Physical characteristics of instantized cocoa drink formulated with maltodextrin produced using continuous-type steam jet agglomerator

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Abstract. Cocoa drinks are greatly demanded by consumers, considering that Indonesia has a relatively high temperature. The purpose of this study was to examine mathematically, the characteristics of instantized cocoa powder produced using continuous-type steam jet agglomerator with 8 hours drying duration. The variables used in this study were fat content (11, 27%, and a mixture of both) and maltodextrin content (25, 30, 35, and 40%). The results of this study indicated that fat, maltodextrin and their interactions affected the characteristics of instantized cocoa powder. It can be seen from several characteristics that instantized cocoa powder had higher solubility values (40-65%) and lower dispersibility values (3-5%) than those of reference sample, made without “hot” steaming process.

1. Introduction
Cacao is one of the most important Indonesia’s plantation commodities. Indonesia is the 5th largest cocoa producer in the world, based on International Cocoa Organization [1]. This fact supports the development of cocoa-based products, such as chocolate bar, chocolate candy, and cocoa drink. Cocoa/chocolate drink are currently become more popular in Indonesia [2, 3].

The main raw material for making instantized cocoa drink is cocoa powder. Due to its relatively high fat content (10-20%) [4], hot water is commonly used to make cocoa drink with good solubility. This is very impractical, considering that most of consumers prefer to drink cold cocoa drinks, especially during the day. Therefore, after adding hot water, ice cube must be added. Because of this, it is necessary to find a method that can be used to dissolve cocoa powder without using hot water.

One method that can be used to increase the solubility of cocoa powder is by applying hot steam [4, 3]. This process can be carried out by various methods such as fluidized bed agglomeration [5], thermal agglomeration [6], and steam agglomeration [7]. The use of fluidized bed agglomeration has several disadvantages, such as only suitable for middle-large industrial scale, ineffective system, and requires maintenance that is more intensive. Therefore, steam agglomeration is the most effective and simple process due to the easiness of processing and operating conditions.

Based on the fact that consumers also like a thick cocoa drink, therefore, maltodextrin as thickening agent was used in this study. Maltodextrin is capable to dispersing rapidly and has a high solubility [8, 9]. Maltodextrin is also inexpensive to be used as a filler, suitable for small-scale industries [10]. This research aimed to investigate the impact of fat and maltodextrin content and their interactions on
moisture content, color, solubility, and dispersibility of cocoa drink made using a continuous-type steam jet agglomerator.

2. Materials and methods

2.1. Location
This research was conducted at Laboratory of Food and Postharvest Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada, Indonesia.

2.2. Tools and materials
The materials used in this research consisted of cocoa powder with 27% fat content (ICCRI, Jember), cocoa powder with 11% fat content (Chockless, Yogyakarta) and maltodextrin (Intisari, Yogyakarta). Continuous-type steam jet agglomerator was used to produce instantized cocoa drink. Drying oven (Memmert) was used for drying process.

2.3. Preparation and processing of making instantized cocoa drink powder
The cocoa drink powder in this research was produced with three levels of fat content, namely cocoa powder with low fat as much as 11% (C), high fat as much as 27% (P) and medium fat from a mixture of cocoa with low and high fat content (CP). Moreover, four levels of maltodextrin proportion (M) were also used, namely 25, 30, 35, and 40%.

Prior to the steaming process, the two ingredients were mixed and stirred using a mixer for 4 minutes with a stirring speed of 58 rpm [2, 4, 11]. Afterwards, cocoa powder was produced in a continuous-type steam jet agglomerator at a steam temperature of about 80-95°C and a pressure of 1 bar. After steaming process, wet instantized cocoa power was then dried in a circulated air-drying oven at 80°C for 8 hours. The proportion of the ingredients can be seen in Table 1 (100 grams each samples).

| Table 1. Proportion of the ingredients |
|----------------------------------------|
| Cocoa fat content | Maltodextrin content (%) |
| | 25 | 30 | 35 | 40 |
| C | CM25 | CM30 | CM35 | CM40 |
| CP | CPM25 | CPM30 | CPM35 | CPM40 |
| P | PM25 | PM30 | PM35 | PM40 |

2.4. Analytical methods

2.4.1. Solubility. This test was carried out by dissolving 1 gram of cocoa powder in 10 ml of distilled water. The first step was done by putting the cocoa powder into a 100 ml beaker and then pouring 10 ml of distilled water. Hot plate magnetic stirrer was used for uniform stirring, without applying heat (temperature 0°C). Stirring was carried out for 5 minutes, then the solution was put into a tube to be deposited using a centrifuge for 15 minutes at a speed of 5,000 rpm. The precipitate was dried for 24 hours at a temperature of ± 105°C. Solubility was calculated using equation 1 [2-4].

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\text{Solubility (\%) = } \frac{\text{Solids in supernatant (1 gram – the mass of dried solids)}}{\text{Solids in solution (1 gram)}} \times 100\%
\] (1)

2.4.2. Dispersibility. Dispersibility was calculated based on the procedure developed by Jinapong et al. [12] and Sorensen et al. [13] with some modifications. Ten ml of distilled water was put into a 50 ml beaker and 1 gram of cocoa powder was added to the beaker. The stopwatch was started simultaneously with the stirring process using a hot plate magnetic stirrer for 15 seconds. The powder was filtered using a filter pan (mesh size of 212 μm). The solids stayed in the filter pan was dried for 4 hours at ± 105°C. Dispersibility value of powder can be calculated using equation 2.
Dispersibility (%) = \frac{\text{dried solids mass}}{10 \text{ ml aquades} + \text{wet solids mass}} \times 100\% \quad (2)

2.4.3. Water content. The water content of samples was measured using a thermogravimetric method [2]. Samples that had been placed on plates were dried for 24 hours at 105°C. The water content of the chocolate sample can then be calculated using equation 3 [14].

\text{Water Content} (%) = \frac{\text{mass}_{\text{wet}} - \text{mass}_{\text{dried}}}{\text{mass}_{\text{wet}}} \times 100\% \quad (3)

2.4.4. Color. Color of the sample was measured using a colorimeter (Minolta CR-200). The parameters recorded were were L *; a *; b * [2-4,15,17]. The L * (lightness) parameter indicates the brightness of the sample with values of 0 (black) to 100, a * indicates red (+60) to green (-60) and b * indicates yellow (+60) to blue (-60) [2,17].

2.4. Data analysis. Data analysis was performed using IBM SPSS version 25.0 software. One-way and two-way Analysis of Variance (ANOVA) tests were used after the homogeneity test using Levene’s Test was performed. One-way ANOVA was used to see the differences among cocoa drink powder characteristics. The Tukey test was chosen to determine the differences between these samples. Two-way ANOVA was used to determine the effect of the two variables involved. In addition, Principal Component Analysis (PCA) was also used to visualize the relationship among parameters and the relationship among samples. All the analysis was conducted at a significance level of 5%.

3. Results and discussion

3.1. Relationship among research variables and parameters of cocoa drink

It can be seen in Table 2 that water content of cocoa drink powder was only influenced by fat content. Color parameters were influenced by fat, maltodextrin and their interaction. Lightness was used as the main parameter of cocoa drink appearance because it shows the brightness of the product [18]. Solubility was influenced by fat and maltodextrin. Dispersibility was influenced by fat content and interaction between fat and maltodextrin content.

| Parameters                  | Water Content (% wb) | Color | Solubility (%) | Dispersibility (%) |
|-----------------------------|----------------------|-------|----------------|--------------------|
| Fat content (F)             | *                    | *     | *              | *                  |
| Maltodextrin content (M)    |                      | *     | *              |                    |
| Interaction F x M           |                      | *     | *              | *                  |

*) significance on p < 0.05

Principal Component Analysis (PCA) explained more than 88% of the variance in the first 2 factors, namely PC1: 57.4% and PC2: 31.2%. In general, it can be seen in Figure 1 that color parameter was directly proportional to the water content. Solubility had propensity to be inversely correlated with dispersibility, color parameters and water content.

Based on Figure 2, it can be seen that samples with high fat content and high maltodextrin levels (PM40, PM35, and PM30), tended to have a higher solubility values compared to other samples. PM40 also tended to have a higher lightness value. Sample with low fat content and low maltodextrin content such as CM25 had a higher water content than other samples. PM25 exhibited a higher redness values as well as moisture content compared to other samples. Samples with medium fat content, namely CPM25, CPM30, CPM35, CPM40 had a dispersibility values that tended to be higher when compared to the other samples.
3.2. Solubility
Solubility is the ability of particle to dissolve in a solvent or solution at a certain temperature [2, 19]. The solubility increased as the maltodextrin proportion increased (Figure 3). This result was in accordance with previous studies conducted by Diasti et al. [2], Dyaningrum et al. [4] and Lutfiyah et al. [3]. Different superscripts (significance P < 0.05) were obtained for low (C) and medium (CP) fat content of cocoa powder, showing that the samples were significantly different. This increase in solubility value occurs with increasing levels of maltodextrin due to the nature of maltodextrin, which dissolves and disperses quickly.

3.3. Dispersibility
Dispersibility is the ability of agglomerate particles to be dispersed in a solution with minimal stirring. Based on Figure 4, it is known that the dispersibility value tended to decrease as the maltodextrin proportion increased. In contrast to the solubility, the impact of maltodextrin value was only significantly observed (P < 0.05) in cocoa drink powder with high fat content.
3.4. Water content after drying process

It can be seen in Figure 5 that in each level of fat content, the water content of cocoa drink powder was not significantly different (p < 0.05) as the maltodextrin proportion increased. There’s no trend of water content after the drying process. Regardless of the maltodextrin proportion, it can also be seen that cocoa drink powder with high fat content (P) had the highest water content. This phenomenon can be happened due to the presence of more fat, covering the particles, resulting in the difficulties of water evaporation.

3.5. Color

Figure 6, 7, and 8 shows that in general, the L, a*, and b* values of cocoa drink powder containing the highest fat content exhibited the highest L, a*, and b* values. In more detail, Figure 5 shows that the lightness (L) values of the samples were significantly different (p < 0.05%). The L values tended to increase as the maltodextrin proportion increased. No clear trend was observed in a* values.

However, b* values of cocoa drink powder containing the lowest fat content tended to decrease as the proportion of maltodextrin increased. The changes of color parameters in this study might be due to the occurrence of Maillard reaction and caramelization. These processes result in a brownish color [2,3,16,20,21]. Regardless of the maltodextrin content, it can be seen that instantized cocoa drink made of high fat cocoa powder (P), had higher lightness, redness, and yellowness.
4. Conclusion
Fat content and maltodextrin affected the characteristics of cocoa drink powder, to some extent. The solubility and dispersibility values increased with the maltodextrin levels. The higher cocoa fat content, the higher water content, lightness, redness, and yellowness of the samples.

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