Physical characteristic of instanised chocolate beverage powder produced with palm sugar and sucrose as sweeteners

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Abstract. Cold cocoa beverage is one of the derivative products of cacao. It has sweet taste and refreshing sensation which is popular in tropical countries. Sweetener is added mainly to reduce the bitterness of the cocoa powder. Normally, before adding ice cube, hot water is used to dissolve cocoa drink powder. Nevertheless, this method is not efficient. Therefore, a method that can produce cocoa drink powder which can be easily dissolved is required. This study aimed to investigate the impact of palm sugar: sucrose (P:S) proportion and drying duration on the characteristics of cocoa drink powder made using continuous-type steam jet agglomerator.

The result showed that the solubility, bulk and tapped density increased as the proportion of palm sugar and drying duration increased. However, the lightness tended to be comparable and moisture content after drying process decreased as the proportion of palm sugar increased.

1. Introduction
Cocoa is one of the Indonesia’s plantation commodities which has a significant role in the past 20 years [1]. One of the derivative products of cacao is cold chocolate/cocoa beverage. This drink, which is suitable for tropical countries, has sweet, unique flavour and refreshing sensation. In 2017, chocolate/cocoa beverage was the second most consumed beverage in Indonesia after tea [2].

The process of cold chocolate beverage making is still not efficient. People have to use hot water to dissolve cocoa powder and add some ice cube afterwards. If cold water is directly use, the cocoa powder is difficult to dissolve. This can be due to the fact that cocoa powder contains high amount of fat (10%-25%) [3, 4].

There are several solutions to overcome this problem. Some big scale producers use stabilizer [5, 6]. Another way is using high power press machine to take out the fat [7]. These methods are not suitable for small-medium scale producer since they increase the production cost.

Agglomeration process using hot steam is one of the methods which can be used to improve powder’s solubility [5,8,9,10]. In general, agglomeration is a process to increase the particle size of powder. In detail, primary particles are stick to each other, creating big and porous particles [11, 12]. This condition can be achieved by exposing free-falling cocoa powder to hot steam.

In the process of chocolate beverage powder making, sweetener is added to reduce the bitterness of cocoa and improve the overall flavour [13]. In the previous study, sucrose [8] and palm sugar [9] were used as sweetener. Both of researches used different percentages of sugar in cocoa drink powder,
namely 15%, 30% and 45%. The result showed that instanised chocolate beverage powder with 45% of sweetener had the highest solubility [5, 8].

In order to gain a better understanding, in this research, the ratio between cocoa powder and sweetener used was 55% and 45%, respectively. However, the sweetener used in this research was a mixture of sucrose and palm sugar with several proportions. Aside from sugar proportions, drying duration (4,6,8 hours) was also used as research variables. The aim of this study was to investigate the impact of sweetener and drying duration on solubility and appearance of instanised chocolate beverage powder produced using continuous steam jet agglomerator.

2. Materials and methods

2.1. Research location
This research was conducted at Laboratory of Food and Postharvest Engineering, Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia.

2.2. Tools and materials

2.2.1. Tools. A continuous-type steam jet agglomerator was used in this research. Drying oven (Memmert) was used for drying process.

2.2.2. Materials. Cocoa powder was obtained from local supplier (Chockles, Yogyakarta). Palm sugar and sucrose sugar was purchased from PT. Pondasi Inti Sejahtera.

2.3. Preparation of samples.
The ratio of cocoa powder and sweetener was 55%:45%. The sweetener used was mixtures of palm sugar and sucrose. The proportions of palm sugar and sucrose are shown in Table 1. In order to create homogeneous mixtures, sweetener and cocoa powder were mixed in a food mixer with the speed of 58 rpm for 4 minutes [9].

Table 1. Cocoa powder samples

| Drying Duration (Hours) | Proportion of Palm Sugar : Sucrose (P : S) |
|-------------------------|------------------------------------------|
|                         | 0% : 100%      | 25% : 75%      | 50% : 50%      | 75% : 25%      | 100% : 0%      |
| 4                       | 4P0S100        | 4P25S75        | 4P50S50        | 4P75S25        | 4P100S0       |
| 6                       | 6P0S100        | 6P25S75        | 6P50S50        | 6P75S25        | 6P100S0       |
| 8                       | 8P0S100        | 8P25S75        | 8P50S50        | 8P75S25        | 8P100S0       |

2.4. Production process
A Continuous-type steam jet agglomerator was used in this process. The process was started by boiling the water inside the steam boiler until the internal pressure reached 1 bar. Afterwards, the steam valve was opened so the steam flew to the agglomeration chamber. After the flow and temperature of the steam was constant (around 80°C), the mixture of cocoa powder and sweetener was poured into chamber. This process was done 3 times. Subsequently, the samples were dried for 4, 6 and 8 hours at 80°C.

2.5. Analytical methods

2.5.1. Moisture content. The moisture content of the instanised cocoa drink powder was measured using thermogravimetric method. The principle of this method was to dry the powder for 24 hours at 105°C. With this method, all the water in the powder was evaporated. This process was done in 3 repetitions.
The moisture content was calculated using equation 1.

\[
\text{Moisture content} (\% db) = \frac{W_1 - W_2}{W_2} \times 100\%
\] (1)

\(W_1\) = Powder mass before 24 hours drying process  
\(W_2\) = Powder mass after 24 hours drying process

2.5.2. Lightness. The lightness of the powder was measured using Chromameter (Konica Minolta Inc, Japan). The powder was poured into sample box and flattened with spatula. CIE L* (from 0 which is black to 100 which is white), a* (from negative value which is green to positive value which is red), b* (from negative value which is blue to positive value which is yellow) was used for colour quantification. However only the L* value was used. This process was done in 3 repetitions.

2.5.3. Density. There were 2 types of density which were analysed, namely bulk and tapped density. Bulk density was measured by pouring instanised cocoa drink powder into 10 mL measuring cylinder. Tapped density was measured by tapping the instanised cocoa drink powder (in the 10 mL measuring cylinder) for 5 times using flow table. Subsequently, the mass was weighed. The bulk and tapped density of the instanised cocoa drink powder was calculated using equation 2.

\[
\text{Density} = \frac{\text{Powder mass}}{\text{Powder volume}}
\] (2)

2.5.4. Solubility. The solubility was measured by dissolving 1 gr of powder in 10 mL of distilled water. Stirring was carried out with magnetic stirrer in a 250 mL beaker glass at 200 rpm for 5 minutes. After that, the solution was poured into test tube to be centrifuged for 15 minutes at 5000 rpm. This process separated the insoluble particles. After the separation, the precipitate was dried for 24 hours at 105°C. The solubility was calculated using equation 3.

\[
\%\text{Solubility} = \frac{1\text{gr-dried precipitate}}{1\text{gr}} \times 100\%
\] (3)

2.6. Statistical analysis
The data was analysed statistically with IBM SPSS 25. One-way analysis of variance (ANOVA), two-way ANOVA and Principal Component Analysis (PCA) were used for data analysis with significance level of 5%. Homogeneity test was conducted with Leven’s test to ensure all the data could be analysed with one-way and two-way ANOVA.

3. Results and discussion
3.1. Relationship among sugar proportion, drying duration, and instanised cocoa drink powder’s characteristics.
The results showed that all the parameters, namely solubility, moisture content, lightness, bulk density and tapped density were influenced by sucrose and palm sugar proportion, drying duration as well as their interaction (Table 2).

| Table 2. Relationship among research variables and parameters of instanised cocoa drink | Parameters | Solubility | Moisture Content | Lightness | Bulk Density | Tapped Density |
|-----------------------------------------------|------------|------------|-----------------|-----------|--------------|----------------|
| Sucrose and Palm Sugar Proportion (S)         | *          | *          | *               | *         | *            | *              |
| Drying Duration (D)                           | *          | *          | *               | *         | *            | *              |
| Interaction between S x D                     | *          | *          | *               | *         | *            | *              |

*) significant at p<0.05

Principal Component Analysis (PCA) explained more than 96.6% of variance in the first two factors, namely PC1: 59.294% and PC2: 341%. The interactions between the parameters were showed by the distances within each other. It can be seen in Figure 1 that the parameters was grouped into 3
cluster. Lightness was inversely correlated with the moisture content (along PC 2) and solubility (along PC1). Solubility was directly proportional to the tapped and bulk density.

![Figure 1. PCA loading plot of parameters](image)

**Figures 1 and 2.** PCA score plot of cocoa drink samples

Figures 1 and 2 showed cocoa drink powders made with drying duration of 4 hours and palm sugar proportions below 40% tended to have a higher lightness and a lower moisture content than other samples. In contrast, cocoa drink powders made with drying duration of 8 hours and palm sugar proportions higher than 50% tended to have a higher solubility. Cocoa drink powders made with drying duration of 6 hours and palm sugar proportions higher than 50% tended to have a higher tapped and bulk density.

3.2. **Solubility**

Solubility was the most important parameter in this study since the purposes of agglomeration process was to increase the solubility. Solubility is the capability of a substance to be dissolved into certain amount of solvent in certain temperature [5]. Solubility can also be interpreted as a capability of a substance to be dissolved in water [10]. Hot water dissolves the powder because heat reduces the forces between water molecules, provide enough force to overcome the forces between water molecules [5]. In this research, room temperature was used to dissolve the cocoa drink powder.
Figures 3 showed that regardless of the drying duration, the solubility of cocoa drink powder increased as the proportion of palm sugar increased (p<0.05). Product contained more palm sugar had a higher solubility level. This occur might be due to the presence impurities such as reducing sugars, namely glucose and fructose in palm sugar [14]. Palm sugar also contains relatively high amount of amorphous sugars [9]. The amorphous sugar was also responsible for increasing the solubility since amorphous sugar tends to be more unstable than crystalline sugar [15, 16]. The result also showed that the solubility had propensity to increase as the drying duration increased and water content decreased (Figure 3 and 4).

![Figures 3. Solubility of cocoa drink powders](image)

3.3. **Moisture content**
After steaming, the moisture content of the powder increased. Therefore, drying was needed. Drying process decreases the water content, thus the shelf life of product will be longer [11]. Figures 4 showed that the water content decreased as the proportion of palm sugar and drying duration increased (p<0.05).

![Figure 4. Moisture Content of cocoa drink powders](image)

3.4. **Lightness**
Lightness is one of the parameters which is seen by consumer. Dark colour in the powder gives an perception of wet and dark [8]. Figures 5 showed the tendency of the lightness to be comparable along with the increase of palm sugar proportion in sugar mixture. Palm sugar had a lower lightness level
than sucrose which could decrease the product’s lightness [14, 17]. Furthermore, the dark colour of
instanted chocolate beverage powder might be affected by Maillard reaction and caramelization. Both
of these reactions might have a role in decreasing the powder’s lightness [14,17,18, 19].

3.5. Bulk density and tapped density
Density is the ratio between the mass and the volume of the product. Figures 6 and 7 showed that bulk
and tapped density of the samples increased as the proportion of palm sugar increased.

4. Conclusion
Palm sugar proportion, drying duration and their interactions highly influenced the cocoa drink
powder parameters. The moisture content decreased as the proportion of palm sap sugar in the sugar
mixture and drying duration increased. The solubility increased as the drying duration increased and
water content decreased. The lightness of the samples tended to be comparable. The bulk and tapped
density tended to increase as the palm sugar proportion and drying duration increased.

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