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RESEARCH **Open Access**

Qualitative Study and Antioxidant Activity Herbal Tea Bag of Moringa Leaves (Moringa oleifera Lam.) and Red Ginger (Zingiber officinale var. Rubrum)

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Abstract
Moringa (MO) leaves contain several chemical substances of high value, including vitamin C, flavonoids, phenolic compounds, carotenoids, tannins, and triterpenoids, among which one functions as an antioxidant. Previous research observed that MO leaves have already been developed into various formulations; unfortunately, these formulas could not completely obscure the aroma and taste problems that rendered MO leaves less acceptable to consumers. In this research, Moringa leaf powder (MLP) and red ginger (RG) are combined to cover the unpleasant taste and aroma of MO leaves. The purpose of this study assess the quality of three tea bag formulations, including their water content, ash content, hedonic and antioxidant activities, by quantitative tests; F0 (3 Gr of MLP), F1 (2.25 Gr of MLP, and 0.75 Gr of RG), and F2 (the amount of MLP and RG is equal to 1.5 Gr). This experimental study employs a completely randomized design, three special treatments, and three repetitions. Statistical analysis of quality test results and antioxidant activity uses One-Way ANOVA followed by a post hoc test utilizing the Least Significant Difference (LSD). The water content tests revealed that all three formulations qualified the Indonesian National Standard (SNI), ranging from 3.86% to 4.29%. Adding ginger did not influence the water content ($p > 0.05$). Otherwise, it increases the ash level from 8.65% to 9.98%. Based on the results of the hedonic test, the panelists preferred F0 over F1 and F2 concerning color by a score of 86%. In contrast, they preferred F2 regarding aroma and taste by a score of 82%. The addition of RG in F1 and F2 was significant to the preference level of panelists ('p <0.05). The IC50 value for the antioxidant activity test was highest for F2 at 59.31 ± 0.13 ppm. The addition of RG boosted the antioxidant activity of MO tea products considerably (sig <0.05). Consequently, developing MO tea products containing RG in F2 could be potentially produced as herbal tea beverages with antioxidant properties.

Keywords: Antioxidants, Moringa Leaves, Red ginger, Tea bags.

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1. INTRODUCTION

Free radicals and Reactive Oxidative Stress (ROS) are frequently discussed as causes of various human chronic diseases (Ghezzi et al., 2017). Stroke, diabetic nephropathy, cancer, hypertension, cardiovascular disease, acute lung inflammation, neurological illnesses, cataracts, obesity, hyperglycemia, and aging are triggered by reactive oxygen species (ROS), which are produced due to exposure to radiation, pollutants, and drug metabolites (Davies et al., 2017). Antioxidants are one of the available solutions for preventing the development of endogenous and exogenous ROS and free radicals through a variety of mechanisms of action. In addition, antioxidants are frequently implemented in cancer therapy to reduce the side effects of anticancer therapy (Casas et al., 2020).

Synthetic drugs can function as antioxidants. However, their high costs provide an incredible opportunity for herbal medicines to be employed as an affordable source in antioxidant development. Furthermore, antioxidants generated from synthetic materials, such as butylated hydroxyl anisol (BHA; 320), butylated hydroxyl toluene (BHT; E321), tert-butylhydroquinone (E-319), and propyl gallate (E-311), have unidentified side effects. Therefore, natural antioxidants may be employed as a source for the development of antioxidants (Malekmohammad et al., 2019). Natural ingredients with chemical compounds such as alkaloids, terpenoids, tannins (Pisoschi et al., 2016), flavonoids, anthocyanins, carotenoids, and vitamins C and E (Xu et al., 2017) are proven to have antioxidant potential with various mechanisms of action that are influenced by geographical conditions or location where the medicinal plants are grown or processed (Cardoso, 2019).

MO leaves contain many active compounds, such as vitamins A and C, flavonoids, phenolic compounds, and triterpenoids (Farooq et al., 2021). The high content of phenolic bioactive compounds in MO leaves contributes to their ability to scavenge free radicals strongly (Kou et al., 2018). Previous studies have proven that MO leaf extract has antioxidant activity using the DPPH method with an IC50 value of 87.54 ppm (Muna, 2022).

People usually consume MO leaves as lalapan (raw vegetables) by boiling them. Modification of MO leaves is produced in the development, manifested in dry powder as a nutritional addition to children's food (Singh et al., 2018). Additional formulations have also been implemented in food products to increase their nutritional value such as soy meatballs (Evivie et al., 2016), and candy MO served in the form of tea (Darna et al., 2019). Despite their unpleasant taste, MO leaves in tea provide certain health benefits, particularly antioxidant properties. To solve that problem, it is necessary to include other ingredients for the product to be accepted by people and provide more health benefits (Fatima et al., 2020). Moringa leaves tea bags are formulated by adding red ginger (Zingiber officinale var. rubrum) to increase its antioxidant potential due to the high chemical composition of gingerols, oleoresin, and essential oils in red ginger and to provide a distinctive taste (Suhendy, 2021).

The widespread use of MO in the community encourages researchers to develop MO into other products so that consumers have a wide range of options for consuming MO. Moreover, in Kupang-East Nusa Tenggara, MO is widely available, and the provided technology is relatively simple to implement in the community. This research intends to produce a tea bag containing MO leaves and RG to reduce the unpleasant aroma. The current study did a qualitative test to measure phytochemical screening, water content, ash content, hedonic and in vitro antioxidant activity. In this study, Moringa leaves are produced as a product packaged in bags made of filter paper as tea bags. Moringa tea preparations are then carried out with qualitative tests, including phytochemical screening, water content test, ash content test, hedonic tests, and in vitro antioxidant activity tests using the 2,2-diphenyl-2 picrylhydrazil (DPPH) method as a quantitative aspect of testing. Then, Moringa tea preparations are carried out with qualitative tests, including phytochemical screening, water content test, ash content test, hedonic tests, and in vitro antioxidant activity tests using the 2,2-diphenyl-2 picrylhydrazil (DPPH) method as a quantitative aspect of testing.

2. RESEARCH METHOD

The research design is completely randomized design (CRD), consisting of three treatments and three replications with variations in ginger addition. The first formula is F0, with the composition of 3 Gr of MLP without the addition of red ginger (0%). The second formula is F1, with the composition of 2.25 Gr of MLP and 0.75 grams of red ginger. The third formula is F2, with the composition of MLP 1.5 Gr and red ginger 1.5 Gr (50%). This study aims to assess the herbal tea bags of MO leaves in qualitative and quantitative aspects. Numerous procedures are performed to achieve this aim; a) determination of MO and red ginger plants, b) manufacture of MO leaves and red ginger powder, c) manufacture of herbal tea combined with MO leaves and red ginger as well as quality tests including water content, ash content, hedonic test and antioxidant activity test of tea bag products using DPPH method. The ANOVA test analyzes statistical data on water content, ash content, and antioxidant activity. If the findings indicated a significant or very significant impact, a post hoc test using the LSD technique would be performed.

a. Plants determination and MO leaves and red ginger powder preparation.

In May 2022, MO leaves, and red ginger were produced at Penfui, Kupang, East Nusa Tenggara. The collected MO leaves were green, not old or too young, fresh, and intact. The certification of plant identification was achieved from the Jatinangor Herbarium, Laboratory of Plant Taxonomy, Department of Biology, Mathematics and Natural Science Faculty, Padjajaran University, following the letter of determination No.47/HB/02/2022.

The MO leaves and red ginger that is to be dried are carefully cleaned and drained in running water. The MO leaves are dried properly by aerating them at room temperature while flipping them over continuously. The drying process is continued until the water content is reduced which is indicated by the fragility of the leaves when it is held. MO leaves Simplicia are powdered using a grinder with a 60-mesh powder particle size (Irwan, 2020). The ginger rhizome is chopped longitudinally (split), then dried by airing it for seven days (Siampa & Jayanto, 2020). The dried Simplicia is then mashed using a blender and sifted using a 60-mesh sieve (Ngatirah & Dewi, 2020). The simplicial is then formulated into tea bags.

b. Herbal tea bags made from a combination of MO leaves and red ginger.

The tea bags are formulated into three formulas weighing 3 Gr each. MO tea formula 1 (F0) is made by weighing 3 Gr of MO powder, formula 2 (F2) consists of 2.25 Gr of MO powder and 0.75 Gr of red ginger, formula 3 (F3) consists of MO and red ginger in equal amount, namely 1.5 Gr Each material that is weighed is then mixed until homogeneous, and put into a tea bag (Santi et al., 2022). Then, quality tests are carried out including phytochemical screening, water content test, ash content test, hedonic organoleptic test, and antioxidant activity as quantitative test parameters.

c. Phytochemical screening

The material used to analyze chemical content is brewed from tea bags. The tea bags of each formula are dipped up and down with 200 mL of warm water at 40 °C for 5 minutes. The tea bags are removed from the solute ion (Nikmah et al., 2022), cooled to room temperature, and then analyzed for their chemical content (Sucianti et al., 2021).

1). Flavonoids identification.

The flavonoid test was carried out using the Wilstater test. A sample dissolved in 2 mL of warm water was added to a spatula of Mg powder and four drops of HCl 2% (Nikmah et al., 2022).

2). Steroids and triterpenoids identification.

1 mL of sample was added with 3 mL of 70% ethanol and 2 mL of concentrated H_2SO_4 and 2 mL of acetic acid anhydrous (Liebermann-Burchard reagent). A color change from purple to blue or green indicated the presence of steroids. In contrast, the formation of a brownish-red color at the interface showed the presence of triterpenoids (Purwoko et al., 2022).

3). Tannins identification.

2 mL of sample was taken and put into a test tube, and added 2-3 drops of 1% $FeCl_3$. The formation of a green-black or dark-blue solution indicated that the sample contained tannin (Ruwandha et al., 2021).

4). Alkaloids identification.

The identification of alkaloids was accomplished by reacting 1 mL of chloroform and ammonia with each sample. The results of the reaction were then warmed over a Bunsen flame, instead shaken, and filtered. The filtrate was divided into three equal parts. In each portion, three drops of 2N H_2SO_4 were added, shaken, and allowed to stand separately. The supernatant was taken to be reacted with several reagents, and the color of the precipitate was observed. A positive sample contained alkaloids if the Meyer reagent identified an orange precipitate, a brown precipitate formed in the Wagner reagent, and a white precipitate formed in the Dragendorf reagent (Khanifah, Puspitasari, & Awwaluddin, 2021).

5). Saponins.

The sample was heated to boiling using 5 mL of distilled water and filtered. The filtered results were shaken and then allowed to stand for 15 minutes. Samples that positively contained saponin were indicated by the formation of stable foam (Dena et al., 2021).

d. Water content test.

The test was carried out employing the gravimetric method. A total of approximately 2 g of tea product samples were weighed carefully and placed into a container that had been sterilized. The sample was then cooked in the oven at +/- 105 °C for 5 hours and weighed. Drying and weighing were performed at 1-hour intervals until the difference between 2 consecutive weighings did not exceed 0.25% (Tuapattinaya et al., 2021).

e. Ash content test

Samples of tea products in each formula were weighed accurately as much as 2-3 grams; then the samples were put into a silicate crucible that had been ignited and tared. The sample was ignited slowly until the charcoal ran out, cooled in a desiccator then weighed until the weight remains constant (Widanti & Wahyudi, 2019).

$$\text{Ash content} = \frac{W1}{W2} \times 100\% \quad (1)$$

Description :

W1 = sample weight after ashing (grams)

W2 = sample weight before ashing (grams)

f. Hedonic organoleptic test

The hedonic test was assessed using a hedonic or preference-level scale. In this study, the panelists consisted of 50 people from the community surrounding the city of Kupang. The panelists were selected using the Simple random sampling technique with inclusion criteria including tea and MO consumption. The method was based on observations utilizing the five senses or organoleptic (Tiyani, Suharti, and Andriani, 2020). Panelists were given samples to be tested along with a form to write down the results of the hedonic test, which was carried out independently with directions from the researcher. In this study, a hedonic scale of 5 was used, a relatively simple scale but with good sensitivity in assessment (Wangiyana et al., 2021). Ratings were expressed in numbers: 1 (dislike highly), 2 (dislike slightly), 3 (neither like nor dislike), 4 (like slightly), and 5 (like significantly) to assess the level of panelists' preference for the color, taste, and aroma of tea products (Wangiyana et al., 2021).

Formula 0, 1, and 2 of tea bags were made in 5 pouches each (5 tea bags) put in a glass, and then dipped up and down with 200 ml of warm water at 40 °C for 5 minutes. The test was carried out in stages, namely every 10 people per day over 5 days. Clearwater was provided to rinse the mouth to become neutral, and a 3-minute interval was offered after attempting each formula. The data obtained were calculated by means and standard deviation to get the percentage level of preference for the tea bag product (Yusfiani et al., 2021). The research was conducted after obtaining approvals from the health research ethics committee at the Health Polytechnic of the Ministry of Health Kupang (Reference LB.02.03/1/0148/2022).

g. Antioxidant activity test

The antioxidant activity of MO tea products was measured using the 2,2-diphenyl-2-picrylhydrazyl (DPPH) method. The principle of this method is based on the ability of the sample to inhibit the DPPH free radical by donating an H atom to form a non-radical compound (Zela & Diah, 2021). This test was preceded by preparing a 0.2 mM DPPH solution and determining the maximum λ. The ethanol extracts of F0, F1, and F2 were made at concentrations of 10, 50, 100, 150, and 200 ppm, respectively. 4 mL of the solution was taken, then 1 mL of DPPH reagent was added. Then put it in a vial and vortex. The solution mixture was allowed to stand for 30 minutes in a room without light. The absorbance was read using a UV-Vis spectrophotometer at a maximum wavelength of 519 nm. The measurements were repeated three times. This procedure was also carried out for vitamin C blanks and control solutions (Aryanti et al., 2021). The percentage of DPPH free radical scavenging was calculated based on its absorbance value with the formula:

% Scavenging = [(blank abs-sample abs)/(blank abs)]x 100%…………………..………. (2)

Description:
Abs blank = absorbance blank
Abs of sample = absorbance of the sample

The DPPH free radical scavenging effect (percent of reduction) of MO tea was shown by IC_{50} value and calculated using linear regression analysis y = ax + b which was the relationship between x (log concentration) and y (probit). The IC_{50} value as the effective concentration of the sample in absorbing 50% of total DPPH was obtained from the linear regression equation by substituting the y value as the percent scavenging of 50% (Aulyawati et al., 2021).

3. RESULTS AND DISCUSSION

The assessment of MO leaves tea bags combined with red ginger quality was established according to the characteristics of the material used to evaluate the degree of quality of the ingredients. It implements standards based on two parameters, namely particular parameters, including plant identity, organoleptic, and chemical content of Simplicia, and non-specific parameters: moisture/water content, ash content, and hedonic or preference level (Yana et al., 2022). The assessment for the specific parameters of the simplicial material is shown in Table1.

Table 1. Specific parameters of Moringa leaf and red ginger Simplicia powder

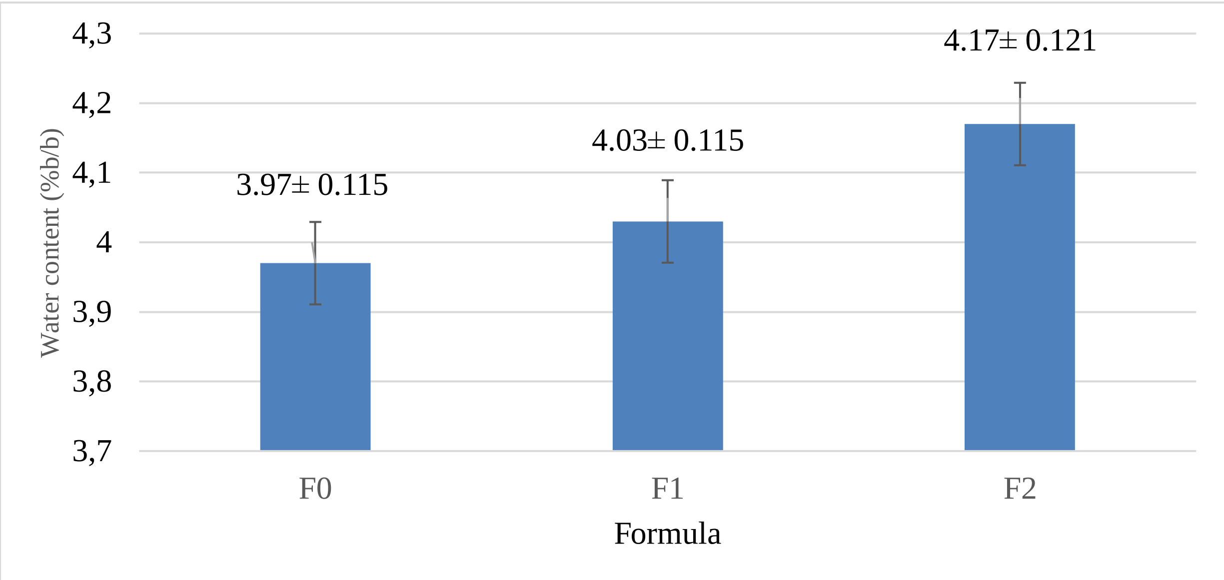
No	**Evaluation parameters**	**Result**			
		Moringa	**Picture**	**Ret Ginger**	**Picture**
1	Plants Identity Scientific Name Sinonim Local name Family	*Moringa oleifera* Lam. *Moringa zeylanica* Burmann Kelor Moringaceae		*Zingiber officinale* Roscoe *Zingiber officinale* var. Rubrum Theilade Jahe Merah Zingiberaceae	
2	Organoleptic Simplicia powder	Green color, typical smell, tasteless		Brownish-yellow color, typical smell of ginger, spicy taste	
3	Chemical content of moringa powder and red gingers: flavonoids, tannins, terpenoids, alkaloids, saponins				
		Orange color in the Wilstater test: positively contains flavonoids		Green color with ferric chloride reagent 1%: positively contains tannins	
		Brownish-red color with Liebermann-Burchard reagent: positively contains terpenoids		Brown precipitate with Wagner reagent: positively contains alkaloids	
		Stable foam: Negative saponins			

Determination of plants was the first procedure implemented in this research to identify plants accurately. MO leaves and red ginger were determined at the Jatinangor Herbarium, Plant Taxonomy Laboratory, Department of Biology, Mathematics and Nature Science Faculty, Padjajaran University. The determination results showed that the plants used were MO from the Moringaceae family and red ginger (*Zingiber officinale* Roscoe) from the Zingiberaceae family.

MO leaves, and red ginger rhizome became the sample plant components. Each Simplicia powder was screened for phytochemicals with a color reaction to determine the active compound's content. The results of the phytochemical screening showed that both Simplicia positively contained flavonoids, tannins, terpenoids, and alkaloids, which were supported by the results of previous studies. Research by Isyraqi et al., (2020) proved that MO leaves positively contained flavonoids, tannins, and terpenoids and that they also contained alkaloids (Yulianto, 2020). Red ginger contains phenol compounds, including gingerol, shogaol, and paradol (Mao et al., 2019) which give it a spicy taste (Zhang et al., 2022), and volatile terpenoids, which give ginger a distinctive aroma (Mao et al., 2019). Besides that, it also contained tannins with an astringent taste which was indicated by the formation of a brown color in the color reaction (Szczurek, 2021). Phenols, flavonoids, tannins, and alkaloids were phenolic groups proven to have high antioxidant activity (Widiastini et al., 2021). MO leaves and red ginger powder the chemical content had been identified and then formulated into tea bags and then non-specific parameters were measured, including moisture content, ash content, and hedonic test.

a. Water content

The purpose of determining water content was to identify the amount of water left after drying. It was one of the most important factors in establishing a product's quality. The results of the water content test for tea bags are shown in Figure 1.



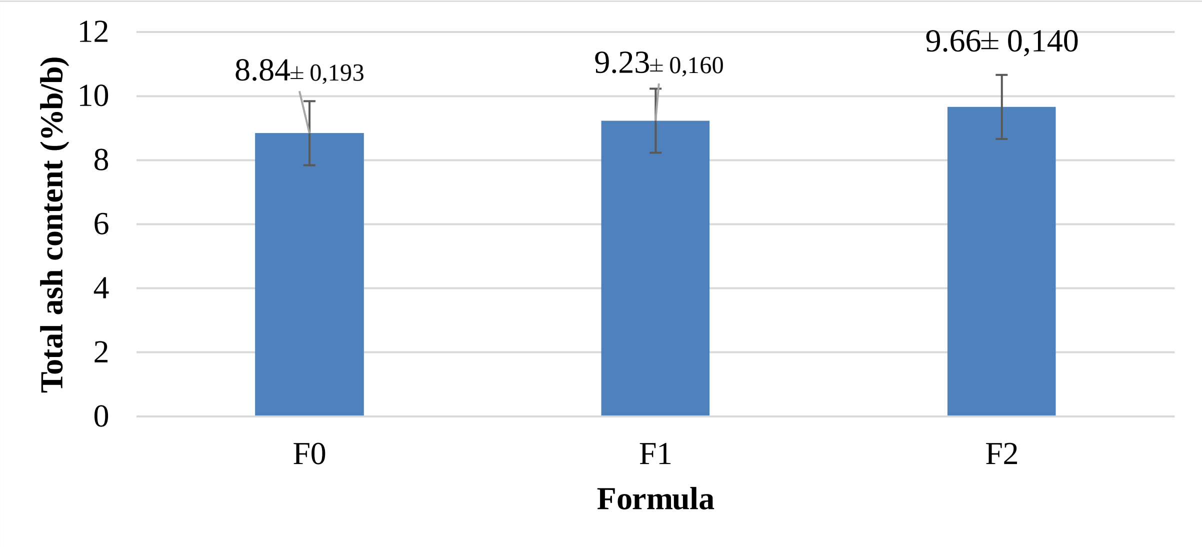
Description: F0, F1, F2, = Concentration of RG: 0%, 25% and 50%

Figure 1. The results of the water content test of tea bag products

According to the findings of the water content analysis that are presented in Figure 1, the average water content of Moringa tea with the addition of red ginger in the three different formulas ranges from 3.86% to 4.29%. This water content successfully met the requirements of the water content standard for tea products that was established by the INS; the maximum water content standard was 8% (Prawira-Atmaja et al., 2021). This is in line with the research conducted by Sinulingga et al (2021), which stated that the water content of tea bags was 2.3%-7.1%. The water content in tea could affect its durability, where the high water content could be a medium for the growth of microorganisms, such as fungi and bacteria, that could damage its biological activities (Palupi et al., 2020). Adding ginger to MO tea products did not significantly affect the water content (‘p>0.05),); this indicated that the MO leaves tea bag combination with red ginger in each formula did not exceed the specified water content quality requirements.

b. Total ash content

The total ash content was another parameter that determined the quality of the tea. This test aimed to acquire a general overview of all inorganic and mineral components used in the manufacturing process. In Figure 2, the results of the ash content test for MO tea products are displayed.



Description: F0, F1, F2, = Concentration of RG: 0%, 25% and 50%

Figure 2. The results of the total ash content of tea bag products.

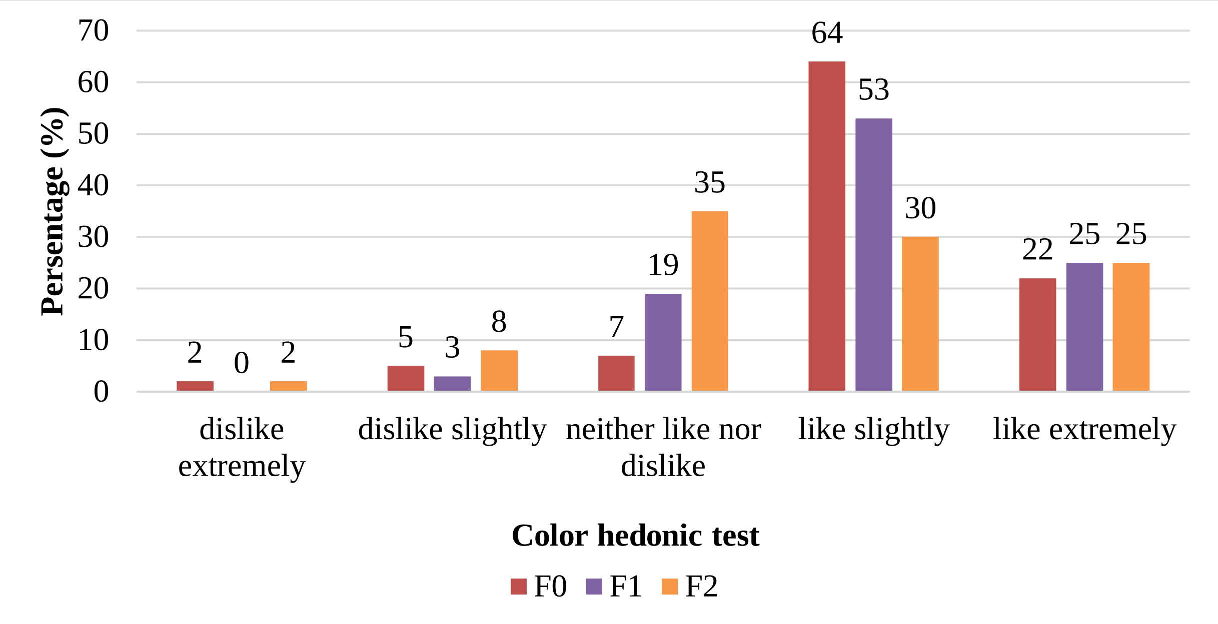
In this study, the total ash content of MO leaves tea bags with the addition of red ginger ranged from 8.65% -9.98%, it was exceeding the INS standard for tea bags which was set at 8% (Prawira-Atmaja et al., 2021). The high ash content of the tea bags illustrated the high mineral components in the MO leaves and red ginger. This result was in line with Bata et al., (2018) research, proving that the total ash content of MO leaves Simplicia was 9.221% ± 0.002. There are 15 mineral components found in MO leaves Simplicia, including Phosphorus, Sulfur, Potassium, Calcium, Titanium, Chromium, Manganese, Iron, Nickel, Copper, Zinc, Molybdenum, Strontium, Barium, and Rhenium which the highest components were calcium and potassium. These minerals could be developed as a mineral supplement (Manggara & Shofi, 2018). Ginger also contains macro and micro minerals such as Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sodium, Manganese, Iron, Zinc, and copper (Jabborova et al., 2021). The statistical analysis results also showed a significant difference in the ash content of the tea bags (‘p <0.05). This result showed that the addition of red ginger in the manufacture of tea bags significantly affected the ash content of the tea bags produced.

c. Hedonic organoleptic test

Tea bag products were also subjected to a hedonic test to determine the preference level and consumer acceptance (Su et al., 2021). The standard was based on the sensory characteristics of the observer, namely the assessment of aspects of color, taste, and aroma (Siow et al., 2022).

1). Color hedonic test

In F0, the tea was green, which was the color of MO leaves without the addition of ginger, while F1 and F2 were yellowish green which was the color of a mixture of MO leaves and red ginger. The results of the color hedonic test of the tea bag product of MO leaves and red ginger combination for each formula were shown in Figure 3.



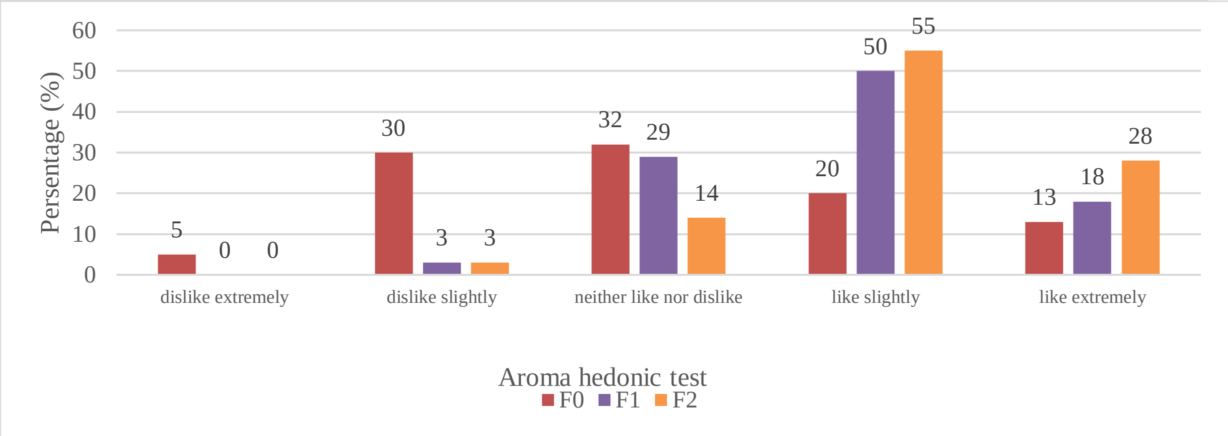
Description: F0, F1, F2, = Concentration of RG: 0%, 25% and 50%

Figure 3. Result of color hedonic test

Based on Figure 3, the color of the tea bag product showed the color of F0 with a composition of 3 Gr MO occupying the highest percentage with a category of like extremely (22%) and like slightly (64%), followed by F1 with a weight of 2.25 Gr of MO and F2 with a weight of 1.5 Gr of MO. MO leaves contained chlorophyll or a natural green leaves dye with high concentrations. The bright dark green color of F1 was due to the high weight of MO and was associated with the chlorophyll content extracted from the brewed water of tea bags (Farooq et al., 2021). The ANOVA results also showed a significant difference between each formula on color organoleptic parameters with a significant value of <0.05.

2). Aroma hedonic test

The role aroma of a product is essential because it will determine consumer acceptance of the product (Arumsari & Aminah, 2019). The aroma produced from the F0 tea bag product was a typical aroma of MO leaves. At the same time, F1 and F2 were the typical aromas of MO leaves and RG.



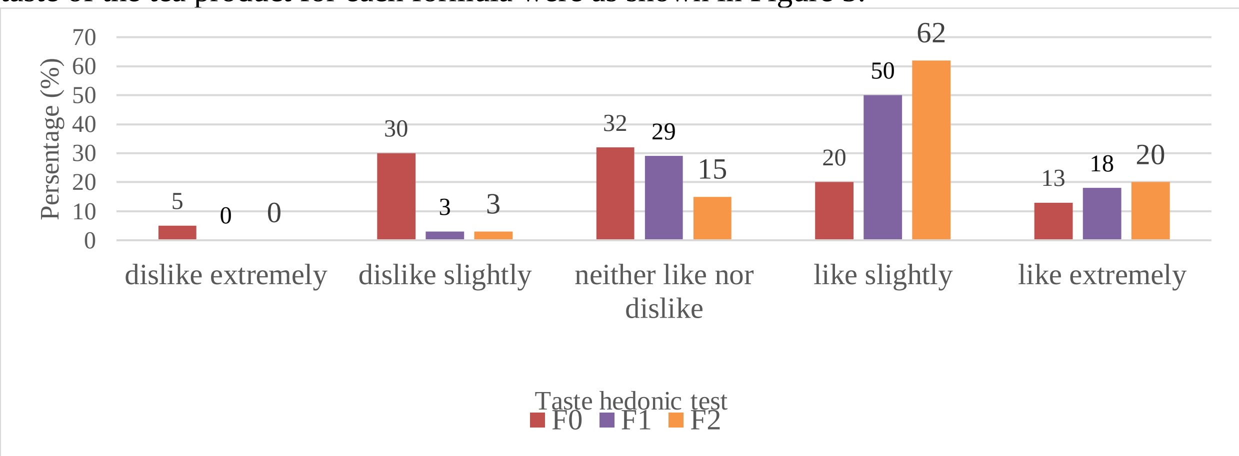
Description: F0, F1, F2, = Concentration of RG: 0%, 25% and 50%

Figure 4. Results of aroma hedonic test

The tea formula with ginger tends to be preferred by the panelists. F2, with a composition of 1.5 Gr of ginger as much as MO was the most preferred by the panelists with the category of like extremely as much as 24% and like slightly (58%) followed by F1 and F0. The higher concentration of MO in F1 (2.25 Gr) and F0 (3 Gr) was less favored by the panelists because of the unpleasant odor of MO. The addition of red ginger aimed to cover the unpleasant odor from MO leaves. Red ginger contains volatile terpenoid compounds that give ginger its distinctive aroma (Mao et al., 2019). The unpleasant smell was more pronounced if the concentration of MO leaves was added more than red ginger. Otherwise, it decreased with increasing concentration of red ginger. This was in line with the research of Fatima et al., (2020) that red ginger could cover the unpleasant odor of MO leaves. The ANOVA results also showed a significant effect between the addition of red ginger to the aroma organoleptic parameters with a significant value <0.05.

3). Taste hedonic test

Taste is one factor that is important for consumers in considering product selection. Although other parameters have good values, consumers will reject the product if the taste is not good (Setiyani et al., 2022). The results of the test of the researcher's preference for the taste of the tea product for each formula were as shown in Figure 5.



Description: F0, F1, F2, = Concentration of RG: 0%, 25% and 50%

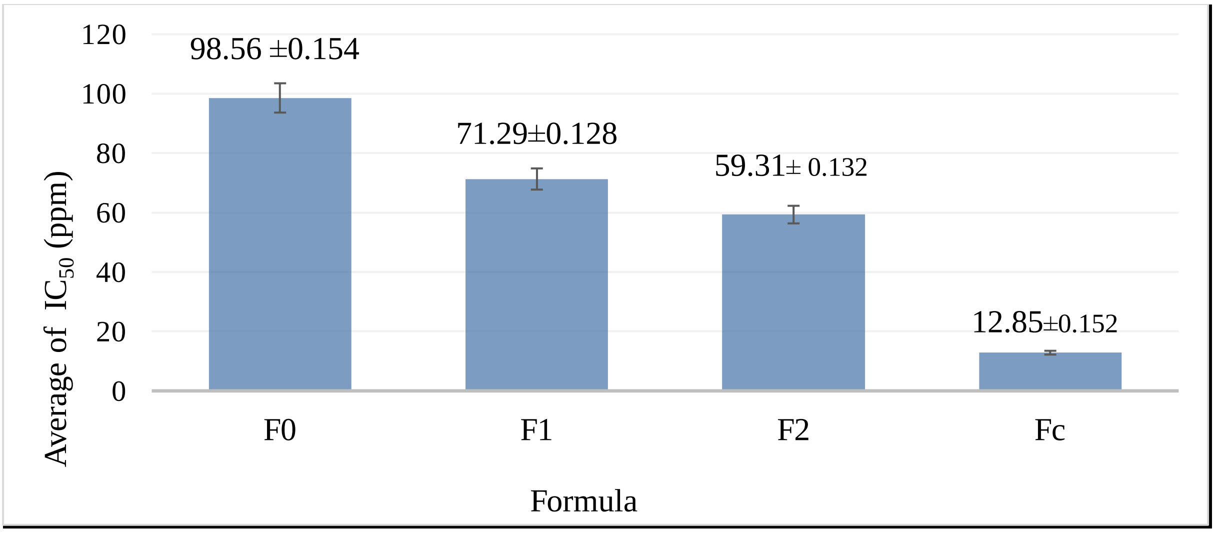
Figure 5. Results of the hedonic taste test

Based on the test results of panelist's preference for the taste of tea bag products in Figure 5, the tea product that obtained the highest level of taste preference was F2 (composition of 1.5 Gr of MO leaves to powder and 1.5 Gr of red ginger) product with a category of 62% like slightly and 20% like extremely. The F1 (composition of 2.25 Gr of MO leaves to powder and 0.75 Gr of RG) product and F0 (composition of 3 Gr of MO leaves powder) product were not liked by panelists because the concentration of MO leaves used was higher than ginger so that the unpleasant and bitter taste of MO leaves tends to be felt. The taste produced by MO leaves tends to be bitter and unpleasant comes from the saponins and tannins it contains. Fatima et al's research (2020) proved that adding red ginger to MO leaf powder could reduce the unpleasant taste of MO leaves. This was associated with phenolic compounds, including gingerol, shogaol, and paradol (Mao et al., 2019), which gave ginger a distinctive taste (Zhang et al., 2022). The ANOVA results also showed a significant effect between the addition of red ginger on the organoleptic parameters of aroma with a significance value of <0.05.

d). Antioxidant activity of tea bags.

The antioxidant activity of tea bags using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method with the principle that reducing compounds donate H atoms caused DPPH to be reduced to form diphenylpicrihydrazine which was characterized by a reduction or loss of purple to a pale yellow color. The intensity of the purple color was measured using visible spectrophotometry at the maximum wavelength of the DPPH (Yang et al., 2020). In this study, the maximum DPPH wavelength was obtained at 519.0 nm. This was in line with the study of Asbabu, (2019), the full wavelength range for sample measurements using the DPPH method was around 400-550 nm.

The ability of Moringa tea products as antioxidants was assessed based on the reduced purple color of the DPPH solution which was read as absorbance on a spectrophotometer and was then quantified and expressed by the IC_{50} value (Muna, 2022). A small IC_{50} value indicated that the antioxidant activity was getting stronger and vice versa, as shown in Figure 6.



Description: F0, F1, F2, Fc = Concentration of RG: 0%, 25%, 50%, Control Vitamins C

Figure 6. The average IC_{50} value for tea bags.

Based on the data above, F2, with a composition of 1.5 grams of MO leaves to powder and 1.5 grams of red ginger, had the highest antioxidant activity with IC_{50} of 59.31 ± 0.132 ppm, followed by F2 of 71.29 ± 0.128 ppm and F0 of 98.56 ± 0.154 ppm. These values indicated that the three formulas have moderate category antioxidant activity with a range of

IC_{50} values between 50-100 ppm (Muna, 2022). This study used pure vitamin C to compare, and IC_{50} of 12.849 ± 0.152 was obtained. Vitamin C was proven to have the potential for extreme antioxidant activity due to oxidative stress (Dotulong et al., 2021).

The ability of antioxidant activity of tea bag products was associated with the contribution of several compounds found in MO leaves and red ginger, including flavonoids, phenols, and tannins. These compounds release H^+ atoms and form stable DPPH molecules. Dillak, Kristiani, & Kasmiyati, (2019) said that the presence of the OH^- group in flavonoids, a phenol group, played a role in donating H^+ atoms to stabilize the DPPH radical. In a study by Rachmatiah et al., (2022), who tested the antioxidant activity of ileum (*Clerodendrum minahassae* Teijsm. & Binn) leaves it was shown that leilem leaves had antioxidant activity in a very strong category because of their flavonoid and phenolic content. In addition, according to Szczurek (2021), tannins have aromatic rings with hydroxyl groups, which also play a role in reducing DPPH free radicals. Adding red ginger to F1 and F2 increased antioxidant activity even though they were in the same range of IC_{50} values. According to Mao et al., (2019), the shogaol content belongs to the phenol group due to the conversion of gingerol, which also has antioxidant activity besides giving ginger a distinctive taste. This was supported by the research of Septiana et al., (2019), which proves ginger could increase antioxidant activity in honey combined with *temulawak*. The results of the statistical analysis of the tea bag products' antioxidant activity showed a significant effect ($p < 0.05$) on the proportion of added RG.

Another parameter related to the quality of tea bag products is the shelf life. It can be determined through several approaches, including distribution turnover, distribution abuse test, consumer complaints, and accelerated shelf-life testing. However, it cannot be undertaken because of the limited time.

4. CONCLUSION

Based on the results of this study, it could be concluded that the tea bag products F0, F1, and F2 qualified the quality requirements for water content yet failed to satisfy ash content. The three formulas had an antioxidant activity with IC_{50} of 59.30 ± 0.132 ppm to 98.56 ± 0.154 ppm. The addition of red ginger to F2 contributed to the preference level of the panelists from the aspect of aroma and taste compared to F1 and F0 so it has the potential to be further developed as an antioxidant herbal drink. For further research, it is possible to conduct a comprehensive life-saving parameter test to determine the life-saving product.

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