Progress in Nutrition 2025; Vol. 27, N. 2: 16750 DOI: 10.23751/pn.v27i2.16750

Original article

Effect of microgreens blanching process time on total dietary fiber, antioxidant activity, and organoleptic

Donna Azhar Nafisah[1], *Nina Resti*[2], *Dewi Marfu'ah Kurniawati*[1], *Fitriyono Ayustaningwarno*[1], *Mohammad Arfan*[3,5], *Wahyu Widodo*[4,5], *Diana Nur Afifah*[1,5,6*]

[1]Department of Nutrition Science, Faculty of Medicine, Universitas Diponegoro, Jl. Prof. Sudarto, Tembalang, Semarang, Central Java, Indonesia; [2]Doctoral Study Program of Medical and Health Sciences, Universitas Diponegoro, Semarang, Central Java, Indonesia; [3]Department of Electrical Engineering, Faculty of Engineering, Universitas Diponegoro, Indonesia; [4]Faculty of Economics and Business, Universitas Diponegoro, Semarang, Indonesia; [5]SDGs Center, Universitas Diponegoro, Central Java, Indonesia; [6]Laboratory of Sustainable Diets and Biodiversity, Center of Research and Services – Diponegoro University (CORES-DU), Integrated Laboratory, Universitas Diponegoro, Semarang, Central Java, Indonesia

Abstract. *Background and aim:* Excessive lipid accumulation is a prevalent condition that causes oxidative stress and bacterial imbalance in the intestine, leading to obesity. To reduce the prevalence, several studies have proposed the use of *microgreens,* such as red spinach, radish, and mustard greens, due to their high dietary fiber content. Therefore, this study aims to determine antioxidant activity, total dietary fiber, and organoleptic properties of different varieties of *microgreens* with and without blanching process. *Methods:* The study procedures were carried out using Completely Randomized Design (CRD) by applying blanching treatment on red spinach, red radish, and mustard greens *microgreens* with variations in time of 10, 15, and 30 seconds. IC50 antioxidant test was performed using DPHH (2,2-dhipenyl1-picryhydrazyl) method, while total dietary fiber was assessed with the enzymatic gravimetric method. Organoleptic tests were carried out using hedonic and Just About Right (JAR) assessments on 67 panelists. Subsequently, the data obtained were analyzed using the *Kruskal-Wallis* statistical test. *Results:* The results showed that the 30-second blanched mustard greens (8401.05 ppm), fresh radish (11793 ppm), and 15-second blanched red spinach (15382 ppm) had the highest IC_{50} antioxidant activity. Meanwhile, the 30-second blanched red spinach (7.9 g/100 g), fresh red radish (7.09 g/100 g), and 10-second blanched mustard greens (6.69 g/100 g) had the highest total dietary fiber. The results also showed that the optimal treatments were observed in 15-second blanched red spinach, fresh red radish, and 30-second blanched mustard greens. *Conclusions:* Blanching process affected antioxidant activity, total dietary fiber, texture, taste, and color of red spinach *microgreens*. The treatment was also known to influence total dietary fiber, texture, taste, color, and aftertaste of red radish *microgreens*. Meanwhile, in mustard greens, blanching process only affected antioxidant activity, texture, and taste.

Key words: microgreens, antioxidant activity, total dietary fiber, organoleptic

Background

A BMI of ≥30 kg/m^2 is indicative of obesity, which is defined by the WHO as an excessive buildup of fat that compromises health (1). The 2023 Indonesian Health Survey (SKI) revealed that the rate of obesity in adults in Indonesia increased to 23.4%. This indicated an increase compared to the 2018 Basic Health Research (Riskesdas) results, where the rate only reached 21.8% (2,3). Several studies have shown that excessive fat accumulation can cause increased production of free radicals both in circulation and adipocyte cells. In addition, the increase in free radicals is accompanied by an elevation in antioxidant enzymes in the body, causing a condition known as oxidative stress. Bacterial imbalance in the gut or dysbiosis has also been reported to be associated with obesity (4). For example, a previous study revealed the presence of an inverse relationship between dietary fiber intake and the risk of developing obesity-related pathologies. Dietary fiber acts as an important substrate for anaerobic fermentation processes by the gut microbiota, thereby facilitating the synthesis of key beneficial metabolites (5). Edible young shoots also called *microgreens* are currently being promoted as promising alternatives for dietary fiber (6). Based on previous studies, *microgreens* are young shoots of horticultural and herbaceous species, which consist of fully developed cotyledons and the first true leaves. Compared to sprouts, their roots are often removed before being consumed as food (7). *Microgreens* are typically consumed between 7 and 14 days after germination, exhibiting a strong flavor, crunchy texture, and very bright color due to the presence of bioactive compounds (8). In addition, these shoots have been shown *to* experience hyperaccumulation of phytochemicals on average 10 times more compared to sprouts and mature plants of the same species (9). *Microgreens* are also very suitable for use as salads or edible garnishes for soups, sandwiches, and various main dishes due to their distinctive flavor, attractive color, and crunchy texture (10). The most commonly grown and studied *microgreens* are from the *Brassicaceae* and *Amaranthaceae* families, with plants such as red spinach, radish, and mustard greens (11). The metabolite profiles of mustard and radish *microgreens* show variations between sugars, amino acids, fatty acids, organic acids, polyphenols, sugar alcohols, and amines content (12). Red spinach has high phytochemical content, such as phenolic compounds, flavonoids, tocopherols, and betalains, which are known as compounds with potential health benefits due to their antioxidant and radical scavenging properties (13). Fiber is one of the complex carbohydrates that cannot be digested by the body but plays an important role in weight management and obesity control (14). Dietary fiber is an important functional ingredient defined as an indigestible carbohydrate, which can regulate the composition of gut microbes to provide health-improving benefits. Previous studies on quinoa *microgreens* showed the presence of high soluble dietary fiber content in the sample (15). Radish *microgreens* have been reported to have a higher fiber content compared to the tubers and leaves of the mature plant (16). Higher intake of polysaccharides and fiber fractions have been reported to be associated with a lower risk of chronic diseases, such as certain types of cancer, diabetes, obesity, and cardiovascular disease in humans. Fiber also promotes the growth of gut microbiota and positively regulates various physiological functions (17). IC_{50} value is the concentration of a sample required to ward off 50% of DPPH free radicals. This indicates that the higher the IC50 value in a sample, the lower its antioxidant activity (18). Antioxidants are substances that directly ward off *Reactive Oxygen Species* (ROS) or indirectly act to increase antioxidant defenses or inhibit ROS production (19). Oxidative stress occurs primarily due to an imbalance between endogenous ROS production and antioxidant activity in the body. Several studies have shown that oxidative stress plays a major role in the development of chronic inflammation associated with obesity (20). Several studies have shown that green vegetables are a good source of antioxidants. In addition, antioxidant activity in polyphenol compounds is associated with a reduced risk of disease (21). Antioxidant content of red spinach, red radish, and mustard greens *microgreens* has been reported to vary, leading to differences in their activity. Increased antioxidant activity indicates a reduction in the accumulation of ROS. Methionine and homocysteine are amino acids that inhibit stress and reduce oxidative damage. Amino acids provide protection to cells against inflammation by working as antioxidants. Previous studies have shown that *microgreens* are very effective with significant results in weight loss. Bioactive substances found in these shoots can affect various inflammatory pathways. Therefore, by following the swelling guidelines, *microgreens* can help prevent diabetes, *Cardio Vascular Disease* (CVD), and weight problems (22). *Microgreens* typically have a different taste, hence, sensory analysis is often an important factor in determining whether new products based on *microgreens* are acceptable. Human sensory analysis in food engineering is usually used as a standard method for evaluating food properties. In Indonesia, *microgreens* are not widely consumed, indicating the need for sensory tests on appearance, texture, taste, color, and aftertaste (23). Blanching is a heating process, which aims to deactivate oxidative enzymes causing changes in color, odor, taste, and texture. Blanching process can improve the appearance of food ingredients (24,25) and affect the physicochemical properties of dietary fiber. These properties include the proportion of soluble and insoluble fiber, viscosity, and molecular weight. During wet heat treatment, insoluble fiber can dissolve or even degrade into smaller fragments in the processing water (26). Therefore, this study aims to determine antioxidant activity, total dietary fiber, and organoleptic properties of different varieties of *microgreens* with and without blanching process.

Method

Study design

This study was carried out using an experimental method with Completely Randomized Design (CRD). The samples were subjected to several blanching treatments, namely A: red spinach *microgreens* (*Amaranthus tricolor L.*), B: red radish *microgreens* (*Raphanus sativus L.*), and C: mustard greens *microgreens* (*Brassica juncea L.*). In addition, the treatments were performed with variations in blanching time (P1: 10 seconds, P2: 15 seconds, P3: 30 seconds) at a temperature of 70°C, with 3 replications. During the procedures, one of the samples served as the control without blanching (P0), leading to a total of 36 experimental units (Table 1).

Table 1. *Microgreens* Blanching Study Design

Sample	Treatment	Repetation		
		1	2	3
A	P0	A01	A02	A03
	P1	A11	A12	A13
	P2	A21	A22	A23
	P3	A31	A32	A33
B	P0	B01	B02	B03
	P1	B11	B12	B13
	P2	B21	B22	B23
	P3	B31	B32	B33
C	P0	C01	C02	C03
	P1	C11	C12	C13
	P2	C21	C22	C23
	P3	C31	C32	C33

Microgreens planting process

Red spinach, red radish, and mustard greens *microgreens* were selected in this study because these plants were the most commonly consumed. Furthermore, seeds were purchased from the e-commerce "Gani The Yong (Jakarta)". In general, seeds were sown in a 32 cm × 25 cm × 5 cm tray with *cocopeat* media, and the prepared media was watered until moist, and then sown evenly. The sown seeds were then stored in a dark place for the first 3 days, and after the seedlings emerged, *microgreens* tray was moved to a shelf that was given a 6000 K LED light with a CRI of 60-70 with an exposure of 8 watts per shelf that was lit for 24 hours (10). Irrigation was carried out every day by watering without using fertilizer, and after *microgreens* reached a height of 6-9 cm, the plants were harvested at the 2-leaf stage when matured. Red spinach *microgreens* (Figure 1) and red radish *microgreens* (Figure 2)

Figure 1. Process of planting red spinach *microgreens* red spinach *microgreens* day 0.

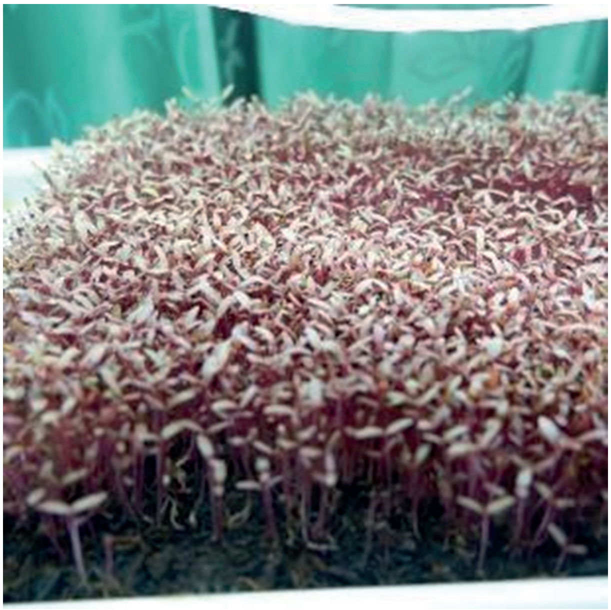

Figure 2. Process of planting red spinach *microgreens* red spinach *microgreens* day 9.

Figure 3. Process of planting red radish *microgreens* red radish *microgreens* day 0.

were harvested on the 9th day, while mustard greens *microgreens* (Figure 3-6) were harvested on the 14th day (16-27).

Microgreens blanching

Microgreens blanching process was conducted in Culinary Laboratory of the Nutrition Study Program, Universitas Diponegoro. The harvested *microgreens* were washed and dried using a *salad spinner*. This study was modified from a previous report on sweet potato leaves with a shorter blanching time because *microgreens* were small. This sprout was blanched with different time variations, namely 10, 15, and 30 seconds, as well as without blanching as a control. After completion, *microgreens* were put into ice water in a basin to stop the cooking process (28). The plants were soaked in ice water and then dried using a *salad spinner* to remove the remaining water and then weighed and put into plastic to be vacuumed.

Total dietary fiber

Total dietary fiber was calculated using the gravimetric enzymatic method carried out at the Chem Mix Pratama Laboratory in Yogyakarta. The samples were dried and ground, and then the fat was extracted when it contained >5% fat. Part of the sample was treated in an autoclave with amylase, amyloglucosidase, and

Figure 4. Process of planting red radish *microgreens* red radish *microgreens* day 9.

Figure 5. The process of planting mustard *microgreens* mustard *microgreens* day 0.

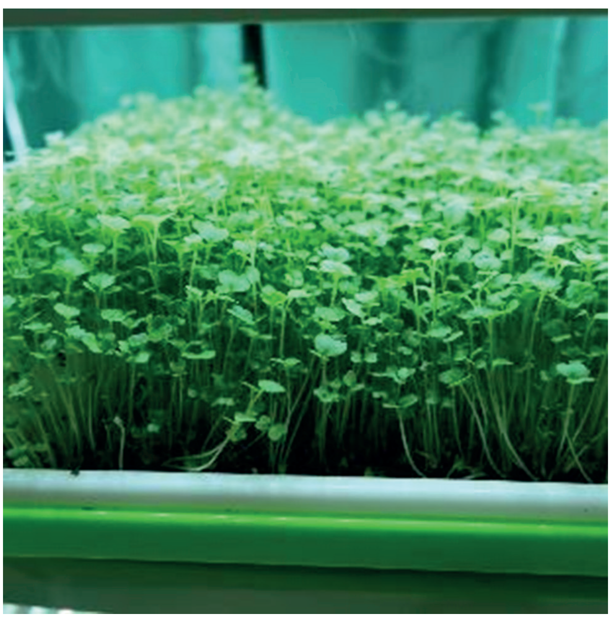

Figure 6. The process of planting mustard *microgreens* mustard *microgreens* day 14.

heat-stable protease to remove starch and protein. The enzymatically undigested fiber was precipitated with ethanol and filtered. The residue was then dried, weighed, ashed, and reweighed. A second portion of the sample was refluxed with neutral detergent and treated with alpha-amylase to remove water-soluble carbohydrates and proteins. The residue was dried, weighed, ashed, and reweighed, and total dietary fiber was calculated as the sum of 2 residues (29).

Antioxidant activity IC_{50}

Antioxidant activity IC_{50} was calculated using DPHH (2,2-dhipenyl1-picryhydrazyl) radical scavenging activity method carried out at the Chem Mix Pratama Laboratory in Yogyakarta (30). IC_{50} test was carried out by adding a constant aliquot of 1 ml of sample at 100, 200, 300, 400, and 500 ppm in 96% ethanol into 1 ml of 200 mM DPPH. The same procedure was carried out for vitamin C as a working reference at 100, 200, 300, 400, and 500 ppm in 96% ethanol. All reactions were incubated in the dark for 30 minutes, and each absorption response from each mixture was measured immediately at 517 nm.

Organoleptic analysis

Organoleptic tests were conducted at the Food Technology Science Laboratory of the Nutrition Study Program, Universitas Diponegoro, and the tests conducted in this study were hedonic tests and Just About Right (JAR) tests. The subjects of organoleptic tests to be conducted in this study were 67 untrained panelists (31) of which were taken from students of the Nutrition Study Program, at Universitas Diponegoro. A study involving humans was reviewed and approved by the Health Study Ethics Committee, Faculty of Medicine, Universitas Diponegoro No. 428/EC/KEPK/FK-UNDIP/VIII/2024. The participants gave written consent to participate in this study which was conducted following the 7 WHO 2011 standards.

Hedonic test

The hedonic test conducted included 5 aspects, namely color, taste, aroma, texture, and overall with 9 assessment scales for the hedonic scale, 9 = like very much, 8 = really like, 7 = like, 6 = kinda like, 5 = neutral, 4 = dislike, 3 = kinda dislike, 2 = really dislike, and 1 = very much dislike (32).

Just About Right (JAR) test

After the panelists conducted the hedonic test, the 9-scale JAR test was used to determine the level of certain sensory attributes related to *microgreens* including texture, unpleasant aroma, bitter taste, color, and bitter aftertaste (Appendix 4.). The midpoint used was represented by the attribute that was considered appropriate and correct (32).

Analysis of the best treatment

The best treatment was selected using the *multi-attribute decision method using a compensatory model and additive weighting technique* (MADCAW) (33). This was selected based on the best value of the calculation of each variable and its score. The calculation was carried out in Microsoft Excel as follows, First, the importance of the variables was sorted and ranked based on their significance to the quality of *microgreens* from highest to lowest as follows, IC_{50}, total fiber, texture, aroma, color, taste, and overall. Second, the normalized weight (A) was calculated by dividing the value of each rank by total rank value. Third, determine the dimensionless value (B) by calculating the difference between the worst value among the formulas and the formulation value divided by the difference between the worst value among the formulas and the best value among the formulas. Fourth, multiply the normalized weight (A) by the dimensionless value (B) to get the weight value. Last, total weight value of each attribute was added up with each formula, and the formula with the highest total weight value was the best.

Statistical analysis

The data on antioxidant activity and total dietary fiber were analyzed for data normality using *Shapiro-Wilk* because the data obtained were <50. Organoleptic test results were tested using *Kolmogorov Smirnov* because the data obtained were >50. The bivariate test was conducted using the *Kruskal-Wallis* statistical test because the data were not normally distributed. The test was conducted to determine the significant difference in blanching process on antioxidant activity and total dietary fiber of red spinach, radish, and mustard greens *microgreens*. Data analysis was conducted with a 95% confidence level with a p-value of 0.05 with $\alpha = 0.05$. When the p-value <0.05 then H0 was rejected, which meant there was a difference in antioxidant activity and total dietary fiber in *microgreens* with blanching process. Meanwhile, when the p value > 0.05 then H0 was accepted, which meant there was no difference in antioxidant activity and total dietary fiber in *microgreens* with blanching process. Organoleptic data were also collected using *Kruskal-Wallis* because the data were not normally distributed. Data analysis was continued with the *Mann-Whitney* test when there was a significant effect in the *Kruskal-Wallis* test.

Result and discussion

Total dietary fiber

Table 2 showed a significant difference between each treatment on total dietary fiber content in red spinach *microgreens*. Based on the results of further tests on total dietary fiber variable, there was a difference between treatments A0 and A3, and treatments A1 and A3. Based on the average treatment that had the highest total fiber was red spinach *microgreens* with 30 seconds of blanching. Furthermore, in red radish *microgreens*, Table 2 showed that there was a significant difference in total dietary fiber content between each treatment. When viewed from the results of further tests, there was no difference in total dietary fiber except between treatments B0 and B3 is slight change. The average with the highest total dietary fiber was fresh radish *microgreens*. This also showed that in mustard greens there was no significant difference in total dietary fiber in each mustard greens *microgreens* treatment. The highest average total dietary fiber was mustard greens with 10 seconds of blanching.

This study showed that total dietary fiber continued to increase with increasing blanching time in red spinach *microgreens*. Conversely, in red radish *microgreens*, total dietary fiber decreased with increasing blanching time. In a previous study, total dietary fiber content in fresh red radish *microgreens* was 1.78 g/100 g and fresh mustard greens was 2.08 g/100 g.

Table 2. Results of Average Level of IC_{50} Antioxidant Activity and Total Dietary Fiber Level of Red Spinach, Red Radish, and Mustard Greens *Microgreens*

Treatment	Total Dietary Fiber (%)	Antioxidant Activity IC50 (ppm)
A0	5,87±0,27[a]	18177,06±1962,96[a]
A1	6,09±0,47[a]	15382,52±318,42[b]
A2	6,89±0,46[ab]	15639,54±101,10[ab]
A3	7,90±0,58[b]	26676,37±709,86[ac]
*p**	0,001	0,000
B0	7,09±0,51[a]	11793,00±215,78
B1	6,47±0,44[ab]	12292,50±924,50
B2	6,39±0,48[ab]	12733,48±486,47
B3	4,78±0,06[b]	11889,32±363,63
*p**	0,001	0,076
C0	5,44±1,48	12448,10±215,88[a]
C1	6,69±1,25	8860,27±220,90[a]
C2	6,58±1,11	8594,22±251,57[ab]
C3	6,58±0,63	8401,05±89,65[ac]
*p**	0,387	0,000

Numbers followed by different superscript letters (a,b,c) indicated significant differences ($p<0.05$) with the *Dunn Bonferroni* test. A: red spinach *microgreens*; B: red radish *microgreens*), and C: mustard greens *microgreens*.

These results were smaller than this report which reached 7.09 g/100 g in red radish microgreens and 5.44 g/100 g in mustard greens (16). In addition, there was an increase in the 10-second blanching treatment but decreased again in the 15 and 30-second blanching treatments. Previous studies had shown that the heating process could change dietary fiber and nutritional content of vegetables. The heating process also changed the texture of vegetables by changing their fibrous components. In previous studies, total dietary fiber content decreased in sesame leaves after blanching, but it could also increase in garlic stems (34). Heating processes such as blanching could cause the release of cell components and the dissolution of dietary fiber components such as pectin, beta-glucan, and oligosaccharides. The solubility level of cell wall components was influenced by the chemical properties of polysaccharides and their bonds with macromolecules in the cell wall, as well as processing parameters such as temperature and duration of processing (35). Before the study conducted on pumpkin leaves, it was reported as an increase in crude fiber of 24.6% after boiling which could be due to increased amylase activity, and loss of sugar and dissolved minerals (14).

IC_{50} Antioxidant activity

Table 2 showed a significant difference between each treatment of IC_{50} antioxidant activity in mustard greens *microgreens*. After further testing, there was a difference in antioxidant activity between treatments A0 and A1, treatments A1 and A3, and treatments A2 and A3. Based on the average treatment, the one with the highest IC_{50} value was red spinach *microgreens* with 30-second blanching. This also showed that in red radish *microgreens*, there was no significant difference in antioxidant activity in each treatment. The one with the highest IC_{50} value was red radish *microgreens* with 15-second blanching. In *microgreens* mustard greens, Table 2 showed that there were significant differences in antioxidant activity in each treatment. Further test results showed that there were significant differences between treatments C0 and C2 and treatments C0 and C3, when viewed from the average IC_{50} results, the highest was fresh mustard greens *microgreens*. Based on the results of this study, IC_{50} levels of red radish *microgreens* continued to increase in fresh *microgreens*, with 10-second blanching, and with 15-second blanching but decreased again in red radish *microgreens* with 30-second blanching. In contrast to red spinach and red radish *microgreens*, IC_{50} levels of mustard greens *microgreens* decreased after blanching. Based on previous studies, the heating process significantly affected antioxidant activity, both positively and negatively. In general, the heating process softened the cell walls of vegetables, released more polyphenols, and produced higher antioxidant properties. High extraction temperatures caused cell wall degradation due to damage to carbohydrates and proteins due to heat which facilitated the release of phenol from plant tissue (36,37). However, the heating process could also cause the degradation of several antioxidants and reduce their antioxidant activity (36). The results of this decrease in antioxidant activity could be associated with enzyme denaturation resulting from blanching process (38).

Increasing blanching time caused the degradation of several compounds such as vitamin C and chlorophyll, however, a decrease in antioxidant activity. Degradation of vegetable antioxidants occurred not only due to temperature but also the length of blanching time. High temperatures for a long time could encourage sample degradation and denature catalytic enzymes that played a role in the oxidation of phenolic compounds (39). Based on the results of IC_{50} test on red spinach, red radish, and mustard greens *microgreens*, antioxidant activity in the 3 types of *microgreens* was classified as very weak. Based on previous studies, antioxidant capacity was divided into several groups, namely very strong antioxidants when IC_{50} value was less than 50 ppm, strong when IC_{50} value was 51-100 ppm, and moderate when IC_{50} value was more than 200 ppm (40). Compared to previous studies with the same analysis method, IC_{50} content of red radish *microgreens* was 155.7 ppm, and mustard greens *microgreens* were 168.4 ppm, which was included in the weak group (21). In other studies, it was found that IC_{50} content of red spinach microgreens was 120.23 ppm, which was included in the moderate group (41). Several factors caused the value of antioxidant activity to decrease, according to the literature which stated that the factors that affected the stability of antioxidant activity were pH, temperature, light, and oxygen (42). This finding suggests that, while red spinach microgreens exhibit moderate antioxidant capacity, other sources such as tempeh gembus hydrolysate may offer higher potential due to the presence of bioactive peptides with strong radical scavenging activity (43). Interestingly, fruit leather made from red dragon fruit and watermelon rind with seaweed addition also demonstrated antioxidant activity, with the best formulation (F2) showing an IC50 value of 107.39 ppm, slightly stronger than red spinach microgreens and indicating its potential as a functional food with extended shelf life (44).

Analysis organoleptic

Table 3 showed that there were differences in color and taste parameters between treatments A0, A1, A2, and A3. However, after further testing, it was found that the highest average, panelists preferred treatment A0 and the lowest treatment A1. In terms of taste attributes, the highest average panelists were in treatment A1 and the lowest in treatment A0. Assessment of aroma, texture, and overall parameters did not show significant differences between treatments A0, A1, A2, and A3. According to the highest average in aroma parameters, treatment A0 was obtained, and the lowest A3, and also the panelist acceptance of texture parameters was highest in treatment A0 and lowest in A1. In terms of overall parameters, the highest average panelist acceptance was in treatment A0 and the lowest in A3.

This table showed that there were differences in taste parameters between treatments B0, B1, B2, and B3. However, after further testing, it was found that in the highest average color parameter, panelists preferred treatment B0 and the lowest treatment B1. Assessment of color, aroma, texture, and overall parameters showed no significant differences between treatments B0, B1, B2, and B3. In the taste parameter, the highest average was obtained in treatment B0 and the lowest in treatment B2. The aroma attribute was based on the highest average panelists in treatment B0 and the lowest in treatment B3. The highest average panelist acceptance in the texture parameter was in treatment B2 and the lowest was in B0. In the overall parameter, the highest average panelist acceptance was in treatment B2, and the lowest was in B0. As shown in Table 3, there were differences in color parameters between treatments C0, C1, C2, and C3. However, after further testing, it was found that in the highest average taste parameters, panelists preferred treatment C3 and the lowest treatment C2. Assessment of taste, aroma, texture, and overall parameters showed no significant differences between treatments C0, C1, C2, and C3. In the color parameter, the highest average was obtained in treatment C0 and the lowest in treatment C2. The aroma attribute was based on the highest average panelists in treatment C0 and the lowest in treatment C2. The panelists' acceptance of the texture parameter was the highest in treatment C1 and the lowest in C2. In the overall parameter, the highest average panelists' acceptance was in treatment C0 and the lowest in C2. Table 4 showed the results of JAR organoleptic test on red spinach *microgreens*, it was found that there was no significant difference in the aroma and aftertaste parameters between treatments A0, A1, A2, and A3.

Table 3. Average Results of *Microgreens* Hedonic Test

Treatment	Color	Taste	Aroma	Texture	Overall
A0	7,63±1,179[a] (very much like)	4,49±1,682[a] (slightly dislike)	4,75±1,501 (neutral)	5,91±1,368 (like)	5,30±1,436 (slightly like)
A1	6,16±1,822[b] (slightly like)	5,57±1,427[b] (slightly like)	4,22±1,423 (slightly dislike)	5,36±1,658 (neutral)	5,18±1,413 (neutral)
A2	6,24±1,715[b] (slightly like)	5,30±1,661[b] (neutral)	4,27±1,822 (slightly dislike)	5,37±1,565 (neutral)	5,19±1,373 (netral)
A3	6,21±1,533[b] (slightly like)	5,18±1,576[b] (neutral)	4,07±1,682 (slightly dislike)	5,39±1,456 (neutral)	5,15±1,317 (neutral)
*p**	0,000	0,009	0,067	0,177	0,940
B0	5,69±1,559 (slightly like)	3,45±2,010[a] (dislike)	4,31±1,626 (slightly dislike)	5,01±2,004 (neutral)	4,15±1,635 (slightly dislike)
B1	5,22±1,613 (neutral)	4,82±1,696[b] (neutral)	4,00±1,670 (slightly dislike)	5,12±1,472 (neutral)	4,70±1,337 (neutral)
B2	4,99±1,581 (neutral)	4,69±1,860[b] (neutral)	3,94±1,766 (slightly dislike)	5,30±1,605 (neutral)	4,72±1,574 (neutral)
B3	5,30±1,567 (neutral)	4,39±1,705[b] (slightly dislike)	3,72±1,722 (slightly dislike)	5,06±1,402 (neutral)	4,55±1,520 (neutral)
*p**	0,090	0,000	0,238	0,708	0,109
C0	6,84±1,123[a] (like)	5,12±1,919 (neutral)	5,12±1,600 (neutral)	5,67±1,761 (slightly like)	5,49±1,655 (neutral)
C1	6,07±1,598[b] (slightly like)	5,30±1,723 (neutral)	4,79±1,513 (neutral)	5,76±1,508 (slightly like)	5,33±1,408 (neutral)
C2	6,03±1,446[b] (slightly like)	4,85±1,820 (neutral)	4,64±1,612 (neutral)	5,46±1,491 (neutral)	5,00±1,518 (neutral)
C3	6,33±1,186[b] (slightly like)	5,37±1,677 (neutral)	4,93±1,682 (neutral)	5,70±1,457 (slightly like)	5,52±1,318 (neutral)
*p**	0,004	0,387	0,475	0,722	0,229

Numbers followed by different superscript letters (a, b) indicate significant differences (p<0.05) with the *Mann-Whitney* test. A: red spinach *microgreens*; B: red radish *microgreens*, and C: mustard greens *microgreens*.

According to the panelists, the aroma of red spinach *microgreens* was slightly too bitter based on the average aroma that was most accepted in the A0 treatment. In the aftertaste parameter, the panelists liked the A3 treatment the most because it was considered appropriate. Assessment of the texture, taste, and color parameters showed significant differences. In terms of texture parameters, according to the panelists, the A0 treatment was appropriate, while the A1, A2, and A3 treatments were slightly too soft. After further testing, it was found that the most preferred treatment was *microgreens* without blanching. In terms of taste, the A0 treatment was slightly too bitter, while A1, A2, and A3 were appropriate. After further testing, the most preferred treatment was red spinach *microgreens* with 15-second blanching. In terms of color, the A0 treatment was appropriate, while A1, A2, and A3 were slightly too colorful. After further testing, the highest average was the A0 treatment.

Table 4 showed the results of JAR organoleptic test on red radish microgreens, which showed no significant difference in aroma parameters between treatments B0, B1, B2, and B3. According to the panelists, the aroma of red radish *microgreens* was a bit too unpleasant, based on the average aroma that was most accepted in treatment B3. Assessment of texture, taste, color, and aftertaste parameters showed significant differences. According to the panelists, the

Table 4. Average Results of JAR *Microgreens* Test

Treatment	Color	Taste	Aroma	Texture	*Aftertaste*
A0	4,55±1,197[a] (just right)	4,33±1,580[a] (a little too bitter)	3,67±1,386 (a little too unpleasant)	4,58±1,281[a] (just right)	4,48±1,673 (a little too bitter)
A1	4,09±1,288[b] (a little too colorful)	4,81±1,328[b] (just right)	3,52±1,418 (a little too unpleasant)	5,66±1,262[b] (a little too soft)	4,66±1,513 (just right)
A2	4,01±1,409[b] (a little too colorful)	4,94±1,217[b] (just right)	3,54±1,599 (a little too unpleasant)	6,04±1,397[b] (a little too soft)	4,85±1,469 (just right)
A3	4,00±1,477[b] (a little too colorful)	4,90±1,383[b] (just right)	3,34±1,297 (a little too unpleasant)	6,09±1,390[b] (a little too soft)	5,01±1,387 (just right)
*p**	0,011	0,016	0,529	0,000	0,103
B0	5,94±1,217[a] (a little too colorful)	2,94±1,516[a] (a little too bitter)	3,19±1,406 (a little too unpleasant)	3,61±1,414[a] (a little too loud)	3,04±1,508[a] (a little too bitter)
B1	5,39±1,230[b] (just right)	4,12±1,297[b] (a little too bitter)	3,01±1,249 (a little too unpleasant)	5,16±1,321[b] (just right)	3,99±1,273[b] (a little too bitter)
B2	5,46±1,428[b] (just right)	4,16±1,298[b] (a little too bitter)	3,18±1,218 (a little too unpleasant)	5,31±1,246[b] (just right)	4,13±1,424[b] (a little too bitter)
B3	5,27±1,452[b] (just right)	3,84±1,797[b] (a little too bitter)	3,21±1,647 (a little too unpleasant)	5,49±1,260[b] (just right)	4,08±1,940[b] (a little too bitter)
*p**	0,020	0,000	0,854	0,000	0,000
C0	5,42±1,183 (just right)	4,28±1,369[a] (a little too bitter)	3,78±1,584 (a little too unpleasant)	4,12±1,187[a] (a little too loud)	4,31±1,489 (a little too bitter)
C1	5,09±1,164 (just right)	4,25±1,341[a] (a little too bitter)	3,75±1,418 (a little too unpleasant)	5,18±1,154[b] (just right)	4,33±1,147 (a little too bitter)
C2	5,09±0,933 (just right)	4,66±1,052[b] (just right)	3,84±1,463 (a little too unpleasant)	5,54±1,092[bc] (a little too soft)	4,61±1,072 (just right)
C3	5,19±0,925 (just right)	4,79±1,441[b] (just right)	3,88±1,451 (a little too unpleasant)	5,73±1,238[c] (a little too soft)	4,63±1,324 (just right)
*p**	0,065	0,019	0,928	0,000	0,179

Numbers followed by different superscript letters (a,b) indicate significant differences ($p<0.05$) with the *Mann-Whitney* test. A: red spinach *microgreens* (Amaranthus tricolor L.), B: red radish *microgreens* (Raphanus sativus L.), and C: mustard greens *microgreens* (*Brassica juncea L.*).

texture parameter of treatment B0 was a bit too hard, while treatments B1, B2, and B3 were just right. After further testing, it was found that the most preferred treatment was *microgreens* with 30-second blanching. In terms of taste, treatment B0 was slightly too bitter, while B1, B2, and B3 were slightly too bitter. After further testing, the most preferred treatment was radish *microgreens* with 15-second blanching. In terms of color, treatment A0 was slightly less colorful, while B1, B2, and B3 were just right. After further testing, the highest average was treatment A0. In terms of aftertaste, according to panelists, treatment A0 was slightly too bitter, while B1, B2, and B3 were slightly too bitter. Afterward, the most preferred treatment was radish *microgreens* with 15-second blanching. Table 4 showed the results of JAR organoleptic test on mustard greens *microgreens*, it was found that there was no significant difference in the aroma, color, and aftertaste parameters between treatments C0, C1, C2, and C3. According to panelists, the aroma of mustard greens *microgreens* was slightly too unpleasant, based on the average aroma that was most accepted in treatment C3. Based on the panelists, the color of the mustard greens *microgreens* was just right, according to the highest average, the most preferred color was treatment C0. In the aftertaste parameter, the panelists liked the C3 treatment the most because it was considered just right. In addition, assessment of the texture and taste parameters showed significant differences. In the texture parameter, according to the panelists, treatment C0 was a little too hard, C1 was just right, while treatments C2 and C3 were a little too soft. In the taste parameter, treatments C0 and C1 were a little too bitter, while C2 and C3 were just right. After further testing, the most preferred treatment was mustard greens *microgreens* with 30-second blanching.

Texture

Based on organoleptic results, the texture of fresh red spinach *microgreens* was considered to be just right compared to red radish and mustard greens which were slightly too hard. One of the factors that influenced this was the morphology of *microgreens* themselves, red spinach *microgreens* had the smallest weight and length followed by mustard greens and red radishes (45). After *microgreens* were blanched, the texture of the red spinach *microgreens* became slightly too soft, the red radish became just right and mustard greens became just right at 10 seconds and slightly too soft at 15 and 30 seconds. This happened because when blanching could remove air from the tissue, and destroyed the microstructure of cells, blanching could soften the texture (46).

Color

Fresh red spinach *microgreens* had a very popular color followed by mustard greens which were considered just right and red radishes which were considered slightly less colorful. Red spinach *microgreens* themselves were considered appropriate by the panelists which came from the anthocyanin content in red spinach *microgreens* (47). After these plants were blanched, the color of red spinach *microgreens* became slightly too colored, the red radish became just right, and the mustard greens were just right. Blanching process could maintain the color of the food ingredients that had undergone blanching process and produced sharp colors (25).

Aroma

The aroma of mustard greens *microgreens* had the highest level of preference followed by red spinach and red radish. According to the panelists, mustard greens *microgreens* had a slightly too rancid aroma like vegetables, spinach *microgreens* were slightly too rancid like soil, while red radish had a slightly too rancid aroma that was pungent. In addition, it was known that the sensory chemistry of *Brassicaceae* species in this study, namely red radish and mustard greens, was complex (due to organosulfur and phenolic compounds). Among organosulfur compounds, glucosinolates were responsible for their respective taste, aroma, and trigeminal characteristics (specifically bitter taste, sulfur aroma, and spicy sensation) (47). Based on previous studies, red radish *microgreens* had the highest glucosinolate compounds while mustard greens had the lowest glucosinolate compounds (49,50). After blanching process, both the aroma and taste changed to be more acceptable because it aimed to deactivate oxidative enzymes that could cause changes in odor and taste (24). In previous studies, this process reduced the glucosinolate levels in white cabbage by 50% (26).

Taste

Mustard greens had the most acceptable level of taste preference, which was considered neutral for both fresh *microgreens* and blanched *microgreens*, the same as in previous studies (51). Followed by red spinach, which was unlike previous studies conducted in Colorado, which was very much liked, the taste of red spinach *microgreens* in this study was smaller, which was rather disliked on fresh *microgreens* to slightly like after blanching process (52). Last, followed by red radish, which was disliked on fresh *microgreens* to neutral on *microgreens* with blanching treatment. However, unacceptable tastes such as bitterness could be caused by various biochemical substances that could be beneficial to health. Since *microgreens* were usually consumed in mixed salads, consumers could include many varieties in mixed salads that produced vibrant colors, flavors, textures, and odors. Reducing the proportion of types that were not so preferred in mixed salads was another way to get health benefits without reducing taste.

Best treatment

Table 5 showed the score values produced to determine the best treatment on red spinach *microgreens*, the highest results were obtained in the 15-second blanching treatment.

As shown in Table 6, the score values produced were to determine the best treatment for red radish *microgreens*, and the highest results were obtained in the treatment without blanching.

Table 7 showed the score values produced to determine the best treatment for mustard *microgreens*, the highest results were obtained in the 30-second blanching treatment.

Table 5. Best Red Spinach *Microgreens* Treatment

Parameter	Relative Rank	A0	A1	A2	A3
Texture	1	0.04	0	0	0
Aroma	4	0.14	0.03	0.04	0
Taste	5	0	0.18	0.13	0.11
Color	2	0.07	0	0	0
Aftertaste	3	0.11	0.02	0.03	0
Antioxidants	7	0.19	0.25	0.25	0
Fiber	6	0	0.02	0.11	0.21
Total	**28**	0.54	0.51	0.56	0.33

Table 6. Best Red Radish *Microgreens* Treatment

Parameter	Relative Rank	B0	B1	B2	B3
Texture	1	0	0.01	0.04	0.01
Aroma	4	0.14	0.07	0.05	0
Taste	5	0	0.18	0.16	0.12
Color	2	0.07	0.02	0.00	0.03
Aftertaste	3	0	0.10	0.11	0.08
Antioxidants	7	0.25	0.12	0	0.23
Fiber	6	0.21	0.16	0.15	0
Total	**28**	**0.68**	**0.66**	**0.51**	**0.46**

Table 7. Best Mustard *Microgreens* Treatment

Parameter	Relative Rank	C0	C1	C2	C3
Texture	1	0.03	0.04	0	0.03
Aroma	4	0.14	0.04	0	0.09
Taste	5	0.09	0.15	0	0.18
Color	2	0.07	0	0	0.03
Aftertaste	3	0.10	0.07	0	0.11
Antioxidants	7	0.06	0.22	0.24	0.25
Fiber	6	0.05	0.21	0.20	0.20
Total	**28**	**0.54**	**0.74**	**0.43**	**0.87**

Conclusion

In conclusion, blanching process affected antioxidant activity, total dietary fiber, texture, taste, and color in red spinach *microgreens*, and total dietary fiber, texture, taste, color, and aftertaste in red radish *microgreens*. In addition, blanching process also affected antioxidant activity, texture, and taste in mustard greens *microgreens*. The plants with the highest antioxidant activity, namely *microgreens* with the lowest IC50 value were mustard greens with a 30-second blanching treatment, red radish *microgreens* were fresh *microgreens*, and red spinach *microgreens* were *microgreens* with a 15-second blanching treatment. *Microgreens* with the highest total dietary fiber content were red spinach *microgreens* with a 30-second blanching, red radish *microgreens* were fresh red radishes, and mustard greens were blanching treatments of 10 seconds. The selected treatment on red spinach *microgreens* was red spinach with a 15-second blanching treatment, on red radish *microgreens* was fresh red radish *microgreens*, and on mustard greens was a 30-second blanching treatment.

Acknowledgments: The author is grateful to the panelists for participating in this activity, and to the Universitas Diponegoro for funding this study with an International Publication Study grant No. 753-18/UN7.D2/PP/IX/2022.

Authors' Contribution: DAN and NR contributed to the study design and data collection. DMK and FA performed data analysis and interpretation of results. MA and WW provided conceptual input and critical review of the manuscript. DNA drafted the manuscript and supervised the article submission process until publication. All authors read and approved the final version of the manuscript.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

References

1. Blüher M. Obesity global epidemiology and pathogenesis. Nat Rev Endocrinol. 2019;15(5):288-98. doi: 10.1038/s41574-019-0176-8
2. Midah Z, Fajriansyah F, Makmun A et al. The relationship between obesity and oxidative stress. UMI Med J. 2021;6(1):62-9. doi: 10.33096/umj.v6i1.140
3. Ministry of Health of the Republic of Indonesia. Indonesian health survey 2023 in figures. Jakarta: Health Development Policy Agency; 2023.
4. Lara-Guzmán ÓJ, Rivera DA, Corrales-Agudelo V et al. Dietary antioxidant intake is inversely associated with 2,3-dinor oxylipin metabolites, the major excreted oxylipins in overweight and obese subjects. Free Radic Biol Med. 2022;190:42-54. doi: 10.1016/j.freeradbiomed.2022.07.023
5. Zheng B, Ao T, Zhao X et al. Comprehensive assessment of the anti-obesity effects of highland barley total, insoluble, and soluble dietary fiber through multi-omics analysis. Food Res Int. 2024;189:114535. doi: 10.1016/j.foodres.2024.114535
6. Bhaswant M, Shanmugam DK, Miyazawa T et al. Microgreens—a comprehensive review of bioactive molecules and health benefits. Molecules. 2023;28(2):867. doi: 10.3390/molecules28020867
7. Marchioni I, Martinelli M, Ascrizzi R et al. Small functional foods: comparative phytochemical and nutritional analyses of five microgreens of the Brassicaceae family. Foods. 2021;10(2):427. doi: 10.3390/foods10020427
8. Xiao Z, Lester GE, Park E et al. Evaluation and correlation of sensory attributes and chemical compositions of emerging fresh produce: microgreens. Postharvest Biol Technol. 2015;110:140-8. doi: 10.1016/j.postharvbio.2015.07.021
9. Mir SA, Shah MA, Mir MM. Microgreens: production, shelf life, and bioactive components. Crit Rev Food Sci Nutr. 2017;57(12):2730-6. doi: 10.1080/10408398.2016.1144557
10. Partap M, Sharma D, Hn D et al. Microgreen: a tiny plant with superfood potential. J Funct Foods. 2023;107:105697. doi: 10.1016/j.jff.2023.105697
11. Belošević SD, Milinčić DD, Gašić UM et al. Broccoli, amaranth, and red beet microgreen juices: the influence of cold-pressing on the phytochemical composition and the antioxidant and sensory properties. Foods. 2024;13(5):757. doi: 10.3390/foods13050757
12. Pant Y, Lingwan M, Masakapalli SK. Metabolic, biochemical, mineral and fatty acid profiles of edible Brassicaceae microgreens establish them as promising functional food. Food Chem Adv. 2023;3:100461. doi: 10.1016/j.focha.2023.100461
13. Supapvanich S, Sangsuk P, Sripumimas S et al. Efficiency of low dose cyanocobalamin immersion on bioactive compounds contents of ready to eat sprouts (sunflower and daikon) and microgreens (red-amaranth) during storage. Postharvest Biol Technol. 2020;160:111033. doi: 10.1016/j.postharvbio.2019.111033
14. Kumar A, Gupta K, Islam Apu MdA et al. Effect of household processing on nutritional and antinutritional composition, mineral-mineral ratios, and functional properties of Colocasia leaves. Heliyon. 2023;9(6):e17137. doi: 10.1016/j.heliyon.2023.e17137
15. Wu DT, Li J, Wang J et al. Comparison of soluble dietary fibers from various quinoa microgreens: structural characteristics and bioactive properties. Food Res Int. 2024;181:114108. doi: 10.1016/j.foodres.2024.114108
16. Ghoora MD, Babu DR, Srividya N. Nutrient composition, oxalate content and nutritional ranking of ten culinary microgreens. J Food Compost Anal. 2020;91:103495. doi: 10.1016/j.jfca.2020.103495
17. Zhu F. Dietary fiber polysaccharides of amaranth, buckwheat and quinoa grains: a review of chemical structure, biological functions and food uses. Carbohydr Polym. 2020;248:116819. doi: 10.1016/j.carbpol.2020.116819
18. Syafrida M, Darmanti S, Izzati M. The effect of drying temperature on water content, flavonoid content and antioxidant activity of leaves and tubers of nutsedge (Cyperus rotundus L.). Bioma Berk Ilm Biol. 2018;20(1):44-50. doi: 10.14710/bioma.20.1.44-50
19. Gulcin İ. Antioxidants and antioxidant methods: an updated overview. Arch Toxicol. 2020;94(3):651-75. doi: 10.1007/s00204-020-02689-3
20. Nani A, Murtaza B, Sayed Khan A et al. Antioxidant and anti-inflammatory potential of polyphenols contained in Mediterranean diet in obesity: molecular mechanisms. Molecules. 2021;26(4):985. doi: 10.3390/molecules26040985
21. Ghoora MD, Haldipur AC, Srividya N. Comparative evaluation of phytochemical content, antioxidant capacities

and overall antioxidant potential of select culinary microgreens. J Agric Food Res. 2020;2:100046. doi: 10.1016/j.jafr.2020.100046
22. Sehrish A, Majeed I, Zongo E et al. A review on various extraction and detection methods of bio-functional components from microgreens: food applications and health properties. Int J Food Prop. 2023;26(2):3082-105. doi: 10.1080/10942912.2023.2272564
23. Renna M, Di Gioia F, Leoni B et al. Culinary assessment of self-produced microgreens as basic ingredients in sweet and savory dishes. J Culin Sci Technol. 2017;15(2):126-42. doi: 10.1080/15428052.2016.1225534
24. Lawalata VN, Tetelepta G. Acceptability of Tongka Langit banana juice drink with long blanching treatment. Agritekno J Agric Technol. 2019;8(1):24-8. doi: 10.30598/jagritekno.2019.8.1.24
25. Oktaviani D, Maflahah I, Supriyanto S. Effect of blanching time on the healthy salt characteristics of sealible (Suaeda maritima) flour. IOP Conf Ser Earth Environ Sci. 2023;7(3):128-40. doi: 10.1088/1755-1315/1182/1/012047
26. Wennberg M, Ekvall J, Olsson K et al. Changes in carbohydrate and glucosinolate composition in white cabbage (Brassica oleracea var. capitata) during blanching and treatment with acetic acid. Food Chem. 2006;95(2):226-36
27. Yadav LP, Koley TK, Tripathi A et al. Antioxidant potentiality and mineral content of summer season leafy greens: comparison at mature and microgreen stages using chemometric. Agric Res. 2019;8(2):165-75. doi: 10.1007/s40003-018-0378-7
28. Kamsiati E, Rahayu E, Herawati H. The effect of blanching on the characteristics of instant cassava leaves. Metana. 2020;16(1):39-46. doi: 10.14710/metana.v16i1.30461
29. Mongeau R, Brassard R. Comparison and assessment of the difference in total dietary fiber in cooked dried legumes as determined by five methods. J AOAC Int. 1994;77(5):1197-202
30. Molyneux P. The use of the stable free radical diphenylpicryl-hydrazyl (DPPH) for estimating antioxidant activity. Songklanakarin J Sci Technol. 2004;26(2)
31. Ayustaningwarno F, Rustanti N, Afifah DN et al. Theory and application of food technology. Semarang: Faculty of Medicine, Diponegoro University; 2020.
32. Lawless HT, Heymann H. Acceptance testing. In: Sensory evaluation of food. New York: Springer; 2010. p. 325-47. (Food Science Text Series)
33. Sullivan WG, Wicks EM, Koelling CP. Engineering economy. Global edition. 17th ed. 2019. 756 p.
34. Lee R, Kim Y. Effect of blanching on dietary fiber and free sugar content of vegetables. J Food Hyg Saf. 2023;38(3):164-9. doi: 10.13103/JFHS.2023.38.3.164
35. Agustin AT, Zaini MA, Handito D. The effect of blanching method and temperature on the compounding of banana stem fiber as a raw material for making ares. Pro Food J Food Sci Technol. 2020;6(1):609-22. doi: 10.29303/profood.v6i1.117
36. Wu Y, Liu Y, Jia Y et al. Effects of thermal processing on natural antioxidants in fruits and vegetables. Food Res Int. 2024;192:114797. doi: 10.1016/j.foodres.2024.114797
37. Narsih A, Agato. Efek kombinasi suhu dan waktu ekstraksi terhadap komponen senyawa ekstrak kulit lidah buaya. J Galung Trop. 2018;7(1):75. doi: 10.31850/jgt.v7i1.320
38. Zhan X, Zhu Z, Sun DW. Effects of pretreatments on quality attributes of long-term deep frozen storage of vegetables: a review. Crit Rev Food Sci Nutr. 2019;59(5):743-57. doi: 10.1080/10408398.2018.1496900
39. Le NL, Le TTH, Ma NB. Effects of air temperature and blanching pre-treatment on phytochemical content, antioxidant activity and enzyme inhibition activities of Thai basil leaves (Ocimum basilicum var. thyrsiflorum). Food Res. 2021;5(1):337-42
40. Apriani S, Pratiwi FD. Antioxidant activity of butterfly pea flower extract (Clitoria ternatea L.) using the DPPH (2,2 diphenyl-1-picrylhydrazyl) method. Cohesion Sci J. 2021;5(3)
41. Amalia R, Fardhani DM, Syarifah SM et al. Biostimulant effects of Moringa oleifera on growth and antioxidant activity in red amaranth (Amaranthus tricolor L.) microgreens. In: Purwestri YA, Sawitri WD, Nuringtyas TR et al., editors. BIO Web Conf. 2024;127:01005. doi: 10.1051/bioconf/202412701005
42. Diantika F. Effect of long extraction and concentration and concentration of ethanol solvent extraction antioxidant cocoa beans (Theobroma cacao L.). J Agric Technol. 2014;15(3):159-65
43. Agustina RK, Dieny FF, Rustanti N et al. Antioxidant activity and soluble protein content of tempeh gembus hydrolysate. Hiroshima J Med Sci. 2018;67
44. Ayustaningwarno F, Ayu AM, Afifah DN et al. Physicochemical and sensory quality of high antioxidant fruit leather of red dragon fruit and watermelon rind enriched with seaweed. Discover Food. 2024;4(92). doi: 10.1007/s44187-024-00169-6
45. Gunjal M, Singh J, Kaur J et al. Comparative analysis of morphological, nutritional, and bioactive properties of selected microgreens in alternative growing medium. S Afr J Bot. 2024;165:188-201. doi: 10.1016/j.sajb.2023.12.038
46. Zhang C, Hu C, Sun Y et al. Blanching effects of radio frequency heating on enzyme inactivation, physiochemical properties of green peas (Pisum sativum L.) and the underlying mechanism in relation to cellular microstructure. Food Chem. 2021;345:128756. doi: 10.1016/j.foodchem.2020.128756
47. Maseva S, Utama P, Sodiq AH et al. Pengaruh lama penyinaran lampu LED (light emitting diode) dan jenis media tanam terhadap pertumbuhan microgreens bayam merah (Amaranthus tricolor L.). J Agros Agric. 2024;26(1):102. doi: 10.37159/jpa.v26i1.4204
48. Cano-Lamadrid M, Martínez-Zamora L, Castillejo N et al. How does the phytochemical composition of sprouts and microgreens from Brassica vegetables affect the sensory

profile and consumer acceptability? Postharvest Biol Technol. 2023;203:112411. doi: 10.1016/j.postharvbio.2023.112411
49. Dereje B, Jacquier JC, Elliott-Kingston C et al. Brassicaceae microgreens: phytochemical compositions, influences of growing practices, postharvest technology, health, and food applications. ACS Food Sci Technol. 2023;3(6): 981-98
50. Xiao Z, Rausch SR, Luo Y et al. Microgreens of Brassicaceae: genetic diversity of phytochemical concentrations and antioxidant capacity. LWT. 2019;101:731-7. doi: 10.1016/j.lwt.2018.10.076
51. Senevirathne GI, Gama-Arachchige NS, Karunaratne AM. Germination, harvesting stage, antioxidant activity and consumer acceptance of ten microgreens. Ceylon J Sci. 2019;48(1):91. doi: 10.4038/cjs.v48i1.7593
52. Michell KA, Isweiri H, Newman SE et al. Microgreens: consumer sensory perception and acceptance of an emerging functional food crop. J Food Sci. 2020;85(4):926-35. doi: 10.1111/1750-3841.15075

Correspondence:
Received: 30 December 2024
Accepted: 23 April 2025
Donna Azhar Nafisah
Department of Nutrition Science, Faculty of Medicine, Universitas Diponegoro, Jl. Prof. Sudarto, Tembalang, Semarang 50275, Central Java, Indonesia
E-mail: d.nurafifah.dna@fk.undip.ac.id