E-ISSN: 2614-0934
SEAS (Sustainable Environment Agricultural Science)
https://www.ejournal.warmadewa.ac.id/index.php/seas
https://doi.org/10.22225/seas.10.1.14434.31-44

Functional Characteristics of Blanched Dried Gonda Vegetables (*Sphenoclea zeylanica*) Using Freeze Drying

I Wayan Ryantama Swastika Braja[1], Anak Agung Istri Sri Wiadnyani[1*]

[1] Department of Food Technology, Faculty of Agricultural Technology, Udayana University, Bali, Indonesia

*Corresponding author. Email: sriwiadnyani@unud.ac.id

Article info :
Article History:
Received: January 31, 2026
Revision: April 5, 2026
Accepted: April 27, 2026
Online Publication: April 30, 2026

Abstract
Gonda vegetable (Sphenoclea zeylanica) is a functional food rich in phenolic compounds, flavonoids, tannin, and vitamin C, which contribute to its antioxidant activity. Fresh gonda has a relatively short shelf life therefore, dried gonda products are developed to improve practicality, extend shelf life, and preserve bioactive components. This study employed a Completely Randomized Design (CRD) with a single treatment factor (pre-treatment) consisting of two levels, namely blanching and unblanching. The drying process was carried out using the freeze-drying method. Each treatment was replicated three times, resulting in a total of 6 experimental units. The data were statistically analyzed using an independent two-sample t-test to determine differences conducted to compare the findings with those of previous studies. The results indicated that the blanching pre-treatment combined with the freeze-drying produced the most favorable functional characteristics of dried gonda. These included a moisture content of 13.64%, yield of 16.11%, rehydration capacity of 116.36%, flavonoid content of 0.066 mg QE/g, tannin content of 0.57 mg TAE/g, vitamin C content of 0.19 mg AAE/g, and antioxidant activity of 66,43%. Color analysis showed L and a values of 23.65 and -29.21, respectively. Sensory evaluation revealed that the color of dried gonda was rated as bright with a scoring value of 3.00 and was well accepted, with hedonic score of 4.47. The texture received a scoring value of 2.00 (slightly soft) and a hedonic score of 3.00 (neutral), while the overall acceptability reached 3.60 indicating a favorable level of consumer acceptance.*

Keywords:
Blanching, Dried Vegetables, Freeze Drying, Functional Food, Gonda

1. Introduction

Gonda (*Sphenoclea zeylanica*) belongs to the family *Sphenocleaceae* and is widely distributed in tropical regions, where it is often regarded as a weed that interferes with rice cultivation in paddy fields [1]. This plant grows readily in wetland areas, along riverbanks, sand in paddy fields, resulting in abundant availability. Morphologically, *Sphenoclea zeylanica* exhibits an erect growth habit, reaching heights of up to approximately 150 cm. It possesses simple, light-green leaves that are oblong with pointed tips, measuring about 10 cm in length, and has a slightly bitter taste when consumed [2]. Gonda is a traditional indigenous food plant native to Bali and is commonly consumed as a vegetable due to its high nutritional value. Moreover, it shows considerable potential for development as a functional food, as it contains various bioactive compounds, including phenolics, flavonoids, tannins, and vitamin C, which contribute to its antioxidant activity. Gonda contains high moisture (93.35%), along with protein (23.73%), carbohydrates (7.90%), fat (2.90%), ash (16.91%), and crude fiber (13.73%) [3]. In addition, gonda is rich in bioactive compounds, including phenolics (4.37 mg GAE/g) and flavonoids (3.17 mg RE/g), and exhibits strong antioxidant activity with an IC_{50} value of 2.88 mg/mL. Supporting these findings, [4] demonstrated that steamed gonda showed higher antioxidant activity (43.47%) compared to other indigenous vegetables, such as kejompot and *don muncuk waluh*. However, fresh gonda has a relatively short shelf life due to its high moisture content and susceptibility to postharvest deterioration. Therefore, drying is required as a preservation method to extend shelf life while maintaining its bioactive compounds, making it more suitable for further utilization and product development. These results indicate that gonda has significant potential for development as an antioxidant-rich functional food through product innovation and diversification.

The shift in consumer dietary patterns toward more practical, efficient, and health-oriented lifestyles has become an increasingly prominent trend. This change has driven the development of innovative instant food products, including dried vegetables that offer ease of preparation, extended shelf life, and retention of bioactive compounds with preserved quality. In dehydrated products, the drying technique plays a critical role in determining final product quality. Commonly applied drying methods include freeze drying, oven drying, and microwave drying. Among these, freeze drying is particularly suitable for materials that are sensitive to heat and oxidative degradation. According to [5] freeze drying is a low-temperature drying technique conducted under vacuum conditions that effectively preserves product quality by maintaining structural integrity, nutritional composition, and heat-sensitive bioactive compounds, such as vitamins and antioxidants. In a related study, [6] compared oven and microwave drying methods and reported that oven drying produced dried gonda with superior characteristics, including moisture content (13.34%), yield (12.84%), rehydration ratio (115.49%), flavonoid content (0.0569 mg QE/g), vitamin C content (0.1734 mg AAE/g), tannin content (0.45 mg TAE/mg), and antioxidant activity (62.64%).

One effective approach to enhance the drying process is the application of a combined treatment involving preliminary heating through blanching. Blanching is a short-term thermal treatment applied prior to further processing, followed by rapid cooling, commonly achieved by immersion in ice water. This process is known to inactivate enzymes such as polyphenol oxidase and peroxidase that are responsible for enzymatic browning, loosen plant tissue structure, and reduce microbial load [7]. [8] reported that blanching treatment enhanced the nutritional quality and antioxidant constituents of *Moringa oleifera* leaves, as indicated by higher total phenolic content (59.25 mg/100 g), flavonoid content (51.77 mg/100 g), and total antioxidant capacity (70.03 mg/100 g) compared to unblanched samples. These findings suggest that blanching can effectively increase bioactive compound retention and contribute to extending product shelf life prior to subsequent drying processes.

Therefore, this study is of significant importance in developing dried gonda as an innovative and diversified indigenous vegetable product from Bali with potential application as a functional food. This research investigates the effect of blanching as a pre-treatment combined with freeze-drying on the production of dried gonda, with the resulting product characteristics analyzed using an independent *t*-test. In addition, a descriptive comparison is conducted with previous findings reported by [6], that applied blanching followed by oven and microwave drying methods to evaluate the characteristics of dried gonda.

2. Material and Methods

2.1 Materials

The primary raw material used in this study was gonda (*Sphenoclea zeylanica*), which was sourced directly from local farmers in Timpag Village, Kerambitan District, Tabanan Regency, Indonesia. The gonda leaves were selected at the mature vegetative stage, characterized by fully expanded leaves with a uniform green color, indicating optimal physiological development. Only fresh samples with intact physical structure were used, free from mechanical damage, pest infestation (e.g., insect bites), disease symptoms, or discoloration. The chemicals and reagents employed included distilled water, analytical-grade ethanol (Merck), quercetin standard (Sigma), Folin–Ciocalteu reagent (Merck), sodium carbonate (Na_2CO_3; Merck), sodium nitrite ($NaNO_2$; Merck), aluminum chloride ($AlCl_3$; Merck), sodium hydroxide (NaOH; Merck), 1,1-diphenyl-2-picrylhydrazyl (DPPH; Sigma-Aldrich), gallic acid standard (Sigma), sulfuric acid, sodium sulfate, ammonium molybdate, petroleum ether, EDTA, phosphate buffer, α-amylase, pepsin, pancreatin, hydrochloric acid, and acetone.

The equipment used in this study included a freeze dryer, chromameter/colorimeter, aluminum foil, labeling paper, knives, plastic basins, trays, plastic containers, HDPE plastic packaging, a hot air oven (Labo DO 225), a UV–Vis spectrophotometer (Biocheme, SN 133467), a water bath (Memmert), an analytical balance (Sartorius), a vortex mixer, Whatman No. 1 filter paper, a blender (Miyako BL-101 PL), a 60-mesh sieve, test tube rack, graduated pipettes (1 mL; Iwaki; 2 mL and 10 mL; Pyrex), a funnel, forceps, a desiccator, and a burette.

2.2 Experimental Design

This study employed an experimental approach using a Completely Randomized Design (CRD) with a single treatment factor (pre-treatment) consisting of two levels: blanching and unblanching. Each treatment was replicated three times, resulting in a total of six experimental units. The dried gonda samples were subsequently evaluated for moisture content, yield, and rehydration ratio, as well as for bioactive components, including flavonoids, tannins, vitamin C, and antioxidant activity. In addition, color parameters and sensory properties were assessed, comprising color scoring, color hedonic evaluation, texture scoring, texture hedonic evaluation, and overall acceptability.

2.3 Research Procedure

The research procedure consisted of two main stages: pre-treatment through blanching and subsequent drying using the freeze-drying method.

2.3.1 Blanching Process

The blanching method used in this study was based on [6]. Fresh gonda vegetables were sorted and cut into approximately 5 cm segments, then washed and drained. The samples were divided into two treatments: blanching and unblanching. For the blanching treatment, gonda samples were subjected to steam blanching at 70°C for 1.5 minutes. Subsequently, the blanched samples underwent a precooling step by immersion in ice water for 30 seconds to prevent further thermal effects, followed by draining. Unblanched gonda samples were used as controls and subjected to the same subsequent analyses.

2.3.2 Drying Process

The freeze-drying method used in this study was based on [9] with modifications. Gonda samples subjected to blanching and unblanching treatments were subsequently dried using the freeze-drying method. Prior to drying, the samples were frozen at −18°C and then placed in a freeze-vacuum chamber operated at a pressure of 2 mbar and a temperature of −110°C. This process resulted in dried gonda samples that were ready for further observation and analysis.

2.4 Variabels Observed

The analyses performed on dried gonda samples included chemical, bioactive, physical, and sensory evaluations. Chemical analyses comprised moisture content determination using the oven-drying method [10] and yield measurement. Bioactive component analyses included total flavonoid content [10], tannin content [10], vitamin C content [10], and antioxidant activity [11]. Physical analyses involved color measurement using a chromameter and determination of the rehydration ratio [12]. Subjective analysis was conducted through sensory evaluation of dried gonda, including scoring tests for color and texture and hedonic tests for color, texture, and overall acceptability [13].

2.5 Data Analysis

The data were statistically analyzed using an independent two-sample *t*-test to determine differences between blanching and unblanching treatments at a 5% significance level ($p < 0.05$), with the assistance of IBM SPSS Statistics version 31. Prior to the analysis, normality and homogeneity of variance assumptions were evaluated using the Shapiro-Wilk and Levene's tests, respectively, and all variables satisfied these assumptions ($p > 0.05$). In addition, descriptive analysis was applied by systematically presenting and interpreting the obtained data to support problem identification and discussion [14]. The results were further compared descriptively with previous studies, particularly the work of Dewi and Wiadnyani [6], that investigated dried gonda leaves subjected to blanching combined with oven and microwave drying methods.

3. Results and Discussion

3.1 Moisture Content

The moisture content of freeze-dried gonda subjected to blanching and unblanching treatments is presented in Figure 1.

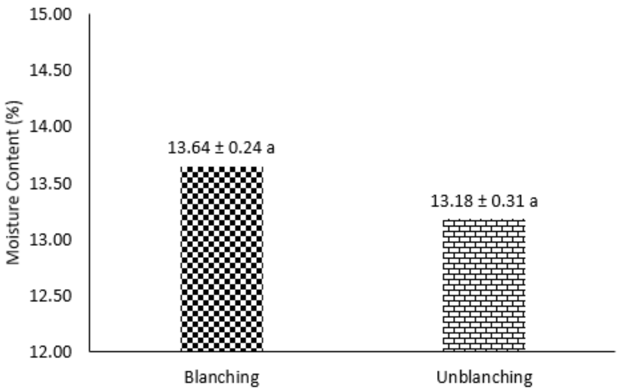

Figure 1. Moisture content of dried gonda

Notes: the same superscript notation indicate no significant difference between treatments based on the independent t-test ($p > 0.05$).

Figure 1 presents the moisture content of dried gonda subjected to blanching (13.64%) and unblanching treatments (13.18%). Numerically, the blanched samples exhibited a slightly higher moisture content than the unblanched samples. However, statistical analysis using an independent t-test indicated no significant difference between the two treatments ($p > 0.05$), as reflected by the identical notations. These results suggest that blanching prior to freeze drying did not significantly affect the moisture content of dried gonda.

The moisture content of dried vegetables plays a crucial role in determining the shelf life of food products. Lower moisture levels can inhibit microbial growth and reduce deterioration during storage [15]. The higher moisture content observed in blanched dried gonda may be attributed to structural modifications of the plant tissue induced by thermal pretreatment, which soften the tissue and enhance its water-binding capacity. Blanching increases the porosity and softness of leaf cell walls, thereby facilitating greater water absorption and retention [16], [17]. During freeze drying, water within the plant tissue is converted into ice crystals and subsequently removed through uniform sublimation across all treatments [9]. As a result, the moisture contents of the blanched and unblanched samples were comparable and did not differ significantly. [18] reported that freeze drying is conducted at low temperatures using a sublimation mechanism, which prevents the complete removal of bound water from the material. Generally, the moisture content of freeze-dried fruits and vegetables ranges from 10–13% to ensure product stability [19]. Similar findings were reported by [6], that observed moisture contents of 12.92% and 13.29% in blanched dried gonda processed using oven and microwave oven drying methods, respectively.

3.2 Yield Content

The yield content of freeze-dried gonda subjected to blanching and unblanching treatments is presented in Figure 2.

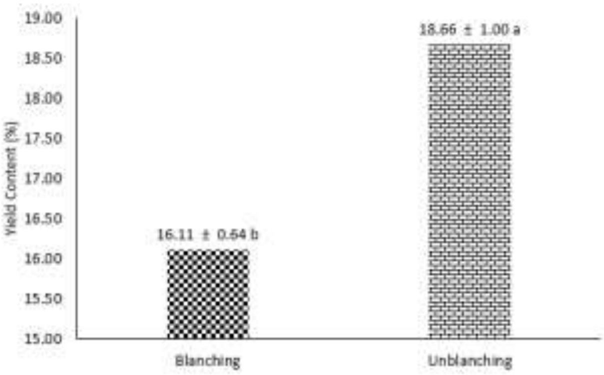

Figure 2. Yield content of dried gonda

Notes: the different superscript notations indicate significant differences between treatments based on independent t-test ($p < 0.05$).

Figure 2 shows that the yield of dried gonda obtained without blanching (18.66%) was higher than that of the blanched treatment (16.11%). Statistical analysis using an independent t-test revealed a significant difference between the two treatments ($p < 0.05$), as indicated by the different notations. These findings demonstrate that blanching prior to freeze drying had a significant effect on reducing the yield of dried gonda.

Yield represents the percentage of the final dried product relative to the initial fresh material, with higher yield indicating lower losses of nutrients. The yield of dried gonda subjected to blanching was lower than that of the unblanched treatment, which may be attributed to the leaching of soluble components during blanching. Thermal treatment, particularly when water is involved, increases cell membrane permeability and disrupts cell wall integrity, allowing water-soluble compounds such as sugars, organic acids, minerals, and certain phenolic compounds to diffuse into the blanching medium. In addition, the degradation of structural polysaccharides, such as pectin, contributes to tissue softening and further facilitates the loss of intracellular contents. As a result, the overall solid content retained in the material decreases, leading to a lower yield after drying. Previous studies have reported that blanching of leafy vegetables such as spinach and kale results in losses of potassium and water-soluble vitamins, including vitamin C and B-complex vitamins [20].

Freeze drying is considered an effective drying method for producing dried gonda with relatively high yield. During freeze drying, frozen water within the material is directly converted into vapor without passing through the liquid phase, thereby minimizing the loss of water-soluble compounds such as vitamins, minerals, and sugars that commonly occur during conventional heat-based drying processes [21]. Blanched gonda processed through oven and microwave drying methods resulted in yields of 12.84% and 15.54%, respectively [6]. These findings indicate that blanching combined with freeze drying in the present study resulted in a higher yield of dried gonda, reaching 16.11%.

3.3 Rehydration

The rehydration value of freeze-dried gonda subjected to blanching and non-blanching treatments are presented in Figure 3.

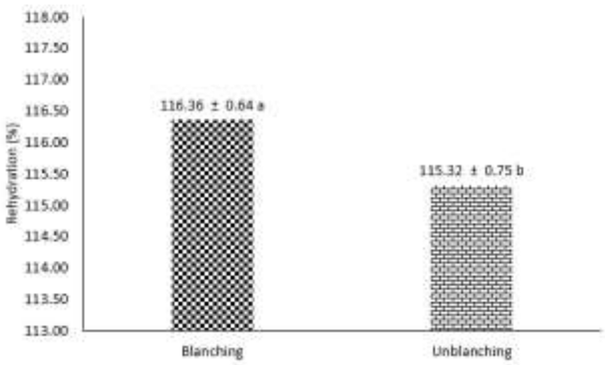

Figure 3. Rehydration value of dried gonda

Notes: the different superscript notations indicate significant differences between treatments based on independent t-test ($p < 0.05$).

Figure 3 shows that the rehydration value of blanched dried gonda (116.36%) was higher than that of the unblanched treatment (115.32%). Statistical analysis using an independent t-test revealed a significant difference between the two treatments ($p < 0.05$), as indicated by the different notations. These results suggest that blanching prior to freeze drying had a significant effect on the rehydration capacity of dried gonda.

The rehydration value reflects the ability of a dried product to absorb water and approach its fresh-like condition after reconstitution. Products with good rehydration properties are more likely to recover their original texture, shape, and appearance upon water addition [21]. In the present study, the rehydration value of blanched dried gonda was higher than that of the unblanched samples. According to [22] thermal treatment during blanching induces microstructural changes in leafy materials, resulting in increased porosity and enhanced cell membrane permeability, which contribute to improved rehydration. Moreover, the application of freeze drying was more effective in enhancing rehydration properties. The high porosity of freeze-dried products facilitates rapid water penetration into the material matrix during rehydration. The preservation of tissue integrity through ice sublimation during freeze drying prevents structural collapse, allowing the product to more closely regain its original form after rehydration [23]. Previous studies by [6] demonstrated that blanching followed by oven and microwave oven drying resulted in lower rehydration values of dried gonda, at 115.49% and 115.93%, respectively. These findings indicate that blanching combined with freeze drying is more effective in enhancing the rehydration capacity of dried gonda.

3.4 Flavonoid

The flavonoid content of freeze-dried gonda subjected to blanching and non-blanching treatments are presented in Figure 4.

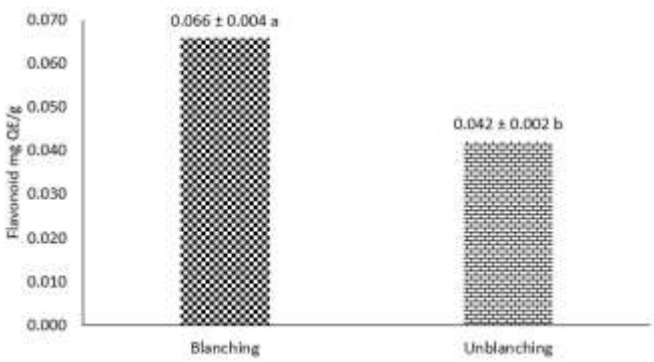

Figure 4. Flavonoid content of dried gonda

Notes: the different superscript notations indicate significant differences between treatments based on independent t-test ($p < 0.05$).

Figure 4 shows that the flavonoid content of blanched dried gonda (0.066 mg QE/g) was higher than that of the unblanched treatment (0.042 mg QE/g). Statistical analysis using an independent t-test revealed a significant difference between the two treatments ($p < 0.05$), as indicated by the different notations. These results demonstrate that blanching prior to freeze drying had a significant effect on the flavonoid content of dried gonda.

Flavonoids constitute a large group of polyphenolic compounds known for their antioxidant properties. In the present study, the flavonoid content of dried gonda subjected to blanching was higher than that of the unblanched samples. This increase may be attributed to the blanching process, which disrupts plant cell walls and facilitates the release and extraction of flavonoids that were previously bound within the cellular matrix [24]. Higher flavonoid levels are positively correlated with enhanced antioxidant activity. Flavonoids act as antioxidants by scavenging free radicals through hydrogen atom donation from their hydroxyl groups, thereby neutralizing reactive species [25]. In addition, freeze drying can minimize thermal degradation of bioactive compounds in dried gonda. The present results showed that the total flavonoid content of blanched freeze-dried gonda (0.066 mg QE/g) was higher than that obtained using oven and microwave oven drying methods, which yielded 0.056 mg QE/g and 0.049 mg QE/g, respectively [6]. These findings are supported by [26], who reported that freeze drying operates under vacuum and low-temperature conditions, thereby reducing oxidative reactions and effectively preserving polyphenolic and flavonoid compounds.

3.5 Tannin

The tannin content of freeze-dried gonda subjected to blanching and non-blanching treatments are presented in Figure 5. The tannin content of blanched dried gonda (0.57 mg TAE/g) was higher than that of the unblanched treatment (0.20 mg TAE/g). Statistical analysis using an independent t-test revealed a significant difference between the two treatments ($p < 0.05$), as indicated by the different notations. These results indicate that blanching prior to freeze drying had a significant effect on the tannin content of dried gonda.

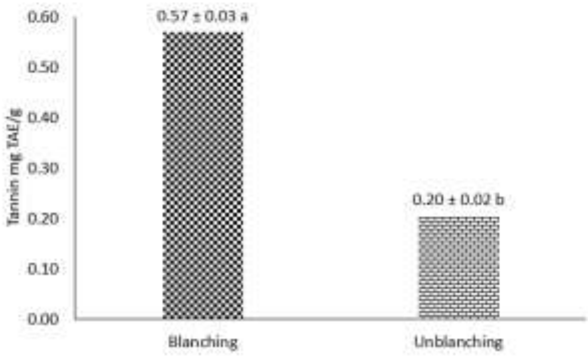

Figure 5. Tannin content of dried gonda

Notes: the different superscript notations indicate significant differences between treatments based on independent t-test ($p < 0.05$).

Tannins are important plant secondary metabolites with antioxidant and antibacterial properties, and their content is positively correlated with antioxidant activity. According to [27] tannins act as metal chelators and protein-binding agents, thereby inhibiting oxidative processes. In the present study, the total tannin content of dried gonda subjected to blanching was higher than that of the unblanched samples. Thermal treatment during blanching may inactivate oxidative enzymes, leading to increased tannin availability in the material [28]. Thermal treatment can induce structural disruption of plant cell matrices, thereby enhancing the extractability of bioactive compounds. Furthermore, blanching may promote the release of bound tannins from complexes with cell wall constituents, contributing to an increase in measurable tannin content. In addition, freeze drying was more effective in preserving tannin content compared with conventional drying methods, as the low temperatures employed during freeze drying help prevent the degradation of polyphenolic compounds, including tannins. Previous studies by [6] reported tannin contents of 0.45 mg TAE/g and 0.15 mg TAE/g in blanched dried gonda processed using oven and microwave drying methods, respectively. These findings indicate that the combination of blanching and freeze drying in the present study resulted in a higher total tannin content in dried gonda.

3.6 Vitamin C

The vitamin C of freeze-dried gonda subjected to blanching and non-blanching treatments are presented in Figure 6.

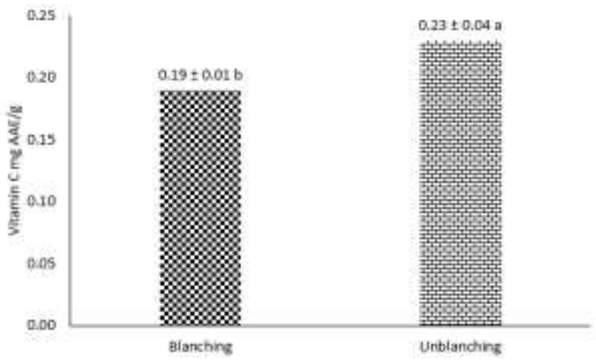

Figure 6. Vitamin C of dried gonda

Notes: the different superscript notations indicate significant differences between treatments based on independent t-test ($p < 0.05$).

Figure 6 shows that the vitamin C content of blanched dried gonda (0.19 mg AAE/g) was lower than that of the unblanched treatment (0.23 mg AAE/g). Statistical analysis using an independent t-test revealed a significant difference between the two treatments ($p < 0.05$), as indicated by the different notations. These results demonstrate that blanching prior to freeze drying had a significant effect on reducing the vitamin C content of dried gonda.

Vitamin C is an essential micronutrient required for various physiological functions; however, it is highly sensitive to heat and light and is therefore prone to degradation. The results of the present study indicate that blanching reduced the vitamin C content of dried gonda. Blanching can cause substantial losses of vitamin C due to its high water solubility and susceptibility to elevated temperatures [29], [30]. Blanching at 70 °C resulted in a higher vitamin C content (34.44 mg/g) than blanching at 80 °C (2.66 mg/g) in bitter melon (*Momordica charantia* L.), demonstrating that higher blanching temperatures accelerate vitamin C degradation [31]. These findings suggest that blanching at relatively high temperatures leads to greater vitamin C loss compared with unblanched treatments. Nevertheless, freeze drying offers advantages in preserving vitamin C compared with other drying methods. The low temperature and vacuum conditions employed during freeze drying minimize thermal and oxidative degradation of heat-sensitive compounds such as vitamin C [5]. Previous studies by [6] reported vitamin C contents of 0.17 mg AAE/g and 0.15 mg AAE/g in dried gonda processed using oven and microwave oven drying, respectively. These results indicate that freeze drying in the present study resulted in a higher vitamin C content in dried gonda, reaching 0.19 mg AAE/g.

3.7 Antioxidant Activity

The antioxidant activity of freeze-dried gonda subjected to blanching and non-blanching treatments are presented in Figure 7.

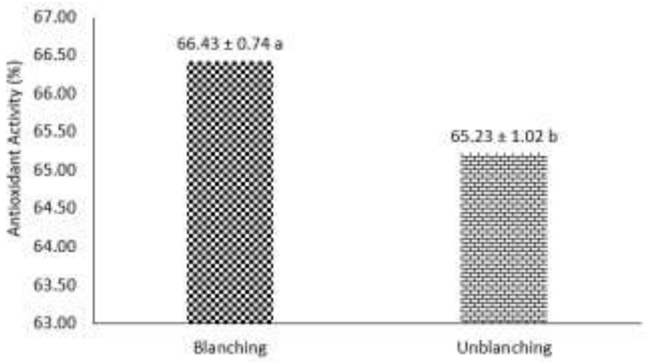

Figure 7. Antioxidant activity of dried gonda

Notes: the different superscript notations indicate significant differences between treatments based on independent t-test ($p < 0.05$).

Figure 7 shows that the antioxidant activity of blanched dried gonda (66.43%) was higher than that of the unblanched treatment (65.23%). Statistical analysis using an independent t-test revealed a significant difference between the two treatments ($p < 0.05$), as indicated by the different notations. These results indicate that blanching prior to freeze drying had a significant effect on the antioxidant activity of dried gonda.

Antioxidant activity refers to the ability of compounds to scavenge, neutralize, or inhibit free radicals and reactive oxygen species (ROS) [32]. Antioxidant activity is positively correlated with phenolic compounds, including flavonoids and tannins [33]. This relationship is consistent with the present findings, in which blanching resulted in higher flavonoid and tannin contents than the unblanched treatment in dried gonda. Higher levels of flavonoids and tannins are associated with increased antioxidant activity in plant materials. Blanching can inactivate oxidative enzymes such as polyphenol oxidase (PPO) and peroxidase (POD), which are responsible for accelerating the degradation of phenolic compounds, thereby enhancing the stability of antioxidant constituents [34]. These findings are supported by [8] who reported higher antioxidant activity in blanched moringa leaf flour (70.03 mg/100 g) compared with unblanched samples (27.36 mg/100 g). In addition, freeze drying minimizes the degradation of bioactive compounds, including phenols, flavonoids, and tannins, which contribute to elevated antioxidant activity [9]. Previous studies by [6] reported antioxidant activities of 62.64% and 63.84% in blanched dried gonda processed using oven and microwave drying methods, respectively. These results indicate that blanching combined with freeze drying in the present study resulted in higher antioxidant activity of dried gonda, reaching 66.43%.

3.8 Color

The color characteristics of freeze-dried gonda subjected to blanching and non-blanching treatments are presented in Table 1.

Table 1.
Color characteristics of dried gonda

Treatment	L*	a*
Blanching	23.65 a	-29.21 a
Unblanching	11.77 b	-26.81 b

Notes: the different superscript notations indicate significant differences between treatments based on independent t-test ($p < 0.05$).

Based on the color analysis presented in Table 1, blanched dried gonda exhibited a higher L value (23.65) compared with the non-blanched samples (11.77). The a* value of the blanched treatment was more negative (−29.21) than that of the non-blanched treatment (−26.81), indicating a greater degree of greenness. Statistical analysis revealed significant differences between the two treatments for both L* and a* values ($p < 0.05$), as indicated by the different notations. The L* parameter represents lightness on a scale of 0 to 100, with lower values indicating darker color and higher values indicating greater brightness. The a* parameter describes the green–red color axis, where negative values correspond to green coloration and positive values indicate red coloration.

Blanching is applied to inactivate enzymes, inhibit browning reactions, and suppress microbial growth, thereby improving the quality of the final product. Blanched dried gonda exhibited higher L values, indicating greater brightness compared with the non-blanched treatment. This result is supported by [15], who demonstrated that steam blanching for 120 seconds effectively inhibits enzymatic browning, leading to a brighter color in red beetroot powder. More negative a* values observed in blanched dried gonda indicate a higher degree of green coloration. This is likely due to the inactivation of pigment-degrading enzymes, such as chlorophyllase, during blanching, which enhances the stability of green pigments (chlorophyll) [35]. Previous studies by [6] reported L* and a* values of 11.30 and −27.64, respectively, for blanched dried gonda processed using microwave drying. These findings indicate that blanching combined with freeze drying produces dried gonda with improved brightness and greenness compared with conventional drying methods.

3.9 Sensory Evaluation

The sensory evaluation of freeze-dried gonda subjected to blanching and non-blanching treatments are presented in Table 2.

Table 2.
Sensory evaluation of dried gonda

Treatment	Sensory Evaluation				
	Color Scoring	Color Hedonic	Texture Scoring	Texture Hedonic	Overall Acceptance
Blanching	3.00 ± 0.01 a	4.47 ± 0.64 a	2.00 ± 0.65 b	3.00 ± 0.92 a	3.60 ± 0.63 a
Unblanching	2.33 ± 0.48 b	2.40 ± 0.828 b	2.60 ± 0.50 a	3.07 ± 0.96 a	3.47 ± 0.74 a

Notes: Different superscript letters indicate significant differences between treatments based on the independent t-test ($p < 0.05$). Color scoring: 1 = dull, 2 = moderately bright, 3 = bright. Texture scoring: 1 = hard, 2 = slightly soft, 3 = soft. Hedonic evaluation for color, texture, and overall acceptance: 1 = strongly dislike, 2 = dislike, 3 = neutral, 4 = like, 5 = strongly like.

3.9.1 Color Scoring and Hedonic

As presented in Table 2, color scoring of dried gonda indicated that the blanched treatment achieved a score of 3.00, corresponding to a “bright” appearance, whereas the non-blanched samples obtained a score of 2.33, classified as “moderately bright”. Statistical analysis using an independent t-test revealed a significant difference between the two treatments ($p < 0.05$), as indicated by different notations. This is consistent with the colorimeter results, where dried gonda subjected to blanching exhibited a higher L* value (23.65) compared to the unblanched treatment (11.77), indicating a brighter appearance. In addition, the blanching treatment showed a lower (more negative) a* value (-29.21) than the unblanched samples (-26.81), indicating a stronger green color. These results suggest that blanching produced a brighter product and better preserved the green color of dried gonda.

These results suggest that blanching was more effective in preserving the brightness of dried gonda compared with the non-blanched treatment, which produced a moderately bright color. This finding is consistent with the report of [36], that showed that blanching for 1 min resulted in the highest brightness level in carrot leaf flour due to the inactivation of polyphenol oxidase (PPO) responsible for enzymatic browning. Enzymatic browning primarily occurs due to the activity of polyphenol oxidase (PPO), which catalyzes the oxidation of phenolic compounds, resulting in the formation of dark-colored melanin pigments [37]. In the hedonic color evaluation, the blanched samples received a score of 4.47 ("liked"), while the non-blanched samples scored 2.40 ("slightly disliked"). Independent t-test analysis confirmed a significant difference between treatments in hedonic color preference ($p < 0.05$), as reflected by the different notations. These results indicate that panelists preferred the color of dried gonda produced with blanching compared with that of the unblanched samples.

3.9.2 Texture Scoring and Hedonic

As shown in Table 2, the texture scoring of dried gonda indicated that the blanched samples obtained a score of 2.00, corresponding to a "slightly soft" texture, whereas the unblanched samples achieved a score of 2.60, classified as "soft." Statistical analysis using an independent t-test revealed a significant difference between the two treatments ($p < 0.05$), as indicated by different notations. These results suggest that blanching produced dried gonda with a texture ranging from slightly soft to soft. In the hedonic texture evaluation, the blanched and unblanched samples received scores of 3.00 and 3.07, respectively, both corresponding to a "neutral" level of acceptance. Independent t-test analysis indicated no significant difference between treatments ($p > 0.05$), as reflected by identical notations. These results are consistent with a previous study conducted [6], which reported that panelists' preference for the texture of dried gonda treated with blanching and non-blanching using oven and microwave oven methods did not differ significantly, with both treatments receiving neutral ratings. This finding indicates that panelists found the texture of dried gonda acceptable regardless of blanching treatment.

3.9.3 Overall Acceptences

As shown in Table 2, the overall acceptability scores of dried gonda were 3.60 for the blanched treatment ("liked") and 3.47 for the unblanched treatment ("neutral"). However, statistical analysis using an independent t-test indicated no significant difference between the two treatments ($p > 0.05$), as evidenced by identical notations. These results suggest that, although blanched dried gonda was slightly more preferred by panelists, the unblanched treatment did not differ significantly in overall acceptability. Previous studies by [6] reported overall acceptability scores of 2.93 and 3.93 for blanched dried gonda processed using oven and microwave drying methods, respectively, corresponding to neutral to liked categories. These findings indicate that the treatments applied in the present study produced dried gonda with overall acceptability levels that remain acceptable to panelists.

4. Conclusion

Based on the results of this study, blanching combined with freeze drying produced dried gonda with the most favorable functional characteristics. Blanching and unblanching treatments combined with the freeze-drying method for dried gonda leaves resulted in significant differences in yield, rehydration capacity, flavonoid content, tannin content, vitamin C content, antioxidant activity, color parameters (L* and a*), color scoring and hedonic evaluation, as well as texture scoring. In contrast, no significant differences were observed in moisture content, texture hedonic evaluation, and overall acceptance.The resulting product exhibited a moisture content of 13.64%, yield of 16.11%, rehydration capacity of 116.36%, flavonoid content of 0.066 mg QE/g, tannin content of 0.57 mg TAE/g, vitamin C content of 0.19 mg AAE/g, and antioxidant activity of 66.43%. Color analysis showed L and a* values of 23.65 and −29.21, respectively. Sensory evaluation indicated a color score of 3.00 (bright) with a hedonic score of 4.47 (liked). The texture was rated with a scoring value of 2.00 (slightly soft) and a hedonic score of 3.00 (neutral), while overall acceptance reached 3.60, corresponding to a "liked" category.

References

[1] J. Gowri, C. Pragathiswaran, and S. P. Arockia, "Physicochemical and heavy metal analysis of the leaf, stem, and flower extracts of Sphenoclea zeylanica," *Innovare J. Sci.*, vol. 5, no. 1, pp. 29–31, 2017.

[2] H. Narzary and S. Basumatary, "Amino acid profiles, antimicrobial activity and anti-nutritional contents of two wild edible plants (Sphenoclea zeylanica Gaertn. and Sphaerantus peguensis Kurz ex C.B. Clarke.)," *Curr. Biotechnol.*, vol. 8, no. 1, pp. 53–63, 2019, doi: 10.2174/2211550108666190614155321.

[3] C. K. Saikia, D. N. Singha, and A. K. Handique, "Evaluation of nutritive and nutraceutical value of wild non- conventional leafy herbs in Assam , North East India," *Crop res*, vol. 55, no. 5, pp. 268–275, 2020, doi: 10.31830/2454-1761.2020.037.

[4] A. A. I. S. Wiadnyani and I. N. . Putra, "Study of Heat Processing of Bioactive Components of Local Balinese Vegetables," 2019.

[5] S. Bhatta, T. S. Janezic, and C. Ratti, "Freeze-drying of plant-based foods," *Foods*, vol. 9, no. 87, pp. 1–22, 2020, doi: 10.3390/foods9010087.

[6] P. J. N. Dewi and A. A. I. S. Wiadnyani, "Study of blanching and drying methods of bioactive components and antioxidant activities of gonda dried vegetables (Spenoclea zeylanica)," *Itepa J. Ilmu dan Teknol. Pangan*, vol. 12, no. 2, pp. 436–451, 2023, doi: 10.24843/itepa.2023.v12.i02.p17.

[7] A. Korus, "Effect of pre-treatment and drying methods on the content of mineral, B-group vitamins and tocopherols in kale (Brassica oleracea L. var. acephala) leaves.pdf," *J Food Sci Technol*, vol. 59, no. 1, pp. 279–287, 2022, doi: 10.1007/s13197-021-05012-9.

[8] A. T. Ola-Adedoyin, S. O. Etatuvie, I. M. Luke, and K. O. Olaniyan, "Effect of different blanching treatments on the nutritional composition, phytochemical contents and antioxidant activity of dried moringa oleifera Lam . leaf flour," *Trop. J. Nat. Prod. Res.*, vol. 5, no. 6, pp. 1094–1100, 2021, doi: 10.26538/tjnpr/v5i6.19.

[9] N. Coskun, S. Saritas, Y. Jaouhari, M. Bordiga, and S. Karav, "The impact of freeze drying on bioactivity and physical properties of food products," *Appl. Sci.*, vol. 14, no. 9183, pp. 1–30, 2024, doi: 10.3390/ app14209183.

[10] AOAC, *Official Methods of Analysis of The Association of Agriculture Chemist A.O.A.C*. Washington D.C., 1995.

[11] R. Sompong, S. Siebenhandl-Ehn, G. Linsberger-Martin, and E. Berghofer, "Physicochemical and antioxidative properties of red and black roce varieties from Thailand, China, and Srilanka," *J. Food Chem*, vol. 124, no. 1, pp. 132–140, 2011, doi: doi.org/10.1016/j.foodchem.2010.05.115.

[12] D. Histifarina, D. Musaddad, and E. Murtiningsih, "Oven Drying Technique for Quality Dried Carrot Slices," *J. Hortik.*, vol. 14, no. 2, pp. 107–112, 2004.

[13] S. . Soekarto, *Organoleptic Assessment for Food and Agriculture Industry*. Jakarta: Bharata Karya Aksara, 1985.

[14] Z. E. Fitri and A. Jumiono, "Halal certification of processed food products," *J. Pangan Halal*, vol. 3, no. 2, pp. 1–7, 2021.

[15] Y. Kristianto *et al.*, "Effects of blanching and drying on the bioactive compounds of red beetroot (Beta vulgaris L. var rubra) powder," *Acta Sci. Pol. Technol. Aliment*, vol. 24, no. 4, pp. 553–565, 2025, doi: doi.org/10.17306/J.AFS.001413.

[16] M. Sunmonu, M. Odewolf, E. Ajala, R. Sani, and A. Ogunbiyi, "Effect of two blanching methods on the nutritional values of tomatoes and pumpkin leaves," *J. Appl.Sci.Environ. Manag.*, vol. 25, no. 2, pp. 183–187, 2021, doi: 10.4314/jasem.v25i2.7.

[17] W. Nurtiana, Fatmawati, E. Sulistyawati, F. Eris, M. Radiansyah, and R. Rismaya, "The effect of blanching time on the physicochemical characteristics and bioactive compounds of moringa leaves flour," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1428, pp. 1–12, 2025, doi: 10.1088/1755-1315/1482/1/012040.

[18] P. Mohapatra, A. Ray, S. Jena, S. Nayak, and S. Mohanty, "Influence of various drying methods on physicochemical characteristics , antioxidant activity , and bioactive compounds in Centella asiatica L . leaves : a comparative study," *J. Biotechnol. Comput. Biol. Bionanotechnol.*, vol. 103, no. 3, pp. 235–

247, 2022, doi: doi.org/10.5114/bta.2022.118666.
[19] T. M. Oyinloye and W. B. Yoon, "Effect of freeze-drying on quality and grinding process of food produce : a review," *Processes*, vol. 8, no. 354, pp. 1–23, 2020, doi: doi:10.3390/pr8030354.
[20] B. M. Mugo, J. Kiio, and A. Munyaka, "Effect of blanching time – temperature on potassium and vitamin retention/loss in kale and spinach," *Food Sci. Nutr.*, pp. 1–9, 2024, doi: 10.1002/fsn3.4186.
[21] J. Yao, W. Chen, and K. Fan, "Novel efficient physical technologies for enhancing freeze drying of fruits and vegetables : a review," *Foods*, vol. 12, no. 4321, pp. 1–27, 2023, doi: 10.3390/foods12234321.
[22] E. Kamsiati, E. Rahayu, and H. Herawati, "The effect of blanching on the characteristics of instant cassava leaves," *Metana Media Komun. Rekayasa Proses dan Teknol. Tepat Guna*, vol. 16, no. 1, pp. 39–46, 2020, doi: 10.14710/metana.v16i1.30461 Diterima:
[23] D. Nowak and E. Jakubczyk, "The freeze-drying of foods-the characteristic of the process course and the effect of its parameters on the physical properties of food materials," *Foods*, vol. 9, no. 10, 2020, doi: 10.3390/foods9101488.
[24] M. Chauhan, U. A. Khan, G. Zia, and V. Garg, "A review-the impact of different drying method on bioactive compounds and antioxidant activity of fruits and vegetables," *Int. J. Bot. Stud.*, vol. 6, no. 2, pp. 459–462, 2021.
[25] S. Y. Kiptiyah, E. Harmayani, U. Santoso, and Supriyadi, "The effect of blanching and extraction method on total phenolic content , total flavonoid content and antioxidant activity of Kencur (Kaempferia galanga . L) extract The effect of blanching and extraction method on total phenolic content , total flavonoi," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 709, 2021, doi: 10.1088/1755-1315/709/1/012025.
[26] D. Donno *et al.*, "Freeze-drying for the reduction of fruit and vegetable chain losses : a sustainable solution to produce potential health-promoting food applications," *Plants*, vol. 14, no. 168, pp. 1–23, 2025, doi: 10.3390/plants14020168.
[27] S. Sunani and R. Hendriani, "Review article: classification and pharmacological activities of bioactive tannins," *Indones. J. Biol. Pharm.*, vol. 3, no. 2, pp. 130–136, 2023, doi: 10.24198/ijbp.v3i2.44297.
[28] F. Cosme, A. Aires, T. Pinto, I. Oliveira, A. Vilela, and B. Goncalves, "A comprehensive review of bioactive tannins in foods and beverages: functional properties, health benefits, and sensory qualities," *Molecules*, vol. 30, no. 800, pp. 1–28, 2025.
[29] A. Sarkar, S. Rahman, M. Roy, M. Alam, M. A. Hossain, and T. Ahmed, "Impact of blanching pretreatment on physicochemical properties, and drying characteristics of cabbage (Brassica oleracea)," *Food Res.*, vol. 5, no. 2, pp. 393–400, 2021, doi: doi.org/10.26656/fr.2017.5(2).556.
[30] H. H. Ayele, S. Latif, and J. Muller, "Pretreatment of the leaves of ethiopian cassava (Manihot esculenta Crantz) varieties: effect of blanching on the quality of dried cassava leaves," *Appl. Sci.*, vol. 12, no. 11231, pp. 1–11, 2022, doi: 10.3390/app122111231.
[31] T. O. Kilic *et al.*, "Improvement of hot air dried bitter gourd (Momordica charantia L .) product quality: optimization of drying and blanching process by experimental design," *Agriculture*, vol. 13, no. 1849, pp. 1–16, 2023, doi: 10.3390/agriculture13091849.
[32] İ. Gulcin, "Antioxidants: a comprehensive review," *Arch. Toxicol.*, vol. 99, pp. 1893–1997, 2025, doi: 10.1007/s00204-025-03997-2.
[33] J. Y. Yap, C. L. Hii, S. P. Ong, K. H. Lim, F. Abas, and K. Y. Pin, "Effects of drying on total polyphenols content and antioxidant properties of Carica papaya leaves," *J Sci Food Agric*, vol. 100, pp. 2932–2937, 2020, doi: 10.1002/jsfa.10320.
[34] G. Ijod *et al.*, "Inactivation of polyphenol oxidase and peroxidase activity in mangosteen pericarp via blanching: correlation between anthocyanins and enzyme activities," *Int. J. Food Sci. Technol.*, vol. 60, no. 1, pp. 1–9, 2025, doi: 10.1093/IJFOOD/vvae010.
[35] Y. W. H. Wickramasinghe, I. Wickramasinghe, and I. Wijesekara, "Effect of steam blanching , dehydration temperature & time, on the sensory and nutritional properties of a herbal tea developed from Moringa oleifera leaves," *Int. J. Food Sci.*, pp. 1–11, 2020, doi: 10.1155/2020/5376280.
[36] D. N. Azizah and J. M. Nur, "Effect of steam blanching duration on the characteristics of carrot leaves flour," *J. Penelit. Pangan*, vol. 3, no. 1, pp. 35–41, 2023.
[37] L. D. R. Fajarini, I. G. A. M. Putra, P. J. N. Dewi, I. W. R. S. Braja, and R. J. J. Umboh, "Characterization of physical properties and sensory evaluation of pletok bir enriched with apple juice," *Sustain. Environ. Agric. Sci.*, vol. 9, no. 1, pp. 20–28, 2025, doi: 10.22225/seas.9.1.11808.20-28.