The Effect of Various Drying Methods on the Quality of Rose (*Rosa damascena*) Tea

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ABSTRACT

Rose petals is potential ingredient for making a herbal tea. This study was aimed to determine the effect of various drying methods on the physical and chemical properties of the dried rose. The methods tested were freeze drying (FD), cabinet drying (CD), and sunlight drying (SM). Several properties included final moisture content, bulk density, shrinkage ratio, rehydration ratio, color difference, flavonoid content, and surface microstructure of dried petals were examined. The results showed that the best-fit model for the prediction of CD was the first-order kinetic model, with a drying rate constant of 0.0494% d.b./h. Meanwhile, both FD and SM required zero and first-order kinetics to effectively explain the drying characteristics. The drying constant rates for zero-order and first-order kinetics were 39.544 and 0.12% d.b./h for FD as well as 70.6 and 0.413%d.b./h for SM, respectively. The final moisture content of dried rose produced by FD, CD, and SM was 5, 12, and 10% wet basis (w.b), respectively. Based on the Indonesian National Standard, the maximum moisture content of packaged dried tea is 8% w.b. FD successfully reduced the shrinkage ratio to a range of 0.35 – 0.45. Freeze-dried rose petals at 40 °C temperature resulted in the highest flavonoid content of 5.65 g QE/100 g sample. In conclusion FD was the best drying method for producing herbal tea from rose petals. This method could be adopted as a new alternative for producing high-quality healthy herbal tea.

Keywords: Drying kinetics; freeze drying; physical quality; rose tea

INTRODUCTION

Tea is typically prepared by steeping dried leaves and buds from the *Camellia sinensis* plant species in hot water. Tea consumption has become an important alternative approach that significantly contributes to treating illnesses and maintaining human health. Advancement in the field of nutrition have also enabled the preparation of similar beverages from diverse plant species, known as herbal tea. Different plant parts, including roots, leaves, and flowers, are used for herbal tea. Previous studies indicated its health benefits in managing conditions such as diabetes, high blood pressure, and the reproductive health of women (Poswal et al., 2019).

A plant species commonly used for crafting herbal tea is the rose (*Rosa damascena*). The consumption of rose provides numerous health benefits, ranging from alleviating menstrual pain to preventing aging and aiding in psychological well-being (Thring et al., 2011). Tea made from dried rose petals possesses higher antioxidant activity compared to green tea (Vinokur et al., 2006). In Indonesia, rose flower was ranked second-largest in terms of harvested area in 2018, covering 411.10 hectares, which marked a 10.41% increase from the previous year (BPS, 2018). Given this significant rose

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production, the potential for developing rose tea as an herbal beverage is promising in Indonesia. Standardized quality parameters for herbal tea are presently yet to be established. However, conventional packaged tea standards (SNI 3836:2013) can serve as a reference, with the primary standard being a moisture content of less than 8%.

A crucial stage in rose herbal tea production is the drying process. This process results in changes in several physical properties, including color, texture, and size. Chemical changes, such as the loss of aroma and antioxidant content, may occur during convective drying, a method commonly used for processing fruits and vegetables (Selvi et al., 2020). This consideration holds particular significance in the production of rose herbal tea, given the high antioxidant content of rose that must be preserved until consumption.

Previous studies employed various methods for drying flowers and leaves for herbal tea, such as direct sunlight and oven drying (Hayati et al., 2011; Luliana et al., 2016). Drying under direct sunlight has proven to be challenging due to weather dependence and the risk of contamination by insects, dust, and dirt. Rabeta and Vithyia (2013) also reported a reduction in the antioxidant content of legundi flowers after hot air drying.

Another viable method is freeze drying (FD), which involves the crystallization of the moisture content within the material at low temperatures and pressures. This crystallized moisture then sublimates from solid to gas (Ciurzyńska & Lenart, 2011). FD has been shown to reduce moisture content in food materials such as fruits and vegetables while preserving color and nutritional quality (Turkiewicz et al., 2019; Wojdyło et al., 2019). Therefore, this drying method exhibits significant potential for application in rose herbal tea production.

Imaniar et al. (2019) conducted a study to compare the quality of freeze-dried rose petals with those dried using an oven and sunlight. The outcomes showed that freeze-dried rose exhibited brighter colors and lower final moisture content. This study aimed to further explore the effect of different drying methods on the characteristics and quality of dried rose petals. Parameters measured include changes in flavonoid content, shrinkage ratio, rehydration ratio, bulk density, microstructure, and color changes.

METHODS

Materials

The rose petals used in this study were a species of red *Rosa damascena* obtained from Pakis Sub-district, Magelang Regency, Central Java. This species was characterized by a long stalk of 60-100 cm with a freshness resistance of 8-10 days in a vase. In this study, petals were taken from perfectly blooming flowers with a diameter of 9-10 cm and a mass of 100 g for each replicate and treatment.

Material Preparation

Before drying, the rose petals were cleaned to remove dust and dirt. The petals were subjected to a sorting process involving the separation of withered or torn petals from fresh ones. The sorted petals were then placed on the sample tray of each dryer and spread evenly to prevent sticking together. The drying process occurred at ambient temperature and relative humidity ranging from 30.2 – 30.6 °C and 69 – 70%, respectively. Drying time was designed for each method to achieve a final moisture content close to 8% wet basis (w.b).

Freeze Drying (FD)

Freeze drying was carried out using a laboratory-scale freeze dryer, which was designed and constructed independently from food-grade stainless steel (Imaniar et al., 2020). The dryer had a capacity of 1.5 kg, dimension of 0.8 x 0.6 x 1.15 m, and three heating plates were installed with a total power of 500 watts. The process commenced after introducing the prepared materials and freezing to a temperature of -18 °C under a vacuum pressure of -76 cmHg. Furthermore, heating was applied with variations in the temperature of 40, 50, and 60 °C. The duration for FD was 36 hours.

Cabinet Drying (CD)

The drying process with simple CD was carried out in a cabinet dryer (PSN-150, Shimizu Scientific Instruments MFG. CO., LTD., Tokyo, Japan) with a capacity of 10 kg. Drying was performed for 12 hours at a temperature of 50 °C and a mean airflow rate of 1.4 m/s.

Sunlight Drying (SM)

To provide a comparative approach to the common practice of making rose tea, a traditional sunlight-drying method was also employed. The rose petals, arranged on trays, were placed in direct sunlight for approximately 8 hours over three consecutive days.

Moisture Content

The moisture content of the dried rose petals was determined through the oven method using the Memmert UM-400 (Memmert GmbH + Co.KG, Schwabach, Germany), based on the AOAC International method with minor modifications (Karyadi et al., 2021). The content was then calculated using Equation 1, as follows:

$$M = \frac{W_0 - W_1}{W_1} \quad (1)$$

Where M is the moisture content (% d.b.), W_0 is the initial mass of the material before drying in the oven (g), and W_1 is the mass of the material after drying in the oven (g).

The decreased rate of moisture content during drying was divided into two periods. These include constant and falling, described by zero-order and first-order kinetic equations, respectively. The rate of decrease in moisture content was calculated using Equations 2 and 3 (Orikasa et al., 2018), as follows:

$$M_t = M_0 - kt \quad (2)$$

$$M_t = M_0 e^{-kt} \quad (3)$$

Where M_0 is the moisture content at the start of drying (% d.b.), M_t is the moisture content at a specific time (% d.b.), k is the drying rate constant (% d.b./hour), and t denotes the drying time (hours). The constant and decreasing drying rate constants obtained were then used to calculate the predicted moisture content values and assess whether the equations used (zero-order and first-order kinetics) effectively described the drying rate of rose petals.

Bulk Density

The bulk density of dried rose was determined by filling pre-weighed petals into a measuring glass up to a predetermined volume. Bulk density is expressed in units of g/mL.

Shrinkage Ratio

The shrinkage ratio was calculated by comparing the petals area after drying (A_1) with the area before drying (A_0). The shrinkage ratio (S) was calculated using Equation 4 (Zhu et al., 2014), as follows:

$$S = 1 - \frac{A_1}{A_0} \quad (4)$$

Rehydration Ratio (RR)

The rehydration test was conducted based on the method established by Rakesh & Singh (2017), with slight modifications. Pre-weighed dried petals were immersed in hot water for five minutes, and their weights were then re-measured. The rehydration ratio was derived from the comparison between the weight of the petals after and before the rehydration test. A higher rehydration ratio indicated a greater ability of rose petals to reabsorb water.

Color Changes

Color changes are a determining factor in the resulting rose tea quality. Rose that retained the color even after the drying process contributed to a vividly colored tea. In this study, color components including lightness (*L), red/green (*a), and blue/yellow (*b) values were measured using a Color Meter (Color Meter TES-135A, TES Electrical Electronic Corp., Taipei, Taiwan). The measured values of these components were then employed to calculate color changes (ΔE). The ΔE calculation was performed using Equation 5 (Shi et al., 2019), as follows:

$$\Delta E = \sqrt{(L* - L_0)^2 + (a* - a_0)^2 + (b* - b_0)^2} \quad (5)$$

Flavonoid Content

The flavonoid content in rose before and after drying was determined following the method by Fauzi et al. (2016), with slight modifications. A total of 5 g rose petals were weighed and dissolved in 100 mL of ethanol. The clear solution obtained from centrifugation was then mixed with 3 mL of 5% $AlCl_3$ and diluted with distilled water to a volume of 10 mL. Absorbance was measured using a spectrophotometer (Thermo Scientific Genesys 20, Thermo Fisher Scientific, MA, USA) at a wavelength of 420 nm. The flavonoid content was calculated using the Quercetin standard curve and presented in units of g QE/100 g DW (dry weight).

Scanning Electron Microscopy (SEM)

The surface morphology of rose petals after CD, FD, and SM was examined using SEM (JSM 6510LA JEOL Ltd., Tokyo, Japan). Pt-Pd was selected as a coating material before the scanning process, with a magnification setting of x1000.

Statistical Analysis

The drying process and data analysis were conducted with three repetitions, and the results were presented as means ± standard deviation. Analysis of variance (ANOVA) was performed using IBM SPSS Statistics 23 software (SPSS Inc., Chicago, IL). The significant differences between means were determined using the Duncan Multiple Range Test (DMRT) with a significance level of 0.05 ($p < 0.05$).

RESULTS AND DISCUSSION

Rose Drying Characteristics

Figure 1 shows the observed (obs) and predicted (pred) moisture content of rose during petals drying. Drying occurred over varying times of 12, 26, and 36 hours for CD, SM, and FD, respectively. A similar approach was previously undertaken by Chong and Lim (2012), where FD of herbal tea from vitex leaves required more time compared to CD and SM. Generally, the drying cycle can be divided into several stages, including the constant rate period (CRP) and the falling rate period (FRP). In the CRP, the diffusion of free water from within the material to its surface exceeded the evaporation rate, resulting in a constant drying rate. Meanwhile, in the FRP, the availability of free water within the material decreased, causing a decrease in drying rate (Diamante et al., 2010).

Each drying curve exhibits distinct characteristics, with the drying curve in CD displaying an exponential nature. This was well described by first-order kinetics, with the drying rate constant being 0.0494% d.b./hour. Meanwhile, for SM and FD, the CRP extended longer, and the drying characteristics were best described using zero-order (linear) kinetic followed by first-order kinetic. The drying rate constants for zero-order and first-order kinetics were 39.544 and 0.12% d.b./hour for FD and 70.6 and 0.413% d.b./hour for SM, respectively.

Physical Properties of Dried Rose

Table 1 shows the physical properties of dried rose resulting from different drying variations. In this study, the moisture content of fresh petals was 89.06 ± 1.28% w.b. After the drying process, the moisture content decreased to 4 – 12% w.b., depending on the drying method. FD was capable of reducing the moisture content to 4 – 5% w.b., with temperature variations not yielding significant differences in the final moisture content ($p > 0.05$). According to the Indonesian National Standard, packaged dried tea should have a maximum moisture content of 8% (BSN, 2013). Shi et al. (2019) also evaluated the effect of hot air drying on the properties of tea derived from *Camellia sinensis* and stated that 8% was a safe moisture content for storage of dried tea. Based on these pieces of information, the designed FD was effective, as it lowered the moisture content to the required level.

The density of dried rose petals becomes crucial in herbal tea production, particularly during packaging and transportation. Based on the results, the bulk density of dried rose petals ranged from 0.01 to 0.06 g/mL, depending on the treatment. For FD, the resulting bulk density was the smallest, ranging from 0.01 to 0.02 g/mL, which was significantly different from other treatments ($p < 0.05$). This observation aligned with a study on saffron flowers conducted by Emadi and Saiedirad (2011), which reported a bulk density of 0.03

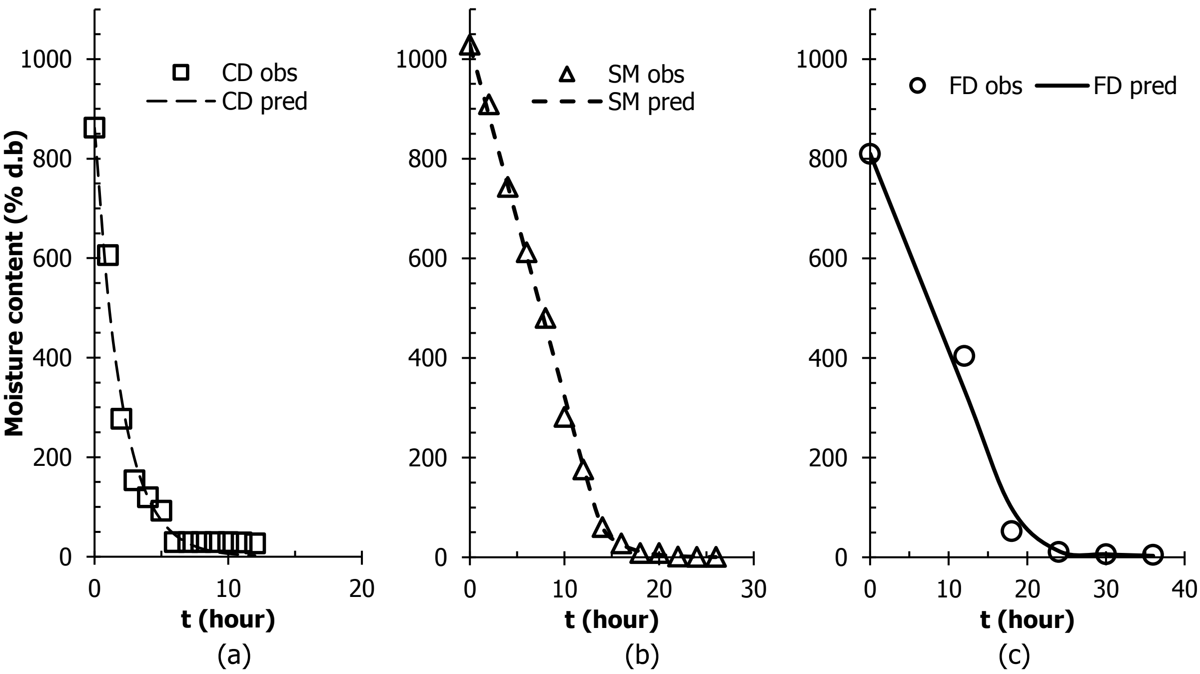


Figure 1. First-order kinetic of drying rose petals for Cabinet drying (CD) (a), Sunlight drying (SM) (b), and Freeze drying (FD) (c)

Table 1. Physical properties of dried rose

Treatment	Moisture content (% w.b.)	Bulk density (g/mL)	Shrinkage ratio	Rehydration ratio	ΔE
FD 40	5.86 ± 0.79^{a}	0.01 ± 0.00^{a}	0.35 ± 0.07^{a}	10.74 ± 0.89^{a}	30.46 ± 7.22^{ab}
FD 50	5.04 ± 0.66^{a}	0.02 ± 0.00^{ab}	0.38 ± 0.05^{ab}	10.89 ± 1.35^{a}	27.51 ± 4.92^{a}
FD 60	4.74 ± 0.53^{a}	0.02 ± 0.01^{ab}	0.45 ± 0.01^{b}	12.78 ± 2.22^{a}	38.22 ± 6.80^{ab}
CD	12.18 ± 0.60^{c}	0.03 ± 0.01^{b}	0.58 ± 0.04^{c}	11.93 ± 1.87^{a}	30.03 ± 4.01^{ab}
SM	9.92 ± 0.46^{b}	0.06 ± 0.0^{0}c	0.66 ± 0.04^{d}	12.00 ± 1.15^{a}	46.82 ± 17.44^{b}

Note: Different letters in the same column indicate a significant difference (p <0.05)

g/mL for dried saffron petals. Furthermore, a shrinkage ratio of rose petals of up to 0.70 was observed. During drying, shrinkage can occur due to the imbalance between internal and external pressures, causing the material to shrink and change shape (Nagvanshi et al., 2017). The smallest shrinkage ratio was observed in FD (p > 0.05), with temperature variations not affecting the shrinkage ratio.

The result showed that the rehydration ratio of dried rose petals ranged from 10 to 12. The variations in treatments did not exert a significant effect on the rehydration ratio (p > 0.05). Similar results were obtained from the color difference test, where the ΔE value varied from 25 to 50, with no significant differences observed among the various treatment results (p > 0.05). The color of rose petals after drying tended to shift towards a darker, reddish-brown hue. This color change may be attributed to non-enzymatic browning or the Maillard reaction, as discussed in prior studies concerning the drying of tomatoes (Cernîşev, 2010) and hibiscus flowers (Hayati et al., 2011).

Flavonoid Content

Flavonoid constitutes a class of phenolic compounds commonly found in plants, characterized by the antioxidant properties (Cendrowsk et al., 2017). Based on the analysis, flavonoid content in fresh rose petals was 12.00 ± 0.06 g QE/100 g DW. Figure 2 shows flavonoid content of dried rose from each drying treatment, with values ranging from 4.42 to 5.65 g QE/100 g DW. This result surpassed the flavonoid content of *Camellia sinensis* plants reported by Izzreen and Fadzelly (2013), which ranged from 1.907 to 3.517 mg QE/g DW. FD at 40 and 50 °C resulted in higher flavonoid content retention compared to other treatment variations. This aligns with a previous study on vitex plants conducted by Chong and Lim (2012), indicating that FD preserves antioxidant activity in these plants. However, flavonoid content for FD at 60 °C was the lowest among the treatments. This

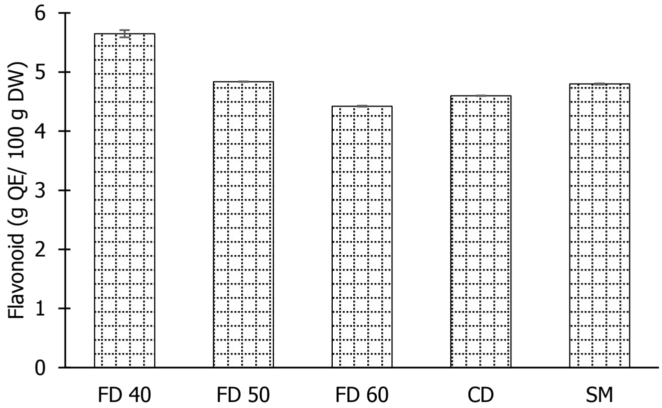
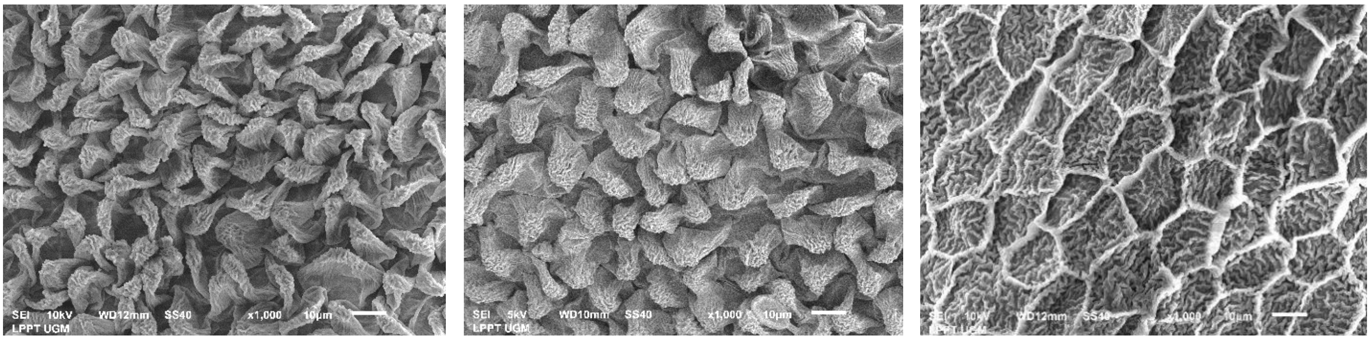


Figure 2. Flavonoid content of dried rose

might be attributed to temperatures exceeding 50 °C potentially decreasing the phenolic content in plants (Roshanak et al., 2016).

Scanning Electron Microscopy (SEM)

Figure 3 shows the observed microstructure on the tea surface before and after drying at a magnification of 1,000x. The results showed that the surface of rose petals dried in sunlight was similar to those dried in a cabinet. The petals appeared perforated, and cells were clustered, forming wrinkled spots. These wrinkles may be attributed to the significant shrinkage resulting from drying. Meanwhile, freeze-dried rose petals exhibited a smoother surface due to the presence of smaller perforations, forming network-like structures resembling beehives. This behavior can be linked to FD, where ice crystals form and then sublime, leaving behind uniformly distributed small voids that prevent the surface of the material from shrinking (Qing-guo et al., 2006). The role of FD in preserving fruit quality by mitigating morphological changes due to shrinkage has also been explored in previous studies, as observed in apple (Wang et al., 2018) and quince (Izli & Polat, 2019) drying.



(a) (b) (c)

Figure 3. Observation results of microstructure from SM (a), CD (b), and FD (c)

CONCLUSION

In conclusion, the designed FD reduced the moisture content of rose petals to 5% w.b., lower than the maximum moisture content specified by the national standard for packaged tea. The shrinkage ratio ranged between 0.35 – 0.45, significantly smaller than the shrinkage ratio observed for CD (0.58) and SM (0.66). FD at temperatures below 50 °C showed better retention of flavonoid content compared to other temperature variations and drying methods with a mean flavonoid content of 5.65 g QE/100 g sample. The designed drying displayed remarkable potential as a new alternative for producing high-quality, healthy herbal tea. However, a drawback of FD was the relatively longer time compared to other drying methods, which presented an opportunity for future study focus.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest from any parties.

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