Drying cabya (*Piper retrofractum* Vahl.) at three ripeness stages

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**Abstract.** Cabya (*Piper retrofractum* Vahl.) is a herbal plant that is widely used as an androgenic, antioxidant, and anticancer agent. Preservation of cabya in dry form is mostly carried out in red-colour only, while green-colour and orange-colour are rarely preserved by this method. The present study aimed to analyze the water content and the drying rate of three different stages of ripeness of cabya, indicated by the colour such as green, orange and red, and to analyze the piperine, antioxidant, and reducing sugar after drying. Drying was conducted by hot air drying method at 70°C for 18 hours. Reducing sugar content was analyzed based on the Somogyi-Nelson method, antioxidant content was analyzed using 1,1-diphenyl-2-picrylhydrazyl (DPPH) method, and piperine was analyzed based on SNI 005:2013 method. The results showed that the water content after the drying process of green, orange, and red cabya were 1.89, 4.53, and 7.55% after 8.5, 7.5, and 7 hours of processing, respectively. Antioxidant and piperine contents of green, orange, and red cabya were 87.15, 75.26, and 63.38 mg/ml; and 2.42, 1.97 and 1.54 %, respectively. Dried red cabya is containing the highest water content, fastest drying rate, highest reducing sugar, while piperine and antioxidant content are lower than green and orange cabya.

1. Introduction

Cabya (*Piper retrofractum* Vahl.) is a native plant of Southeast Asia as an agricultural commodity for herbs and medicinal ingredients. It contains phytochemical properties that potentially provide pharmacological effects such as androgenic, antioxidant, anticancer, and antiobesity [1]. The main phytochemical properties found in cabya are reducing sugar (glucose and fructose), piperine, and antioxidants [2].

Cabya is a fruit that is easily damaged and rots a few days after harvesting due to its high water content (70 - 75%) [3]. Therefore it must be reduced to stop microbial growth so that it can prolong the cabya fresh quality. The drying method is one of the options to maintain the quality of agricultural products. The essence of the drying process is removing volatiles (water vapor) from the mixture of materials to produce a solid product [4].

The drying method, which is widely applied for the production of dried fruits and vegetables, is the hot air drying method since it is the most straightforward and most economical method of various processes. Drying of cabya can stop the growth of spoilage microorganisms and enzymatic and nonenzymatic chemical reactions in the matrix. Takahashi *et al.* [3] reported that drying cabya at a temperature of 70° C for up to 24 hours obtained an insignificant decrease in the levels of piperine and...
antioxidants so that they can maintain their functional value. Therefore, this process is effective in minimizing structural damage, sensory characteristics, nutritional value, and food function substantially.

Drying of cabya has been mostly performed to the ripe and red-colored cabya, but not many have examined the phytochemical content of dry cabya at other stages of ripe, such as orange and green-colored cabya. Cabya has a different phytochemical content at each stage of ripening [2]. The ripeness stage of the cabya is indicated by color changes from green, then orange, and becomes red.

This study aims to analyze the water content and drying rate of three different stages of ripeness of cabya: green, orange, and red. Also, to analyze the content of piperine, antioxidants, and reducing sugars after drying.

2. Materials and Methods

2.1. Sample

Green, orange, and red cabya were collected by purchasing from farmers in Pasuruan, East Java Province, Indonesia. Samples has a conical shape aged of 60, 65, and 70 days (post-harvesting) after blooming and has a L*a*b value based on color reader assay, as following: green was 32.36±1.41; 5.08±0.20; 35.32±0.47, orange was 36.48±1.23; 15.68±1.16; 37.63±1.07, and red was 38.51±0.42; 29.4±0.83; 41.92±1.5 (Figure 1). The L*a*b value expresses color as three numeric values. L* is for the light level, a* for the green to the red component, and b* for the blue to yellow component [5].

![Category the Three Ripeness Stages of Cabya: (a) Green; (b) Oranges; (c) Red.](image)

2.2. Drying method

Fresh samples were weighed as initial mass, then dried with a tray dryer at 70° C for 18 hours, and weighed every 30 minutes. Tray dryer which was used in the present study has an insulated drying chamber (55 cm length × 50 cm width × 45 cm height) [6]. Afterward, the sample was dried in an oven at 105° C for 4 hours and re-weighed as the final mass. Calculation of water content using equation (1) [7], and the drying rate was calculated using the following equation (equation (2)) [8, 9].

\[
\text{Water content (\% wb)} = \frac{\text{initial mass (g)} - \text{final mass (g)}}{\text{initial mass (g)}} \times 100
\]  

\[
\text{Drying rate (\% wb/min)} = \frac{M_t - M_{t+\Delta t}}{\Delta t}
\]

M_t and M_{t+\Delta t}, respectively, are the initial water content and the water content for a specific drying period (% wet basis). Δt is the drying period (minute).

2.3. Piperine content calculation

Piperine content was calculated using the SNI 005:2013 method, according to Shintawati et al. [10]. The principle of this method is conducting a thermal extraction using ethanol proanalysis as the solvent. The absorbance of the solution was measured using Spectrophotometer UV-Vis (λ=343 nm). Piperine content was calculated using the following equation (equation (3)).

\[
(\%) \text{Piperine} = \frac{A \times \frac{V_1}{m_1} \times \frac{V_2}{V_3} \times \frac{100}{100-M}}{A_{1cm1\%}}
\]
A is measured absorbance, \( A_{1\text{cm}1\%} \) is the absorbance at 343 nm of 1% piperine solution and cell 1 cm (1238), \( m_1 \) is a mass sample (g), \( V_1, V_2, \) and \( V_3 \) respectively are solvent volume before extraction, after extraction, and extract volume (mL). M is water content (% wet basis). Testing of piperine content was carried out in triplicate at each ripeness stages.

2.4. Antioxidant content calculation
Antioxidant content was calculated using 1.1-diphenyl-2-picrylhydrazyl (DPPH). Antioxidant content was defined as Inhibition Concentration 50% or IC\(_{50}\) as the concentration of the sample, which can reduce DPPH radical for 50% [11]. Testing of antioxidant content was carried out once at each ripeness stages.

2.5. Reducing sugar content calculation
Reducing sugar content was calculated using the Somogyi-Nelson method to measure total glucose and fructose in the Cabya fruit flesh [12]. Testing of reducing sugar content was carried out in triplicate at each ripeness stages.

3. Results and Discussions

3.1. Water content change

![Figure 2](image)

Figure 2. Variation of water content with drying period on green, orange, and red cabya.

Figure 2 shows that the equilibrium moisture content of green, orange, and red cabya after dried at 70°C was obtained at 8.5, 7.5, and 7 hours after drying. Green, orange, and red cabya each had initial water contents of 66.18, 68.70, and 69.38% and had equilibrium water contents of 1.89, 4.53, and 7.55% after the drying process, respectively. The final moisture content of dry green, orange, and red cabya in this study was <10% wet basis, which corresponds to the trade water content. The recommended water content limit for storing dried cabya is a water content <10% dry basis, which is equivalent to <9.09% wet basis in order to guarantee quality and prolong the fresh quality [12]. According to Hawa et al. [13, 14], that the drying process can be stopped if the difference in mass changes of the sample is less than 2% of the initial mass, and has the equilibrium water level. It is a condition where the mass of the sample does not change at 1.5 hours at the end of drying.

The more mature cabya has higher bound water content and lowers free water content. The lower free water content leads to faster equilibrium water since the amount of free water, which will be quickly evaporated. In contrast, the high bound water content remains in the material until the end of drying. According to Hawa et al. [13], the water content is bound to the material in the pores of small capillaries, making it difficult to evaporate.

The decrease in water content of green, orange, and red cabya in this study occurred quickly at the beginning of the drying process and slower at the end of the drying time. Similar results were also
reported by Kerdpiboon and Devahastin [15], Pimpaporn et al. [16], and Afolabi et al. [17], where the decrease in water content occurs faster at the beginning of the drying process because the moisture gradient in the sample is still plenty available, causing faster water movement. According to Hawa et al. [13], at the beginning of the drying process, there is the evaporation of free water content, which has a weak bond on the surface of the material, thus the decrease in water content takes place more quickly in the beginning. Decreasing the water content of the material at the end of the drying process takes place more slowly because of the evaporated water content in the pores of large capillaries, which are diffused towards the surface of the material and causes the pores to shrink. The diffusion mechanism is the process of moving water or volatile substances from the inside of the material to the surface, which is influenced by the chemical composition and physical structure of the material [18].

3.2. The relation of drying rate and drying period

![Figure 3](image_url)

Figure 3 shows that green cabya has a shorter heating period (3 hours) with a peak drying rate at 0.29% wet basis/min, whereas orange and red cabya has a more extended heating period (4 hours) with a peak drying rate at 0.32% and 0.26% wet basis/min, respectively. After experiencing a heating period, the drying rate tends to decrease until the end of the drying time. The red cabya drying rate is higher than orange and green cabya resulting in faster evaporation and water content reduction, which obtains the shorter drying period. The results of this study are similar to Afolabi et al. [17] and Hawa et al. [6], that the drying process begins with a warming-up period which is marked by an increase in the drying rate and is followed by a period of falling rate in which the drying rate decreases. The increase in drying rate at the beginning of drying due to differences in the moisture content of the material with the drying air is still substantial [19]. During this period, water diffusion occurs from inside the material to the surface of the material, and there is the evaporation of free water from the surface of the material, which will last until all the free water is completely evaporated [17].

3.3. The relation of drying rate and water content

Figure 4 shows that the drying rate of green, orange, and red cabya increased from the initial water content of 66.18, 68.70, and 69.38% wb to the peak of the drying rate at 36.93, 27.13, and 33.58% wb and then continued to decrease. The process ended with a final water content of 1.89, 4.53, and 7.55% wb respectively. These results are similar to Hawa et al. [13] and Afolabi et al. [17], where the drying rate increases when the water content of the cabya decreases significantly at the beginning of drying time and the water content begins to decrease slightly gradual. As the moisture content of the material decreases, the drying rate also decreases until it reaches a water content balance [6].
3.4. The content of piperine, antioxidants, and reducing sugars

Figure 5. Phytochemical composition of dried cabya on each of ripeness stage:
(a) piperine, (b) antioxidants, (c) reducing sugar.

Figure 5a shows that the piperine content of dried cabya in this study was reduced with an increasing cabya ripening stage. The piperin content of dried green, orange, and red cabya were 2.42 ± 0.01, 1.97 ± 0.06, and 1.54 ± 0.05%, respectively. According to Takahashi et al.[2], the piperin content is significantly reduced with cabya ripening. Due to the high piperine content in the unripe cabya, the green cabya can be consumed as a good source of piperine for hepatoprotective, antidepressant, and anticancer drugs. Also, the content of piperine can regulate lipid metabolism by activating protein kinase for fat burning and decreasing the expression of proteins involved in the fat storage mechanism so that it also functions as an antiobesity [1]. The piperin content indicates the spiciness of the cabya [2]. Therefore, the dried green cabya has a higher spiciness level than the orange and red dried cabya.
Figure 5b shows that the antioxidant levels of dried cabya decrease with increasing cabya ripening stage. The antioxidant levels of dry green, orange, and red cabya were 87.15, 75.26, and 63.38 mg/mL, respectively. Antioxidant levels have a positive correlation with cabya piperin levels. According to Takahashi et al. [2], that the antioxidant content is significantly reduced as the cabya ripens from green to red. The piperin compound influences the antioxidant capacity of dried cabya. According to Takahashi et al. [3], cabya contains phenolic amide compounds which show significant antioxidant properties. Due to the high antioxidant level in the unripe cabya, antioxidants from green cabya can function as an anticancer. The risk of developing cancer can be reduced by the use of antioxidant compounds that can fight free radicals [11].

Figure 5c shows that the level of dried cabya reducing sugar increases with increasing cabya ripening stage. Reducing sugar content in dry green, orange, and red cabya were 2.32 ± 0.16, 4.07 ± 0.13, and 6.44 ± 0.13%, respectively. An increase in reducing sugar content with increasing cabya ripening was also reported by Takahashi et al. [2], where the ratio of glucose and fructose (G/F) in the cabya will decrease along with increasing cabya ripening. It means that the amount of fructose is relatively increased compared to glucose during the ripening process so that fructose becomes the dominant sugar content in red dried cabya. According to Winarno [20], reducing sugars are monosaccharides and disaccharides, which have free and reactive hydroxy groups. High sugar content makes cabya useful as a source of energy [1]. High sugar content in more mature cabya can support the use of dried red cabya as a good source of sugar for reinforcing drugs that can stimulate the development and activity of male reproductive organs (androgenic effects).

In this study, the cabya dried at 70° C for 18 hours can still maintain the content of piperine but has decreased antioxidant levels. Takahashi et al. [3] reported that the piperin content of cabya is more stable than antioxidants during the drying process at 70° C for up to 24 hours. This is due to piperine’s naturally present in the cabya flesh, while antioxidants present in the skin of the cabya, making antioxidants has more impact change to heat treatment than piperine. The drying process increases the levels of reducing sugar of cabya because the starch content in degraded cabya forms a component of monosaccharides and disaccharides, leading to increasing the reducing sugar levels [21].

4. Conclusions
Red cabya has the highest drying rate and reaches equilibrium water content with a more rapid period, but the water content ultimately is still higher than orange and green cabya. The more ripe the cabya, the reducing sugar content increases during the drying process; otherwise, the content of piperine and antioxidants decreases. To get the pharmacological efficacy from dry cabya, further studies of the ripening stage of cabya is required.

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