Effect of Withering and Drying Process of Cemara Udang (*Casuarina equisetifolia*) Leaves to Functional Herbal Tea

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ABSTRACT

The industry is intensively producing health product from herbal plants to combat free radicals and prevent the potential of cancer disease in the body. In Indonesia, Cemara Udang (*Casuarina equisetifolia*) leaves have been investigated as herbal tea product for antioxidant purposes as a free radical scavenger from various plants. This herbal tea requires significant attention during processing to produce a quality final product. Therefore, this research aimed to examine the effect of setting withering times of 14 and 16 hours, along with a drying temperature of 40 and 50 °C on cemara udang leaves. Product quality was evaluated based on the chemical components and nutritional characteristics of tea, such as moisture content, pH, antioxidant activity, total phenolic content, and vitamin C, as well as sensory aspects. The evaluation was carried out based on the degree of preference for color, aroma, and taste. Fresh cemara udang samples had 46.57% moisture content, pH 7.05, 131.53 µg/mL IC_{50} value, 1.53 mg/100 g total phenolic, and 43.46% vitamin C. Based on the degree of preference, color, flavor, and taste hedonic score had 3.11, 2.57, and 1.94 out of 7.00, respectively. Tea of cemara udang that was withered for 16 hours and dried at 50°C showed good quality stability with favorable sensory attributes. This varies significantly compared to the control, with 10.32% moisture content, pH 7.04, 137.94 µg/mL IC_{50} value, 1.2 mg/100 g total phenolic, and 29.26% vitamin C. Furthermore, color, flavor, and taste hedonic scores had 6.37, 6.03, and 6.27 out of 7.00, respectively.

Keywords: Cemara udang leaves; drying; herbal tea; quality; withering

INTRODUCTION

Various lifestyle patterns are providing different metabolic systems in the human body due to the selection of diet, daily activities, and sleep quality (Sharifi-Rad et al., 2020). However, society is not aware that an unhealthy lifestyle can generate excess free radicals (Tapan et al., 2020), which are molecular fragments with unpaired electrons capable of triggering the development of various chronic diseases, including cancer (Sharifi-Rad et al., 2020)(Sharma et al., 2022). Since the recognition of the risk of free radicals in human biological systems in the last few decades, prevention and treatment research have gained significant attention (Martemucci et al., 2022). Motivation by industry and the health department for the development of health products from herbal plants is also the best alternative for suppressing the growth of free radicals other than medical drugs or supplements (Rollando et al., 2023) (Yin et al., 2013). Therefore, herbal plants high in antioxidants are promoted as a functional food to combat the number of pro-oxidants in the body (Nwozo et al., 2023).

The abundance of plant diversity in Indonesia provides excellent potential for exploitation, particularly in making herbal consumption products (Yuniati et al., 2021). The exploration of coastal forest vegetation as medicinal plants is essential for further in-depth apart from empirical analysis (Duryat et al., 2023). For example, cemara udang, the Indonesian name for

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beach sheoak (scientific name: *Casuarina equisetifolia*), is among the fast-growing plant that is often found in the city of Surabaya, East Java, Indonesia. This plant thrives in various locations including in the Pakal Mangrove Forest of Gunung Anyar, the Bulak Kenjeran area around the Suramadu Bridge, the Pakal Benowo City Forest, and the Wonorejo-Rungkut Mangrove Forest Area (Angio et al., 2022). Previous research has shown that cemara udang leaves with 10-50 m branches contain sterol antioxidant compounds that can contribute to anti-hypoglycemic and anti-cancer properties (Angio et al., 2022; Tiwari & Talreja, 2023). However, the application is only limited to decorative or abrasion protection trees, requiring further exploration for use in consumption as tea (Syahbudin et al., 2013).

Tea is a type of product that is capable of delivering functional compounds to raw materials, proposing it is acceptable for human consumption (Arbella & Widodo, 2023). Moreover, tea consumption culture in social life has also expanded due to positive health affirmations which are very essential in today's modern life (Zhou et al., 2023). According to (Liu et al., 2023), tea beverage is made from leaves containing tannins and polyphenols, which are dried, brewed with hot water, and consumed for the active compound extracts. Currently, herbal tea is being promoted for a dietary purposes plants due to the use of unique raw materials such as leaves, fruit, seeds, flowers, roots, and stems from plant species other than *Camellia sinensis L* (Zhao et al., 2013). Previous research had reported the ability of coastal plant from *Acanthus Ilicifolius* to be converted into herbal tea products (Wijayanti et al., 2023). By considering the compound content of cemara udang leaves, this plant shows potential to be processed into herbal tea as a functional beverage beneficial for health.

During tea production, the lack of proper production procedure, particularly the withering and drying process, can influence product quality (Zeng et al., 2020). Withering maintains the quality of tea from the potential enzymatic oxidation process which can cause significant damage (Maulana et al., 2020). Previous research has identified the role of withering on the flavonoid metabolomic of Wuyi Rock Tea (Jia et al., 2023), including the flavor formation of black tea (Wenjing Huang et al., 2023) and Taiping Houkui tea (Qiao et al., 2023). Drying is also important to reduce the moisture content of the material and inhibit the growth of bacteria or mold contaminants, thereby increasing longer shelf life (Ji-U & Apisittiwong, 2022). Research on tea leaves drying to 50% of moisture content has proven its effectiveness in improving vitamin and free radical scavenging activity by DPPH test (Wickramasinghe et al., 2020). A major drying method that is widely applied is a food dehydrator, which can provide stability to the bioactive components in the material and maintain functional quality (Yulianti, 2019).

Based on the description, this research aimed to explore the use of cemara udang leaves to produce herbal tea with acceptable nutritional and sensory properties. The research included two different withering times (Deb & Jolvis Pou, 2016) and drying temperatures (Yan et al., 2023). The dried leaves were primarily tested for phytochemical to evaluate the suitability of tea product in providing health benefits. The quality value was tested by investigating the moisture content, acidity (pH), antioxidant activity, total phenols, and vitamin C. Meanwhile, the sensory evaluation was conducted by assessing the acceptability of herbal tea products. The results were expected to increase the quality selling value of the cemara udang plant as a functional drink with antioxidant content, apart from being an ornamental plant.

METHODS

Materials

Cemara udang leaves were obtained from Pakal Forest, Gunung Anyar Mangrove Area, and Sumur Welut City Forest in Surabaya, East Java, Indonesia. The leaves were fresh samples that had been picked, green appearance, with the complete branches. The chemicals used were 1,1-diphenyl-2-picrylhydrazyl or DPPH ($C_{18}H_{12}H_5O_6$, 100%, Aldrich), 96% ethanol (C_2H_5OH, 98%, Merck), ascorbic acid ($C_6H_8O_6$, 99%, Chameleon reagent), distilled water, and sulphuric acid (H_2SO_4, 98%, Merck). Other chemicals used were Potassium iodate (KIO_3), Potassium Iodide (KI), starch indicator, Sodium thiosulfate ($Na_2S_2O_3$), Folin-Ciocalteu reagent, and Sodium carbonate (Na_2CO_3). The equipment used were plastic basin, cake jar, cake pan, food dehydrator (16 tray, Li Bai), analytical balance (ATX324, Shimadzu), kitchen scale, spatula, measuring pipette, dropper, beaker, measuring flask, tea bag, mortar, burette, Erlenmeyer, blender (Kirin, KBB 250 PL1), and pH meter (SP 2500, Suntex).

Research Design

As shown in Table 1, this research used a Completely Randomized Design (CRD) method with two factors and two levels (2 × 2 factorial), namely withering time (14 and 16 hours) (Deb & Jolvis Pou, 2016) and drying temperature (40 and 50 °C) (Yan et al., 2023). The data obtained was analyzed for variance using one-way ANOVA and Duncan test was performed when there were statistical differences in results between treatments.

Table 1. Experimental design with withering and drying variations in producing cemara udang herbal tea

Variable	Withering (hour)	Drying (°C)
P0	-	-
P1	14	40
P2	16	40
P3	14	50
P4	16	50

Herbal Tea Production

Freshly picked cemara udang leaves were initially sorted to remove the stems, followed by washing, cleaning, and draining. The leaves were placed on a net on several baking sheets and spread thinly in one layer to avoid overlapping. Subsequently, withering was carried out for 14 and 16 hours in a room with airflow from a low-speed fan, followed by drying in a food dehydrator at 40°C and 50°C for 2 hours. The dried leaves were ground with a blender to obtain fine leaves powder, sieved using a kitchen sieve, and analyzed for moisture content, pH, antioxidant activity level, vitamin C, and organoleptic tests, as shown in Figure 1.

Phytochemical Screening Test

Phytochemical screening of dried leaves was carried out by testing the content of tannins, saponins, flavonoids, alkaloids, steroids, and phenols. Qualitative testing of samples followed the method references from scientific reports that examined phytochemical tests on medicinal leaves. Several methods were adopted, including ferric chloride for tannins and phenols, foam and alkaline for saponin detection, as well as Salkowski for steroid detection (Rajkumar et al., 2022). Meanwhile, quantitative estimation of dry leaves adopted reference methods from related scientific reports (Mujeeb et al., 2014).

Moisture content

Moisture content testing used gravimetry method, adapting to AOAC method (925.10-1995) (Wandira et al., 2023). Initially, a known mass of cemara udang tea was placed in a petri dish. The drying process was carried out by putting petri dish in an oven set at 105°C for 12 hours. After heating, the petri dish containing the sample was taken out and immediately placed in the desiccator. Every 30 minutes, the petri dish containing the sample was weighed repeatedly, as oven drying process and desiccator storage were being carried out to obtain constant weight. The percentage of moisture content was obtained by Equation 1 formula.

$$Water\ Content\ (= \frac{(W_1 - W_0)}{W_0} \times 100\% \quad (1)$$

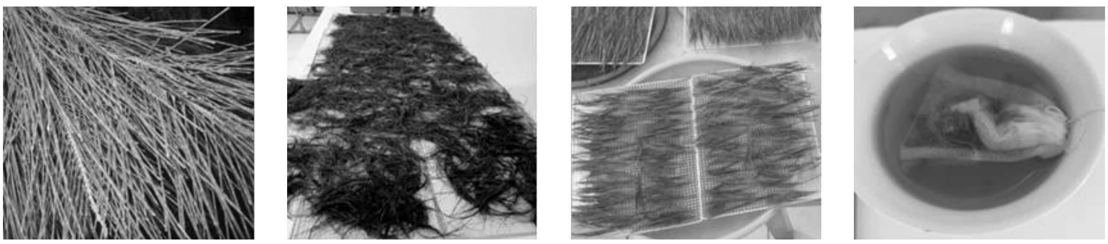
where: W_0: the mass of sample before treatment and W_1: the mass of dried sample.

pH Measurement

pH testing was carried out on cemara udang leaves tea tea bag samples which had been dissolved in 250 mL of hot water at a temperature of 90°C and left for 5 minutes (Wang et al., 2024). This testing used a pH meter calibrated with pH 7 and 4 buffer. The calibrated electrode was dipped into the sample of tea solution until a visible value was shown on the pH meter and waited a few moments to achieve a constant value. Moreover, this test was repeated three times for the same sample.

Antioxidant Activity

Antioxidant Activity testing used DPPH method according to Manongko et al., (2020). Initially, DPPH solution was prepared at a concentration of 0.4 mM in 96% ethanol. The sample solution being tested was diluted with various concentrations of 2.5, 5, 10, and 20 µg/mL with a total volume of 1 mL and put into a test tube as a test solution and also made into a blank.



(a) (b) (c) (d)

Figure 1. (a). The fresh sample (b), withering process (c), drying process (d), tea of cemara udang leaves

This was followed by the addition of 0.2 mL of DPPH solution to the test tube and incubated for 30 minutes in dark conditions. The DPPH method of antioxidant testing analysis was carried out by observing the color change of the sample after incubation with 0.2 mL of DPPH solution for 30 minutes. The samples were measured using a UV-visible spectrophotometer and the absorbance value was recorded at a wavelength of 517 nm. The IC_{50} value calculation was expressed using a linear regression equation, and the free radical scavenging activity was determined with the equation below.

$$Antioxidant\ Activity\ (= \frac{(A_{control} - A_{sample})}{A_{control}} \times 100\% \qquad (2)$$

where:
$A_{control}$: absorbance of DPPH
A_{sample}: absorbance of sample with DPPH

The IC_{50} (Inhibitory Concentration) value was obtained from the linear regression equation of extract concentration (µg/mL) on the free radical scavenger activity value (%). The criteria for an antioxidant were robust, substantial, medium, and frail when the IC_{50} value was less than 50, 50-100, 100-150, and 151-200, respectively (Yuniarti et al., 2020).

Phenolic Content

Total phenolic testing of cemara udang leaves tea was carried out using the Folin-Ciocalteu reagent. Gallic acid was used as a standard solution to create a standard curve (linear regression), before testing the real sample. A solution of gallic acid in 96% ethanol solvent was prepared by making five concentration points. Subsequently, 200 µL of each concentration was taken and 10 mL of distilled water and 1 mL of Folin-Ciocalteu reagent were added, followed by 1 mL of 5% Sodium Carbonate (Na_2CO_3) solution The mixture was incubated for 1 hour in the dark at room temperature and the absorbance of the compound at a wavelength of 725 nm was measured using a spectrophotometer. The total phenolic value was expressed in mg Gallic acid equivalent per 100 g of material (Hidayati et al., 2020).

Vitamin C

As an antioxidant, vitamin C levels were measured based on the iodometric method (Septyani, 2021). Initially, the sample was mixed in an Erlenmeyer by adding 10 mL of sulfuric acid and 5 mL of distilled water. This was followed by the addition of 0.5 g of Potassium Iodide and 6.25 mL of standard potassium iodate solution. Titration was carried out using Sodium Thiosulfate until a pale yellow color formed, which was added with starch indicator to obtain a blue color. Subsequently, titration was conducted again using Sodium Thiosulfate until the blue color disappeared, and the volume used was recorded. At the endpoint of the titration, all the vitamin C would have reacted with iodine.

Table 2. Organoleptic testing scales and categories of cemara udang leaves tea

Scale	Category
1	Dislike very much
2	Dislike moderately
3	Dislike slightly
4	Neither like nor disklike
5	Like slightly
6	Like moderately
7	Like very much

Hedonic Testing

After carrying out physical and chemical tests as preliminary parameters in guaranteeing the benefits of the final product, hedonic testing was performed to determine the level of acceptance of the product taste by consumers. The results of several clinical properties for health purposes and a cytotoxic showed that cemara udang leaves were safe for use by humans. These leaves also possessed good antioxidants, showing the safety of conducting hedonic testing (Handarini et al., 2024).

The leaves powder of cemara udang was stored in tea bags, each containing 3 g. In organoleptic testing, each sample in a tea bag packaging was brewed using 250 mL of hot water at 90°C for 5 minutes, followed by dregs separation. Organoleptic testing was carried out by preparing 30 mL of cemara udang tea solution to be given to 30 untrained panelists with healthy criteria (not sick with the flu or impaired sense of taste), aged 18-60 years, and had the habit of drinking tea (at least once a week). This process was carried out by filling out an e-questionnaire with a sensory test in the form of an assessment of color, aroma, and taste, using a scale of 1-7 with the criteria shown in Table 2 (Tandhanskul et al., 2021).

RESULTS AND DISCUSSION

This research successfully developed tea beverage product using cemara udang plants as the main ingredient. The phytochemical screening results are summarized in Table 3 and quality of the final product after four treatments in the withering and drying process were shown in Table 4.

Table 3. Results of phytochemical screening tests of cemara udang leaves

Parameters	Results	Positive/negative	Quantitative
Tanin	Green or blackish blue	+	1.41 mgTAE/100 g
Saponin	Forms foam as high as 1.5 cm for 30 seconds	+	0.50 mg/100 g
Flavonoid	Reddish orange	+	21.21 mg QE/100 g
Alkaloid	With Mayer's reagent, an orange precipitate is formed	+	39.45 mg/100 g
Steroid	A greenish blue ring is formed	+	1.18 mg/100 g
Phenol	Black bluish to dark black	+	1.27 mg GAE/100 g

Table 4. Effect of different withering and drying processes on the moisture content, pH, antioxidant, total phenolic content, and vitamin C of cemara udang leaves tea

Quality aspects	Average ± SD				
	P0	P1	P2	P3	P4
Moisture content (%)	46.57 ± 0.017[d]	17.55 ± 0.023[c]	15.56 ± 0.015[b]	10.78 ± 0.020[a]	10.32 ± 0.021[a]
pH value	7.05 ± 0.010[a]	7.08 ± 0.015[a]	7.02 ± 0.012[a]	7.04 ± 0.015[a]	7.04 ± 0.012[a]
Antioxidant IC_{50} value (mg/mL)	131.55 ± 0.020[a]	185.55 ± 0.029[d]	168.95 ± 0.016[c]	141.01 ± 0.030[b]	137.94 ± 0.020[b]
Total phenolic Content (mg/100 g)	1.53 ± 0.031[d]	0.57 ± 0.012[a]	0.68 ± 0.010[b]	0.73 ± 0.015[b]	1.20 ± 0.040[c]
Vitamin C (%)	43.46 ± 0,0058[e]	25.81 ± 0.0306[a]	28.98 ± 0,0351[b]	29.06 ± 0,0252[c]	29.26 ± 0.0300[d]

Note: Different superscripts on the same rows indicate significant differences ($p<0.05$) with Duncan test.

Phytochemical Evaluation

Phytochemical screening test is an initial test carried out on plants to determine the secondary metabolite compounds. Based on Table 3, cemara udang leaves showed positive qualitative test results containing tannins, saponins, flavonoids, alkaloids, steroids, and phenolic compounds.

The presence of tannins and phenolic compounds in the cemara udang leaves promoted their potential as free radical scavenger and anticancer agents through several mechanisms including eliminating carcinogenic agents and inducing cell apoptosis programs. The alkaloid and saponin compounds also possessed antioxidant effects by forming reactive species such as hydroperoxide and superoxide as antioxidants, thereby inhibiting the formation of lipid peroxide. Flavonoid and steroid compounds could act as pro-oxidant agents which had antioxidant, antibacterial, and anti-inflammatory activities (Rajkumar et al., 2022).

Moisture content

Moisture content is essential in determining the characteristics of food ingredients, which contributes to stability and shelf life (Lagawa et al., 2019). High moisture content causes food products to be more susceptible to quality degradation due to the threat of the growth of undesirable microorganisms (Adhamatika et al., 2021). In this research, a combination of the withering and drying process of cemara udang leaves was required to monitor the reduction of moisture content, ensuring that the herbal tea product was suitable for commercialization.

Based on Table 4, fresh cemara udang leaves before treatment had a moisture content of 46.57%. After being subjected to the withering and drying process, moisture content was 17.54% (P1), 15.56% (P2), 10.78% (P3), and 10.32% (P4). This research data showed that cemara udang leaves subjected to 16-hour withering process had lower (better) moisture content than the 14-hour. Additionally, samples treated at a drying temperature of 50°C had a lower percentage of moisture content than leaves that were dried at 40°C.

Samples P3 and P4 had moisture content percentages that were not significantly different. This was due to their similarity with quality parameters for tea products based on the Indonesian national standard, SNI 01-3836-2013, which specified 8% moisture content (Atmaja et al., 2021). The moisture content value of the product was still 2% different from the standard point, showing more sensitivity to their resistance to enzymatic oxidation (Abudureheman et al., 2022). Therefore, product packaging technology, such as vacuum packaging was recommended to maintain the moisture content of the product (Purwidiani et al., 2020). In this case, the drying temperature was considered to have a more significant influence on the quality of cemara udang leaves herbal tea than the withering time. Therefore, sample P4 was assessed as the tea product with the best moisture content compared to others. Similar research also reported success in reducing the percentage of moisture content in Liang leaves and red sweet corn by determining the drying process (Anisong, 2024; Ji-U and Apisittiwong, 2022).

pH value

The pH value is the degree of acidity, which implies the level of acidity and alkalinity of a solution (Adhamatika et al., 2021). In this research, the pH of brewing cemara udang leaves tea was measured to determine the level of acidity contained in the leaves after withering and drying. In addition to product stability, the acidity level was also related to the product acceptance level during consumption, as it could reduce the quality of herbal tea products (Rizki et al., 2023).

In this research, the acidity levels of samples P0, P1, P2, P3, and P4 were not significantly different. This showed that the pH of cemara udang leaves tended to be relatively the same before and after treatment. The five samples had pH values of 7.02 to 7.08, which could be considered close to neutral, similar to green tea extract from reference (Rizki et al., 2023). The neutral tea showed that withering had been carried out appropriately, preventing the enzymatic oxidation process. This was significant considering the low pH in several fermented tea, including oolong and black, which predominantly contain polyphenol oxidation products such as theaflavins and thearubigins (Engelhardt, 2020).

Antioxidant Activity

Antioxidant compounds are required to prevent oxidative stress and cell damage of various degenerative diseases such as cancer, stroke, and coronary artery disease (Bijauliya et al., 2017). These compounds work by protecting body cells from chemical species formation with unpaired electrons (Di Meo & Venditti, 2020). Antioxidant analysis of samples with DPPH represents the ability of the active compounds of cemara udang to combat DPPH free radicals (Suryanti et al., 2020).

Table 4 shows that fresh cemara udang leaves (P0) have a medium antioxidant capacity of 131.53 µg/ml. When processed into tea using the withering and drying process, P0 has IC_{50} values ranging from weak to moderate at 137.94 µg/mL to 185.55 µg/mL. This showed that the withering and drying processes affected the antioxidant activity of cemara udang tea products. Therefore, tea product provided antioxidant activity, which was slightly lower than fresh leaves, but had no significant destructive impact.

The four different processing treatments significantly affected the antioxidant capacity of cemara udang leaves. Concerning the period of the withering process, the 16-hour produced leaves with better antioxidant activity compared to 14-hour. Meanwhile, considering the temperature of the drying process, a difference of 10°C in temperature also increased the antioxidant activity. In this research, 16-hour withering process and drying at 50°C (P4) produced herbal tea with the best antioxidant content. This data trend was similar to previous research, where longer withering time increased the antioxidant activity by around 8% (Sari, 2013). During withering and drying, the conversion process of theanine to catechins was high, affecting the number of antioxidants measured in the DPPH test (Huang et al., 2022). However, this research showed the effectiveness of using a food dehydrator as a method to produce dry tea products by maintaining antioxidant activity such as the fresh raw material (Fatchullah et al., 2022). Hossen et al., (2014) stated that cemara udang leaves had bioactive components such as flavonoids, tannins, and phenols, acting as antioxidant. The presence of tannic acid, confirmed from phytochemical screening, suggested potential antioxidant activity as a valuable natural source antioxidant.

Total Phenolic Content

The phenolic group is well represented as the most prominent compound contributing to antioxidant activity. The aromatic ring of phenolic compounds consists of one or more hydroxy groups capable of donating hydrogen atoms to free radicals (Rachmawaty et al., 2019). In this research, the phenolic content was measured using the Folin-Ciocalteu reagent in each extract, which caused a color change from yellow to blue. The blue color was directly proportional to the concentration of phenolic ions formed in the basic solution after the Folin-Ciocalteu reduction reaction occurred by the hydroxyl group. Moreover, a higher concentration of phenolic compound correlated with greater scavenging of free radical (Hidayati et al., 2020).

The fresh cemara udang leaves (P0) have a high phenolic content of 1.53 mg/100 g. The withering and drying process increased the content to 0.57 (P1), 0.68 (P2), 0.73 (P3), and 1.20 (P4) mg/100 g, as shown in Table 4. The minimum decrease was found in the sample P4, accounting for a 22% reduction, compared to P0. The pattern of total phenolic content due to the withering and drying process was directly proportional to the antioxidant activity trend data of the sample in the previous research (Sari, 2013).

Vitamin C Content

Vitamin C (ascorbic acid) is a water-soluble vitamin classified as an indispensable nutrient (Mellidou et al., 2021). In the human body, ascorbic acid can inhibit the occurrence of diseases caused by oxidative stress, thereby the functionality is associated with an antioxidant compound (Villagran et al., 2021). Vitamin C levels were tested on cemara udang leaves, with a compound percentage of 43.46% in cemara udang leaves without any treatment (P0), as shown in Table 4.

Withering and drying processing caused a decrease in the vitamin C content of cemara udang leaves from 14 to 17% compared to fresh ones. As shown in Table 4, the pattern of decreasing vitamin C levels was not similar to antioxidant levels. However, a similar trend was observed in previous scientific reports, where tea processing increased antioxidant activity, flavonoid, and chlorophyll content, but reduced vitamin C levels (Sari, 2013). Heat could destroy the ascorbic acid and oxidize it into dehydro-form, as shown in Figure 2 (Morelli et al., 2020). The highest decrease in vitamin C levels was in sample P1 (25.80%), while the minimum decrease was in sample P4 (29.26%). Vitamin C levels in samples P2, P3, and P4 were not significantly different, indicating that P1 had a more significant impact on reducing vitamin C levels than the other three samples. After comparing the vitamin C level data again in the four samples, the period of the withering process plays a more significant role in reducing the percentage of vitamin C levels than the drying process. One factor behind the significant decrease in vitamin C levels in sample P1 is the defective process of stopping the enzymatic reaction during the 14-hour withering process of cemara udang leaves (Mellidou et al., 2021) (Maulana et al., 2020).

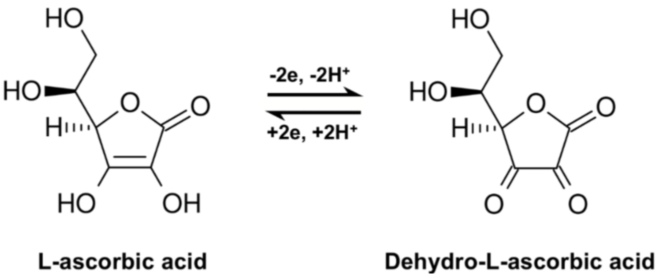


Figure 2. Reaction mechanisms of vitamin C when exposed to heat

Hedonic Analysis

The hedonic test is carried out to determine the degree of preference for a product being consumed. During this test, an assessor will provide a response to the degree of preference by selecting a liking scale based on observations using the human senses (Gusti et al., 2022). Variations in processing affected the quality of the taste, in addition to the physical and chemical parameters of the leaves

The influence of the withering and drying process on the organoleptic properties of cemara udang leaves herbal tea is shown in Table 4, with the radar chart shown in Figure 3. The testing parameters included color (sight), aroma (smell), and taste. By establishing a 7-hedonic scale, the tested herbal tea products could be evaluated for their acceptability.

Color was the first sensory characteristic reviewed in hedonic testing. Before being processed, cemara udang leaves (P0) had a cloudy green color, and when processed into herbal tea (P1, P2, P3, and P4), the product had a green to yellow-brownish color, as shown in mineral water. The sensory test data in Table 4 showed that the withering and drying process influenced the color assessment results ($p<0.05$). The most preferred color intensity of cemara udang leaves tea was produced by the P4 with 16 hours of withering and drying at a temperature of 50°C (average 6.37, category: like moderately). The lowest was produced by P0, which had an average of 4.11 and was found in the neither like category. From the average results, the panelists were less interested in the color given by P0, P1, and P2, while sample P3 was considered neutral. Sample P4 had a brownish-yellow color, which matched the characteristics of tea desired on the market.

Based on the flavor aspect, hedonic test data showed that withering and drying processes influenced the aroma produced, as shown in Table 4. The highest average score was in P4 sample, with a value of 6.03 (like slightly), and the lowest score of 3.87 was in P0, which was in dislike slightly category. Samples P1 and

Table 5. Hedonic test results of cemara udang leaves tea with different withering and drying processes

Sensory Attributes	P0	P1	P2	P3	P4
Color	4.11^a	4.43^b	4.80^c	5.66^d	6.37^e
Flavor	3.57^a	4.20^b	4.47^b	5.37^c	6.03^d
Taste	2.94^a	4.40^b	4.67^b	5.57^c	6.27^d

Note: Different superscripts on the same rows indicate significant differences ($p<0.05$)

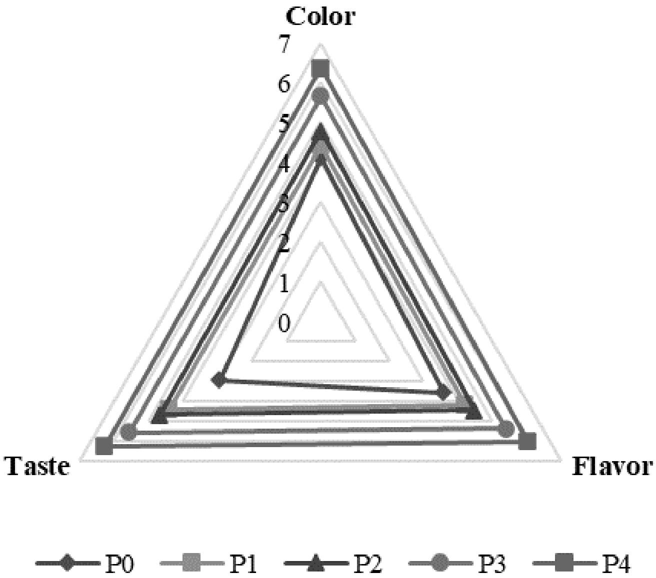


Figure 3. Hedonic scheme of Cemara Udang leaves herbal tea

P2 were considered not significantly different from the assessments' average. The aroma of P3 and P4 was more favorable compared to other samples. This preferred flavor could be influenced by the breakdown of organic compounds in the base material of cemara udang leaves tea when subjected to withering and drying processing at a suitable time and temperature.

According to taste attribute, both processes had a significant influence on the taste of the resulting product (p<0.05). In the P0 (control) sample, the panelists rated "dislike very much" or unacceptable with an average score of 2.94. P1 and P2 were also not considered satisfactory to the panelists having an average acceptance score of 4.40 and 4.67, respectively ("neither like). Drying at 40°C was insufficient to produce the desired quality of tea, thereby the product tends to taste bitter due to the flavonoid, steroid, alkaloid, and tannin compounds (Qiao et al., 2023). By increasing the drying temperature to 50°C, the product hedonic score more acceptable, with an average score of 5.57 (P3) and 6.27 (P4). The panelists assessed these two samples as producing more favorable taste. Apart from the color and aroma aspects, P4 was considered superior in taste compared to other sample variables evaluated in hedonic test.

CONCLUSION

In conclusion, this research successfully developed herbal tea products using cemara udang leaves as the primary material. To create efficacious herbal tea products with depth value for consumption and commercialization purposes, the processing of cemara udang leaves tea was explored by evaluating the withering and drying processing. All parameters such as moisture content, pH, antioxidant activity, vitamin C, and hedonic tests were assessed. Compared to the control variables (P0), the withering process tended to influence the quality of vitamin C in the final product. The drying process also showed a more prevalent effect on the reduction of moisture content and antioxidants by DPPH. Both processes influenced the hedonic assessment of color, aroma, and taste but did not affect the pH value of all product variables. This research concluded that withering for 16 hours with a drying temperature of 50°C (P4) provided the best quality of the final product. P4 had the most sensory pleasing, with moisture content, pH, IC50 value, total phenolic content, vitamin C, color, flavor, and taste hedonic score, of 10.32%, 7.04, 137.94 μg/mL, 29.26%, 1.20 mg/100 g, 5.37, 5.03, and 6.27, respectively. Based on recommendations, continuous improvement should be carried out during the packaging or product handling methods to enhance the quality of cemara udang tea leaves.

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CONFLICT OF INTEREST

The authors declares that the research is original and are responsible for claims relating to the contents.

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