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Original Paper

Characteristics of Takokak (*Solanum torvum Sw*.) Leaves Herbal Tea Based on Drying Temperature

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Abstract*— Pokak plant, also known as takokak or prickly nightshade (*Solanum torvum* Sw.), belongs to the Solanaceae family. The part of the plant commonly utilized was its leaves. Takokak leaves contained numerous bioactive components that can be developed into one of the functional foods, such as herbal tea. One crucial aspect in the herbal tea-making process is the drying temperature. The aimed of this research was to investigate the effect of drying temperature variations on the characteristics of takokak leaves herbal tea and to determined the optimal temperature that can yield the best characteristics of takokak leaf herbal tea. Parameters observed in this study included total phenols, total flavonoids, total tannins, vitamin C, antioxidant activity, and sensory properties comprising hedonic tests on color, taste, aroma, and overall acceptances. Data obtained were analyzed using analysis of variance (ANOVA), and if there was a significant effect of treatment on the results (P<0.05), it would be followed by the Tukey test. The results showed that variations in drying temperature had a significant effect on the total phenols, tannins, flavonoids, vitamin C, antioxidant activity, and sensory properties regarding color, aroma, taste, and overall acceptances of takokak leaf herbal tea. The best treatment was obtained at a drying temperature of 40°C with total phenol content of 31.58 mg GAE/g, total tannin content of 0.79 mg TAE/g, total flavonoid content of 14.23 mg QE/g, total vitamin C content of 7.92 mg AAE/g, antioxidant activity of 84.26%, and sensory properties for color, aroma, taste, and overall acceptances respectively were 5.73 (like), 5.27 (slightly like), 3.77 (neutral), and 3.91 (neutral).

Keywords*— *Takokak Leaves, Temperature, Herbal Tea, Characteristics

I. INTRODUCTION

Pokak plant, also known as takokak or prickly nightshade (*Solanum torvum Sw*.), belongs to the Solanaceae family, and its fruits and seeds are used as vegetables or spices. In international trade, it is commonly referred to as 'turkey berry' or 'mini-eggplant.' Other names in various regions include 'rimbang' (Batak Toba, Minangkabau) and 'takokak' [1]. Pokak plant is widely recognized by the community as an additional dish consumed with rice and chili sauce, utilizing its fruit. The fruit of takokak, also commonly referred to as pokak eggplant, offers beneficial effects on human health due to its content of bioactive components such as flavonoids, saponins, quinones, and steroids containing methyl caffeate isolates, which are beneficial as antihyperglycemic and antidiabetic agents [1]. Unlike its fruit, takokak leaves are seldom utilized. However, takokak leaves themselves possess beneficial properties for human health. Helilusiatiningsih et al. [1] reported that takokak leaves contain total phenols of 44.28 mg GAE/g, tannins of 1.08 mg TAE/g, flavonoids of 0.88 mg QE/g, and antioxidant activity of 68.28%. Processing of takokak leaves is not widely conducted in the food industry due to the bitter taste of the leaves themselves, which makes them less desirable. Therefore, one alternative for processing is to convert them into herbal tea. Herbal tea is one of the herbal beverage variations made from leaves, seeds, flowers, and roots of various plants other than tea plants (*Camellia sinensis*) [3]. Leaves are the main component in herbal tea production, and before being turned into tea, the main leaves are typically dried, either using sunlight or with the assistance of equipment such as food dehydrators or drying ovens [26]. Sun drying is the simplest drying method, but it heavily depends on the climate and can also affect the cleanliness of the leaves, as they are left in open spaces. Therefore, food dehydrators or drying ovens can be alternative options. One crucial aspect to consider in the drying process is the temperature, as excessively high temperatures can damage its bioactive components, while too low temperatures may not adequately dry the leaves. As researched by Sari et al. [17], even with the same drying time but at different temperatures, variations occur in the tannin content, total phenols, antioxidant activity, and resulting color of fig leaf tea. Similarly, Martini et al. [2] conducted a study indicating that with the same drying time but at different temperatures, variations in the contained components of butterfly pea flower tea occurred. Processing leaves into herbal tea also makes leaves with bitter tastes more acceptable, as evidenced by several studies on the processing of various leaves into herbal tea, such as those conducted by Sari et al. [17], Alfira et al. [3], and Martini et al. [2], indicating that, on average, panelists responded neutrally. This suggests that the panelists did not perceive any unpleasant tastes. Development of

takokak leaves into herbal tea has not been conducted. Based on this, research is needed to determine the characteristics of herbal tea leaves regarding drying temperature variations.

II. Materials and Methods

A. Time and place

This research was conducted at the Food Processing Laboratory and Food Analysis Laboratory, Faculty of Agricultural Technology, Udayana University. The study commenced from July to November 2023.

B. Materials

The materials used in the preparation of herbal tea include Takokak leaves (*Solanum torvum Sw*) obtained from Gianyar Regency. The characteristic leaves utilized are the 3rd to 9th leaves from the shoot Putra et al.[11] with modifications. Chemicals used for analysis include Ethanol P/A (*Merck*), DPPH P/A (*Merck*), Folin-ciocalteu (*Supelco*), Sodium carbonate (Supelco), concentrated HCL (*Supelco*), 5% $NaNO_2$ (*Sigma-aldrich*), 10% $AlCl_3$ (*Merck*), Gallic acid (Supelco), Quercetin (*Sigma-aldrich*), Na_2CO_3 (*Supelco*), and Ammonium molybdate (*Supelco*).

The equipment used for processing takokak leaves includes a Food dehydrator (*RSA*), baking trays, scissors, aluminum foil, tweezers, spoons, and glasses. For analysis, the equipment includes an analytical balance (*Ohauss*), aluminum cups, UV-VIS Spectrophotometer (*Biochrom*), micro pipettes (*Accumax*), droppers, beakers (*Pyrex*), measuring glasses (*Pyrex*), and analytical spatulas.

C. Making Takokak leaf herbal tea powder

The process of making Takokak leaf herbal tea powder refers to Putra et al. [11] with modifications. The process begins with sorting, selecting leaves with intact physical shapes and without wilting. After sorting, the takokak leaves are washed with water and then drained, followed by arranging them on aluminum trays and placing them in the food dehydrator. They are then dried at varying temperatures: 40°C, 50°C, 60°C, and 70°C for 24 hours. Once dried, the leaves are reduced in size using a blender and sifted through a 60-mesh sieve. The resulting Takokak leaf herbal tea powder is then analyzed for total phenols [16], total tannins [20], total flavonoids [19], antioxidant activity [18], and vitamin C [23].

D. Making Infusion from Takokak leaf herbal tea

The process of preparing infusion from Takokak leaf herbal tea powder refers to Putra et al. [12] with modifications. The infusion of Takokak leaf herbal tea powder is carried out with boiling water for 5 minutes at a ratio of 1:15 (w/v). Subsequently, sensory properties of Takokak leaf herbal tea were tested using 22 panelists through a hedonic test referring to Lawless [9] for attributes such as color, taste, aroma, and overall acceptances, with criteria ranging from 7 (very liked), 6 (liked), 5 (somewhat liked), 4 (neutral), 3 (somewhat disliked), 2 (disliked) to 1 (very disliked).

E. Data Analysis

The data obtained are analyzed using analysis of variance, and if there is an effect of treatment on the observed variables, it will be followed by Tukey's test using Minitab 19 application.

III. Result and Discussion

A. Total Phenol Content

The analysis of variance results showed that the variation in drying temperature had a very significant effect ($P<0.01$) on the total phenol content of Takokak leaf herbal tea. The total phenol content of Takokak leaf herbal tea can be seen in Fig. 1.

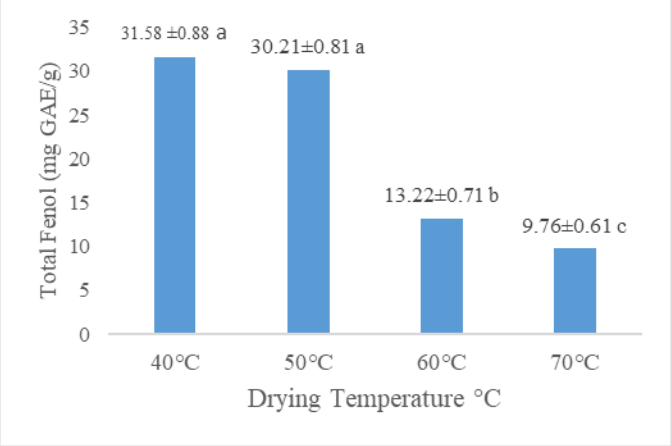

Fig. 1. Total Phenol Content

Based on Fig. 1, the total phenol content of Takokak leaf herbal tea ranged from 9.76 to 31.58 mg GAE/g. The highest total phenol value was obtained at a drying temperature of 40°C, at 31.58 mg GAE/g, which statistically did not differ with drying at 50°C. The lowest total phenol value was obtained at a drying temperature of 70°C, at 9.76 mg GAE/g. The total phenol content of Takokak leaves tends to decrease with increasing drying temperature. This is consistent with the research conducted by Doymaz et al. [6], which reported that the decrease in total phenol value could be attributed to phenolic components vulnerable to heat. A similar finding was also reported in the study conducted by Jamaluddin et al. [8], which also showed similar results of decreasing total phenol values with increasing drying temperature. High drying temperatures can degrade certain bioactive components and result in a decrease in the effectiveness of bioactive components present in the material.

B. Total Tannin

The analysis of variance results showed that the variation in drying temperature had a very significant effect ($P<0.01$) on the total tannin content of Takokak leaf herbal tea. The total tannin values of Takokak leaf herbal tea can be seen in Fig. 2. Based on Fig. 2, the total tannin values range from 0.33 to 0.79 mg TAE/g. The highest total tannin value was obtained at a drying temperature of 40°C, at 0.79 mg TAE/g, while the lowest value was obtained at a drying temperature of 70°C, at 0.33 mg TAE/g.

The decrease in tannin values with increasing drying temperature may occur due to oxidation that occurs in tannins. Tannins are bioactive components commonly found in leaves, as they are one of the secondary metabolite active compounds of the polyphenol group produced by plants [7]. Tannins can oxidize at temperatures of 98.89 - 101.67°C [14]. Although the temperatures used in this experiment did not reach these levels, increasing drying temperatures result will decreased the total

tannin values. This is consistent and supported by the report from Sari et al. [17], which states that the decrease in total tannin values is caused by high drying temperatures. Additionally, it is also stated that tannins have epigallocatechin gallate compounds, which are flavonoid components that act as the largest antioxidants alongside quercetin in flavanol compounds. These tannin components undergo many chemical changes at high temperatures. The oxidation of tannins is influenced by temperature, oxygen, solution pH, and light.

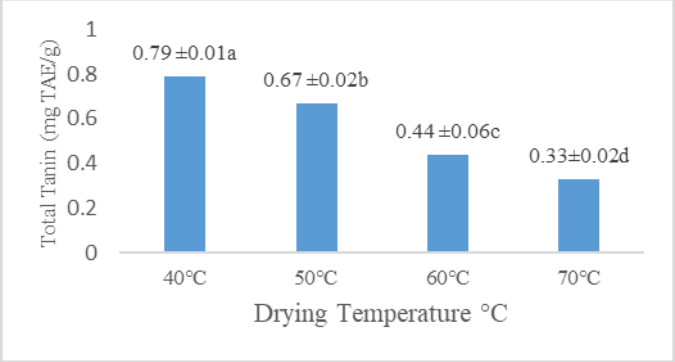

Fig. 2. Total Tannin

C. *Total Flavonoid*

The analysis of variance results showed that drying temperature had a very significant effect (P<0.01) on the total flavonoid content of Takokak leaf herbal tea. Total flavonnoid of takokak leaf herbal tea can be seen on Fig. 3. Based on Fig. 3, the total flavonoid values of Takokak leaf herbal tea range from 4.28 to 15.11 mg QE/g.

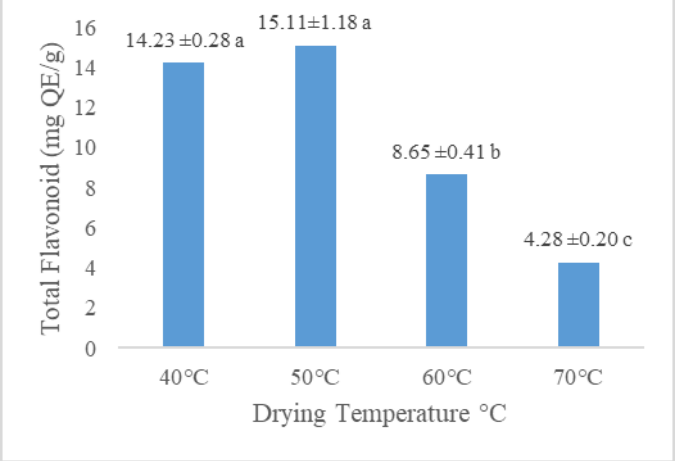

Fig. 3. Total Flavonoid

Flavonoids are secondary metabolite compounds of polyphenols that are widely found in plants or foods and have bioactive effects [4]. The highest total flavonoid value was obtained at a drying temperature of 50°C, at 15.11 mg QE/g, which statistically did not differ with the drying temperature of 40°C, while the lowest total flavonoid value was obtained at a drying temperature of 70°C, at 4.28 mg QE/g. The total flavonoid content decreases with increasing drying temperature. This is consistent with the research conducted by Putri et al. [13] on African leaves, where the total flavonoid value decreased with treatments involving higher heat. This is because flavonoid compounds are thermolabile, which is an active compound sensitive to temperature changes, resulting in flavonoid levels being greatly influenced by treatments that use temperature as a variation [21]

D. *Total Vitamin C*

The analysis of variance results showed that drying temperature had a very significant effect (P<0.01) on the Vitamin C content of Takokak leaf herbal tea. Total Vitamin C of takokak leaf herbal tea can be seen on Fig. 4.

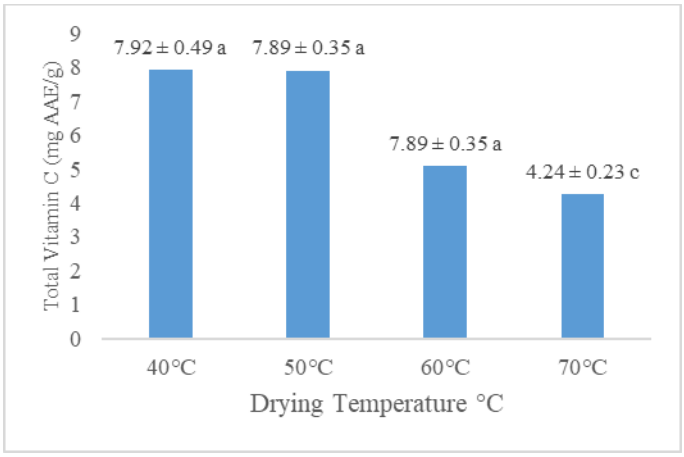

Fig. 4. Total Vitamin C

Based on Fig. 4, the highest Vitamin C content was obtained at a drying temperature of 40°C, with a value of 7.92 mg AAE/g, which statistically did not significantly differ from the drying temperature of 50°C. The lowest value was obtained at a drying temperature of 70°C, with a value of 4.24 mg AAE/g. Vitamin C is an organic substance required by the human body in small amounts, playing a role in maintaining metabolic functions and acting as an antioxidant [15]. Despite its benefits, Vitamin C has a drawback in processing, which is temperature changes, so to obtain the benefits of Vitamin C, the right processing temperature is required. This decrease may be caused by the fact that at high temperatures, the molecules that make up Vitamin C break their bonds, causing Vitamin C to decompose or degrade [24]. The decrease in Vitamin C content due to high drying temperatures also occurred in the research conducted by Yulianto et al. [25], which reported a significant decrease in Vitamin C content in lime wedang with high-temperature heating.

E. *Antioxidant Activity*

The analysis of variance results showed that drying temperature had a very significant effect (P<0.01) on the antioxidant activity of Takokak leaf herbal tea. Antioxidant activity of takokak leaf herbal tea can be seen on Fig. 5.

The average antioxidant activity of Takokak leaf herbal tea ranges from 23.59% to 84.26%. The highest antioxidant activity was obtained at a drying temperature of 40°C, at 84.26%, while the lowest value was obtained at a drying temperature of 70°C, at 23.59%. Based on Fig. 5, the antioxidant activity of Takokak leaf herbal tea decreases with increasing drying temperature. Antioxidants are bioactive compounds that have many benefits for the human body, one of which is to counteract free radicals,

but antioxidants are not stable to temperature changes. This is consistent with several other parameters of bioactive components that also decrease with increasing drying temperature. This is because bioactive components such as phenols, flavonoids, tannins, and Vitamin C also function as antioxidants. The decrease in antioxidant activity with increasing drying temperature also occurred in the research conducted by Taufik et al. [22]. In their study, it was mentioned that the decrease in antioxidant activity is influenced by oxidized bioactive components due to the increase in temperature.

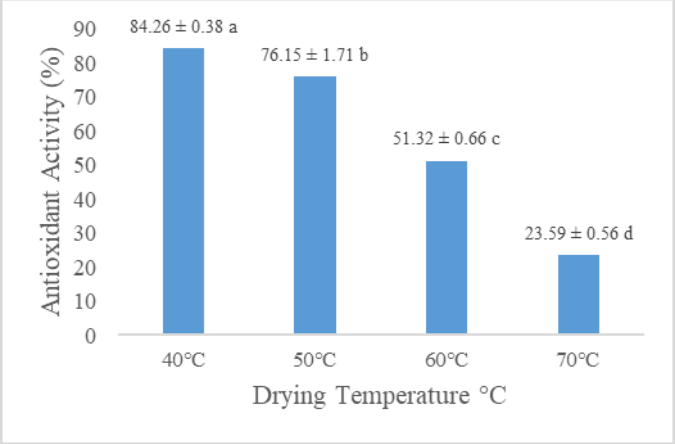

Fig. 5. Antioxidant Activity

F. Sensory Evaluation

The sensory evaluation of takokak leaf herbal tea can be seen on Table 1.

TABLE 1. SENSORY EVALUATION

Treatment	Sensory Evaluation			
	Colour	*Aroma*	*Taste*	*Overall Acceptances*
40ºC	5.73±0.88 a	5.27±1.08 ab	3.77±0.81 b	3.91±0.68 b
50ºC	5.32±0.48 ab	5.73±0.94 a	4.09±0.81 ab	4.14±0.71 b
60ºC	4.95±0.95 bc	4.50±1.63 bc	4.91±0.92 a	4.91±0.87 a
70ºC	4.64±0.90 c	4.32±1.43 c	3.95±1.46 b	4.05±1.00 b

Colour

The analysis of variance results showed that drying temperature had a very significant effect (P<0.01) on the hedonic test for the color attribute of Takokak leaf herbal tea. Based on Table 1, the average liking scores for the color of Takokak leaf herbal tea ranged from 4.64 (Somewhat liked) to 5.73 (Liked). The highest average liking score for the color attribute of Takokak leaf herbal tea was obtained at a drying temperature of 40°C, at 5.73 (Liked), which was not statistically different from the drying temperature of 50°C. Meanwhile, the lowest average liking score for the color attribute was obtained at a drying temperature of 70°C, at 4.64 (Somewhat liked), which was not statistically different from the drying temperature of 60°C. Takokak leaves undergo color changes when dried, as chlorophyll undergoes degradation influenced by the drying temperature. Leaves dried at higher temperatures tend to produce darker tea compared to those dried at 40°C. Based on the results obtained from the hedonic test for the color attribute of Takokak leaf herbal tea across all drying temperature variations, it is indicated that it is still liked by the panelists.

Aroma

The analysis of variance results showed that drying temperature had a very significant effect (P<0.01) on the hedonic test for the aroma attribute of Takokak leaf herbal tea. Based on Table 1, the average liking scores for the aroma of Takokak leaf herbal tea ranged from 4.32 (neutral) to 5.73 (Liked). The highest hedonic test score was obtained at a drying temperature of 50°C, at 5.73 (Liked), which was not statistically different from the drying temperature of 40°C. Meanwhile, the lowest average hedonic test score for the aroma attribute of Takokak leaf herbal tea was obtained at a drying temperature of 70°C, at 4.32 (Neutral), which was not statistically different from the drying temperature of 60°C. The aroma of a material is influenced by its volatile compound content; the more volatile compounds it contains, the stronger the aroma produced [10]. Based on the results obtained, it can be indicated that the panelists still accept the aroma of Takokak leaf herbal tea across all drying temperature variations.

Taste

The analysis of variance results showed that drying temperature had a very significant effect (P<0.01) on the hedonic test for the taste attribute of Takokak leaf herbal tea. Based on Table 1, the average liking scores for the taste of Takokak leaf herbal tea ranged from 3.77 (neutral) to 4.91 (Somewhat liked). The highest average hedonic test score for the taste attribute of Takokak leaf herbal tea was obtained at a drying temperature of 60°C, at 4.91 (Somewhat liked), which was not statistically different from the drying temperature of 50°C. Meanwhile, the lowest average hedonic test score for the taste attribute of Takokak leaf herbal tea was obtained at a drying temperature of 40°C, at 3.77 (Neutral), which was not statistically different from the Takokak leaf herbal tea with a drying temperature of 70°C. The liking score for the taste of Takokak leaf herbal tea is influenced by the bioactive components present in the material. Takokak leaves tend to have a bitter taste, caused by the presence of flavonoids in the leaves [5] and also the high tannin content in the leaves, which makes the taste bitter [17]. Based on the chemical analysis of tannin and flavonoid content in Takokak leaves, it is shown that the treatment at 40°C has the highest tannin and flavonoid content, indicating that this treatment has the most bitter taste among the others. Based on the results obtained, the taste of Takokak leaf herbal tea is indicated to still be acceptable to the panelists across all drying temperature variations.

Overall Acceptances

The analysis of variance results indicate that drying temperature had a very significant effect (P<0.01) on the hedonic test for the overall acceptances of Takokak leaf herbal tea. Based on Table 1, the overall acceptances of Takokak leaf herbal tea ranged from 3.91 (Neutral) to 4.91 (Somewhat like). The highest overall acceptance score for Takokak leaf herbal

tea was obtained at a drying temperature of 60°C, with a score of 4.91 (Somewhat liked), while the lowest score was obtained at a drying temperature of 40°C, with a score of 3.91 (Neutral), which was not statistically different from the drying temperatures of 50°C and 70°C. The results of the overall acceptance test are influenced by other attributes such as color, taste, and aroma. Based on the results obtained, it is indicated that the panelists still accept the Takokak leaf herbal tea produced based on all drying temperature variations.

IV. Conclusion

This research can be concluded that the variation in drying temperature had a very significant effect on the total phenol, tannin, flavonoid, vitamin C content, antioxidant activity, and sensory attributes (color, aroma, taste, and overall acceptances) of Takokak leaf herbal tea. The best treatment was achieved at a drying temperature of 40°C, with total phenol content of 31.58 mg GAE/g, total tannin content of 0.79 mg TAE/g, total flavonoid content of 14.23 mg QE/g, total vitamin C content of 7.92 mg AAE/g, antioxidant activity of 84.26%, and sensory attributes ratings for color, aroma, taste, and overall acceptance were respectively 5.73 (Liked), 5.27 (Somewhat liked), 3.77 (Neutral), and 3.91 (Neutral).

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