The characteristics of corn silk \((Zea\ mays\ L.)\) herbal drinks tea with vacuum drying method as antioxidant

R A Laeliocattleya, E Martati, A N S Alwi, L P Aulia and Yunianta

Department of Agricultural Product Technology, Faculty of Agricultural Technology Universitas Brawijaya, Malang, Indonesia

E-mail: deeochalina@gmail.com

Abstract. The demand for antioxidant beverages made from herbs in the community increases due to the increasing number of types diseases caused by free radicals. One type of potential herbs as antioxidant is corn silk, in the form of corn silk herbal drinks tea. The basic ingredients for making herbal tea drinks is the dried corn silk. However, the temperature and drying time was found to affect the characteristics of herbal tea drinks produced. The purpose of this study was to determine the effect of temperature and drying time with vacuum drying method on the content of bioactive compounds and antioxidant activity of corn silk herbal tea. This study used Randomized Block Design with 3 replications and 2 Factor. Factor 1 is drying temperature (40°C, 50°C and 60°C) and Factor 2 is drying time (3 hours, 4 hours and 5 hours). Each sample was then analysed the bioactive compounds (total phenolics, flavonoids) and antioxidant activity. The study found that the higher of drying temperature resulted on higher phenolics, flavonoids and antioxidant activity. Conversely, drying time showed a declining trend. The best treatment was found from the combination of drying temperature at 60°C with 4 hours drying time, giving the total phenolics of 11.68 mg GAE/g, flavonoids of 6.47 mg QE/g and antioxidant activity with IC\(_{50}\) values of 278.1 ppm, respectively.

1. Introduction
The increasing number of free radical sources in our daily environment can lead to endemically degenerative diseases. Free radicals are unstable molecules or compounds that can damage body tissues. These molecules can arise due to body metabolic processes, cigarette smoke, motor vehicle pollution and solar radiation. For this reason, a food product that can counteract free radicals, such as herbal tea, is required.

Herbal tea is a beverage derived from natural ingredients that are beneficial to the body. Herbal teas are usually made from spices or parts of plants and consumed in the form of tea, by boiling or brewing steeping parts of plants [1]. One of the potential herbs as an antidote to free radical herbal tea is found in corn silk.

Based on research by Nurraihana et al. [2], corn silk contains of phenolic compounds, especially flavonoids which can be useful as antioxidants. Phenolic compounds can be an antidote to free radicals because they can donate hydrogen atoms to free radical compounds to create and attain more stable compounds [3].

To make corn silk herbal tea drinks, it is necessary to have dried corn silk. One of the drying methods that can be used is the vacuum drying method [4]. However, the temperature and drying time using
vacuum drying method give different characteristics to the samples [5]. Both factors were estimated to have a different influence on the characteristics of herbal tea drinks such as the content of bioactive compounds and their antioxidant activity. Therefore, this study aimed to determine the effect of temperature and drying time with vacuum drying method on the content of bioactive compounds and antioxidant activity of corn silk herbal tea.

2. Materials and Method

2.1. Materials

The ingredients needed were corn silk obtained from 80-90 days of sweet corn plants in Sukoman-Pakis-Malang Regency-Indonesia, mineral water, DPPH (diphenyl picrylhydrazyl) 0.2 mM in methanol, standard quercetin, distilled water, standard gallic acid, Folin-Ciocalteau 10%, Na₂CO₃ 7.5%, 95% methanol, 5% NaNO₂, 10% AlCl₃, 1M NaOH.

2.2. Methods

2.2.1. Sample preparation

A 150 g of corn silk was sorted by separating the damaged corn silk from the fresh corn silk. The good quality of corn silk was washed using running water and then dried at room temperature for ~10 hours.

2.2.2. Drying

In the drying process, the cleaned corn silk sample was dried based on vacuum drying method [4]. The drying process was carried out at various temperatures (40°C, 50°C, 60°C) and various duration of drying time (3 hours, 4 hours, 5 hours), in accordance to the test treatment. After that, the dried corn silk was placed in a closed and airtight container for cooling down and arranged according to each treatment.

2.2.3. Brewing

The brewing process is in accordance with SNI 3753: 2014 standards on Black Tea Bags [6]. Each dried sample was weighed 2 g and brewed with 200 mL of boiling mineral water for 5 minutes. Then filtering and the immersion water was taken for further testing.

2.2.4. Total phenolic compounds (TPC) determination

Determination of phenol content was carried out based on colorimetric oxidation/reduction reaction method using Folin–Ciocalteau reagent [7]. In this method, the absorbance was measured using a UV-Vis spectrophotometer with λ at 755 nm. The total phenol content is expressed equivalent to mg gallic acid per g sample (mgGAE / g sample) on a dry basis as presented by the following formula:

\[ \text{TPC (Total Phenolic Compounds)} = \frac{C \times V \times FP}{W} \]  
(1)

Where: \( C = \) phenolic concentration in ppm (mg/L), \( V = \) volume (mL), \( FP = \) dilution factor, \( W = \) weight of sample (g)

2.2.5. Total flavonoid compounds (TFC) determination

Flavonoid content was analysed using aluminium chloride colorimetric assay method [8]. The sample absorbance was measured using a UV-Vis spectrophotometer with λ at 327 nm. The total flavonoid content is equivalent to mg quercetin acid per g sample (mgQE / g sample) on a dry basis as presented by the following formula:

\[ \text{TPC (Total Flavonoid Compounds)} = \frac{C \times V \times FP}{W} \]  
(2)

Where: \( C = \) flavonoid concentration in ppm (mg/L), \( V = \) volume (mL), \( FP = \) dilution factor, \( W = \) weight of sample (g)
2.2.6. IC\textsubscript{50} value of antioxidant activity determination

Samples of beverage were dissolved in 95% methanol with a concentration series of 70, 140, 210; 280 ppm and 350 ppm. Each sample was taken in 4 ml, then added with 1 ml 0.2 mM DPPH in methanol, and absorbance was measured using a UV-Vis spectrophotometer with \( \lambda \) at 517 nm [9]. Calculation of antioxidant activity is presented by the following formula:

\[
\text{Antioxidant Activity (\%)} = \left( \frac{\text{Abs of blank} - \text{Abs of sample}}{\text{Abs of blank}} \right) \times 100 \%
\]  (3)

3. Results and Discussion

3.1. Total phenolic compounds (TPC)

Table 1 indicates the largest TPC of corn silk herbal tea was resulted from the treatment of 60°C drying temperature (with 4 hours drying time). TPC tends to increase along with increasing temperature; however, the decline occurs at the highest temperature. According to Wojdyło [10], most of the phenolic compounds are found in the structure of plant cell tissue. Thus, drying process is required to release the phytochemical compounds which are bound to the network matrix to facilitate the extraction process. However, the drying process with high temperatures and prolonged contact time can damage the phenolic compounds.

| Treatment | Drying Temperature (°C) | Drying Time (hours) | Total Phenolic (mgGAE/g) |
|-----------|-------------------------|---------------------|-------------------------|
| 40        | 3                       | 7.18 ± 0.5\textsuperscript{e} |
|           | 4                       | 8.74 ± 0.3\textsuperscript{d} |
|           | 5                       | 9.87 ± 0.6\textsuperscript{b} |
| 50        | 3                       | 9.05 ± 0.2\textsuperscript{cd} |
|           | 4                       | 9.65 ± 0.2\textsuperscript{bc} |
|           | 5                       | 10.29 ± 0.2\textsuperscript{b} |
| 60        | 3                       | 9.57 ± 0.5\textsuperscript{bc} |
|           | 4                       | 11.68 ± 0.6\textsuperscript{c} |
|           | 5                       | 8.59 ± 0.1\textsuperscript{d} |

Notes: ± refers to standard deviation (3 replications), letter notation means with different letter are significantly different (ANOVA test, \( \alpha=0.05 \))

3.2. Total flavonoid compounds (TFC)

Table 2 indicates the largest TFC was resulted from the treatment of 60°C drying temperature with a drying time of 4 hours. Flavonoids which are classified as phenolic compounds is perfectly extracted from the dry raw material. Another effect due to the drying process is the escalated amount of total solids in the material. According to Nielsen [11], the total solid is the remaining dry component after removing the moisture content in the material. Total solids include carbohydrates, fats, proteins, vitamins and minerals which are components other than water in the ingredients. According to Manach et al. [12], phenolic compounds can bind to other components of materials such as proteins and polysaccharides. Thus, along with the increase in the total solids in the material, it is possible that flavonoid compound is more easily in contact with the solvent because there is no interference from the moisture content that was originally found in the material. However, the drying process with high temperatures and too long contact time can cause phenolic compounds such as flavonoids to be damaged [10]. Flavonoids contain hydroxyl groups that is responsible to the ability of sample as radical scavenger.
and it is contributes to the antioxidant activities of sample, in addition to other bioactive compounds [13].

### Table 2. Total flavonoids of corn silk herbal drinks tea

| Treatment | Drying Temperature | Drying Time (hours) | Total Flavonoids (mg QE/g) |
|-----------|-------------------|---------------------|----------------------------|
|           | 40°C              | 3                   | 4.92 ± 0.2d                |
|           |                   | 4                   | 5.56 ± 0.3bc               |
|           |                   | 5                   | 6.11 ± 0.3ab               |
|           | 50°C              | 3                   | 5.68 ± 0.1bc               |
|           |                   | 4                   | 5.95 ± 0.5abc              |
|           |                   | 5                   | 6.25 ± 0.5a                |
|           | 60°C              | 3                   | 5.97 ± 0.2b                |
|           |                   | 4                   | 6.47 ± 0.3a                |
|           |                   | 5                   | 5.43 ± 0.3c                |

Notes: ± refers to standard deviation (3 replications), letter notation means with different letter are significantly different (ANOVA test, α=0.05)

#### 3.3. IC50 value of antioxidant activity

Table 3 indicates the greatest IC50 value of 278.1 ppm was resulted in the 60°C drying temperature with a drying time of 4 hours. IC50 value is defined as the concentration of the sample to inhibit oxidation up to 50% or the concentration of the test sample to capture 50% of DPPH free radicals. According to Ajila et al. [14], smaller IC50 value indicates stronger antioxidant ability. The antioxidant activity of the sample tends to increase along with the higher drying temperature; however, longer drying time decreases the antioxidant activity. Phenolic compounds can act as antioxidants due to the ability to prevent lipid oxidation and other molecules by donating hydrogen atoms to convert free radicals into stable compounds. But, these bioactive compounds can be damaged if the temperature is too high and the time is too long [10]. According to Gordon [15], the IC50 value of <50 ppm exhibits very active antioxidant strength, the IC50 value of 50-100 ppm exhibits the active antioxidant strength, IC50 value 101-250 ppm indicates moderate antioxidant strength. The IC50 value of 250-500 ppm depicts weak antioxidant strength and the IC50 value of > 500 ppm indicates inactive antioxidant strength. The result presents that the best treatment was at drying temperatures of 60°C with drying time of 4 hours, giving the antioxidant activity (IC50) value of 278.1 ppm which marking a weak antioxidant activity. Another study reported that herbal drinks tea from *Cosmos caudatus* leaves has IC50 value of 1055.37 – 2408.84 ppm [16], which was lower than IC50 value of herbal drinks tea from corn silk. This indicates that corn silk has a great potential to be utilised as herbal tea. Yet, in depth studies on modification of drying methods are still needed to enhance the antioxidant activities of corn silk herbal drinks tea.
Table 3. Antioxidant activity (IC$_{50}$) of corn silk herbal drinks tea

| Treatment | Drying Temperature | Drying Time (hours) | Antioxidant Activity (IC$_{50}$) (ppm) |
|-----------|--------------------|---------------------|---------------------------------------|
|           |                    |                     |                                       |
| 40°C      | 3                  | 484.3 ± 22.6$^c$    |                                       |
|           | 4                  | 380.0 ± 16.5$^c$    |                                       |
|           | 5                  | 330.7 ± 13.0$^b$    |                                       |
| 50°C      | 3                  | 343.3 ± 12.7$^b$    |                                       |
|           | 4                  | 335.5 ± 10.5$^b$    |                                       |
|           | 5                  | 310.2 ± 28.1$^{ab}$ |                                       |
| 60°C      | 3                  | 322.2 ± 30.0$^b$    |                                       |
|           | 4                  | 278.1 ± 18.5$^a$    |                                       |
|           | 5                  | 444.8 ± 14.6$^d$    |                                       |

Notes: ± refers to standard deviation (3 replications), letter notation means with different letter are significantly different (ANOVA test, $a=0.05$)

4. Conclusions

Based on the results of study, the best treatment of corn silk drying using vacuum drying method was on 60°C drying temperature and 4 hours drying time. The characteristics of corn silk herbal drinks tea from these treatments were total phenolics of 11.68 mg GAE/g, total flavonoids of 6.47 mg QE/g and antioxidant activity (IC$_{50}$) value of 278.1 ppm. A modification is needed to increase the antioxidant ability of corn silk herbal drinks tea by using other drying method or adding other bioactive compounds in corn silk herbal drinks tea.

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