisture content of the raw material, the moisture content of the instantized cocoa powder were lower. This phenomenon occurred due to the drying process applied after steaming which easily evaporated the water [16,17].
3.4. Color

3.4.1. L* (Lightness). There are several factors that affect the L* value of cocoa powder, including agglomeration process, composition of ingredients and proportion of ingredients [18]. Figure 4 shows that regardless of the steaming time, cocoa drink powder made from P cocoa powder had propensity to have higher L* values than cocoa drink powder made from C cocoa powder. It showed that fat content influenced the L* value. The higher the fat content, the higher the L* value. On the other hand, it can be seen that regardless of the types of cocoa powder, L* value was not significantly influenced by steaming time (p<0.05).

3.4.2. a* (Redness). Similar to the L* value, regardless of the steaming time, cocoa drink powder made from P cocoa powder tended to have higher a* values than cocoa drink powder made from C cocoa powder that can be seen in Figure 5. On the other hand, it can be also seen that regardless of the types of cocoa powder, a* value was not significantly influenced by steaming time (p<0.05). This showed that the influence of fat content was more pronounced that the influence of steaming time.
3.4.3. \( b^* \) (Yellowness). Similar to the \( L^* \) and \( a^* \) values, regardless of the steaming time, cocoa drink powder made from P cocoa powder tended to have higher \( b^* \) values than cocoa drink powder made from C cocoa powder that can be seen in Figure 6. On the other hand, it can be also seen that regardless of the types of cocoa powder, \( b^* \) value was not significantly influenced by steaming time (p<0.05). This showed that the influence of fat content was higher than the influence of steaming duration.

3.5. Solubility
The solubility value is the number of soluble components of the powder dissolved in the liquid. According to Jinapong et al. [13] the solubility value can be increased by giving steam to the material so that the agglomeration process occurs. The higher the solubility value of one material, the more easily it dissolves in liquid or water [16,17,19]. The results of the solubility test are shown in Figure 7.

It can be seen in Figure 7 that cocoa drink powder made from C and P cocoa powder tended to be comparable. Moreover, it can also be seen that the steaming duration did not give any significant effect (p<0.05). Nevertheless, compared to the initial solubility of the raw material, it can be seen that the solubility values of the cocoa drink powders tended to be higher. This showed that the batch-type steam jet agglomeration could be used to increase the solubility of cocoa drink powder.
Figure 7. Effect of steaming time and cocoa powder on solubility value

3.6. Dispersibility

Dispersibility is the number of insoluble components of powder that distributed uniformly as a single particle throughout a liquid [15,20]. The dispersibility value of cocoa powder is described as one of instantized drink index that simultaneously determined based on the physical factors, namely Uniformity Index (UI) and chemical factors, one of them is water content [13]. The higher the dispersibility value, the more the insoluble solids will be.

Figure 8 shows that the P cocoa powder did not change significantly at p<0.05, while the C cocoa powder tended to decrease. This phenomenon might occur because P cocoa powder contained a higher fat content, resulting in a difficulty of steam to break the structure of the particles. It can be seen in Figure 8 that steaming duration did not significantly affect (p<0.05) the dispersibility value of P cocoa drink powder. However, it can be seen that steaming duration affected the dispersibility value of C cocoa powder drink. The dispersibility value had propensity to decrease as the steaming duration increase.

Figure 8. Effect of steaming time and cocoa powder on dispersibility value

4. Conclusion

According to the research findings, it can be concluded that types of cocoa powder, steaming duration and their interaction influence the characteristics of cocoa drink powder. Moisture content of the cocoa drink powder increased as the steaming duration increased. Cocoa drink powder made from P cocoa powder tended to have higher L*, a*, b* values than cocoa drink powder made from C cocoa powder.
Solubility of the instantized cocoa drink powder was higher than the solubility of raw material. Dispersibility of C cocoa drink powder decreased as the duration of steaming increased.

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