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Quality Characteristics of Functional Beverages from Moringa Leaf Juice with the Addition of Red Ginger Juice and Sucralose

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ABSTRACT

Moringa functional drink is well known for its benefits for health but has weaknesses in the form of sensory value in aroma and taste, so the addition of red ginger juice and sucralose is necessary. The research aims to determine the quality characteristics of functional drink, which is added with varying concentrations of red ginger juice and sucralose and reviewed based on its physical, chemical, microbiological, and organoleptics. Completely Randomized Design (CRD) was used for research design with two factors and two replications: red ginger juice (30%, 40%, and 50%) and sucralose (100 ppm, 150 ppm, and 200 ppm). The ANOVA showed significantly different results (α = 0.05) for total dissolved solids, antioxidant activity values, and organoleptic tests. The best treatment was obtained by adding a concentration of 40% red ginger juice and 150 ppm sucralose, with a total dissolved solids value of 4.97˚Brix, an IC_{50} antioxidant activity value of 46 ppm indicating very strong antioxidant activity, the hedonic test score was in score range of 4 for color and 5 for aroma and taste. The metals contamination is below the threshold, the total plate number is $<1\times10^3$ colonies/ml, and the yeast mold number is $<1\times10^2$ colonies/ml.

1. INTRODUCTION

Moringa leaves (*Moringa oleifera*) are a superfood plant. Superfood itself is a term for an ingredient that is dense in nutrients and rich in benefits for the body. Moringa as a superfood plant is recognized by the Food and Agriculture Organization (FAO) as Crop of the Month in 2018, it is known to have various benefits for body health because it contains phytochemical substances including alkaloids, flavonoids, steroids and tannins (Rahim *et al*., 2019). Moringa has the potential to be processed into functional drinks. Functional drinks are a sort of functional food that is commonly developed using natural substances known as herbal ingredients. There are three concepts of functional food, namely primary function considered from the nutritional aspect, secondary function viewed from the sensory qualities, and tertiary function viewed from physiological aspects (Widyantari, 2020).

Moringa fulfills two of the three functional food concepts, namely the primary function of nutritional value and tertiary physiological function. Functional food functions that moringa does not fulfill are secondary functions related to sensory. One of the drawbacks of Moringa leaf drink is the unpleasant aroma of the drink. According to research by Hadju *et al*., (2021), it is known that the fat content in Moringa leaves ranges from 9.43-9.6%, so it is known that the pleasant aroma is caused by the activity of the lipoxygenase enzyme (Mukarromah *et al*., 2021). Adding red ginger juice is one way to get rid of this unpleasant aroma. Ginger essential oil is primarily composed of terpenes, including β-bisabolene, α-curcumene, zingiberene, farnesene, and sesquiphellandrene (Sandy & Susilawati, 2021). Compared to elephant and emprit ginger, red ginger contains a larger percentage of gingerol, the primary constituent in the form of essential oil (Aryanta, 2019). The unpleasant aroma of Moringa leaves can be masked by the essential oil content that gives red ginger a distinct aroma.

Another disadvantage of Moringa leaf drinks according to research by Wahyudi *et al*., (2018) is in terms of taste. The characteristic flavor of Moringa juice is astringent or bitter. An ingredient's tannin components are what give it this astringent taste; when ingested, they will create cross-links with oral cavity proteins (Perwita *et al*., 2021). The mouth cavity contains salivary proteins (Laputková *et al*., 2018). Covalent connections, hydrophobic interactions, and hydrogen bonds between these substances are what cause the tannin-protein complex. Adding sucralose sugar to Moringa leaf juice beverages is one method to enhance its astringent flavor. According to research by Andarini *et al*., (2018), sucralose added to mundar bark extract drinks produces a sweet taste and increases the sensory value of the product. Apart from that, sucralose does not cause a bitter taste like other sweeteners such as stevia or saccharin and is stable at hot temperatures or low pH (Rianto *et al*., 2018). The astringent taste of mundar bark extract can be covered by sucralose sweetener because it is an artificial sweetener with a sweetness intensity 600 times more than regular sugar, meaning that even little doses can give drinks a sweet taste.

Sucralose and red ginger juice, which are added to the Moringa leaf juice functional drink, are believed to affect the product's qualitative characteristics. Thus, the purpose of this study was to determine the treatment variations that yield the highest quality Moringa leaf functional drink based on panelists and quality standards, as well as to perform physical, chemical, microbiological, and organoleptic characteristic tests to assess the quality characteristics of the Moringa leaf functional drink supplemented with red ginger juice and sucralose.

2. RESEARCH MATERIALS AND METHODS

2.1. Time and Place of Research

The research was conducted from September to January 2024 at PT Medifarma Laboratories. Physical testing including total dissolved solids was carried out at the Chemical Laboratory of PT Medifarma Laboratories. Chemical testing includes antioxidant activity and heavy metal contamination tests carried out at the Chemical Laboratory of PT Medifarma Laboratories. Microbiological testing which includes Total Plate Numbers and Yeast Mold Numbers is carried out at the Microbiology Laboratory of PT Medifarma Laboratories. Organoleptic testing was carried out by 30 non-standard panelists.

2.2. Tools and Materials

The materials used in this research included Moringa leaves obtained from Casuarina Jagakarsa Park, red ginger obtained from Musi Baru Market Depok, sucralose obtained from purchasing from the Yasma Natura online shop with the Kanbo brand, 100 mL glass bottles with lids, and so on. The tools used in this research included digital scale (Good Wife) with a capacity of 10,000 g, Cosmos CB-282-G blender with a capacity of 2 L, and so on.

2.3. Material Preparation

2.3.1. Making Moringa Leaf Juice (Musfiroh *et al*., 2017)

The process of extracting Moringa leaf juice began with sorting to separate the Moringa leaves from the stems and impurities. A total of 40 g of Moringa leaves were weighed, then washed with running water. After the Moringa leaves are washed clean, they are drained and then blanched for 5 min. The Moringa leaves were drained again and 120 mL of water added or a ratio of Moringa to water (1:3), then ground with a blender. Moringa leaves that have been crushed were then filtered to separate the juice and dregs using a filter cloth. The Moringa leaf juice obtained was boiled for 5 min and then put into a sterile glass bottle.

2.3.2. Process of Making Red Ginger Juice (Daniella, 2022)

The process of extracting red ginger juice was carried out by sorting the ginger to select only good quality ginger which is characterized by the absence of defects, for example, there are holes in the red ginger and when pressed it does not feel soft. Red ginger was washed clean and the outer skin was peeled. The red ginger was then weighed and water solvent was added in a ratio of 1:2 (ginger to water) then ground with a blender. The mixture was filtered to separate the juice from the dregs.

2.3.3. Preparation of Moringa Leaf Juice (Musfiroh *et al*., 2017)

Moringa juice was prepared according to Musfiroh *et al*., (2017) where katuk leaf juice was replaced by red ginger juice and liquid sugar was replaced by the addition of sucralose. The process of making functional drinks was done by mixing Moringa leaf juice, red ginger juice, and sucralose. The concentration of red ginger juice added to the Moringa leaf drink was 30%, 40% and 50% (%v/v). For every concentration of red ginger juice added, sucralose was added with a concentration of 100 ppm, 150 ppm and 200 ppm to the total volume of the functional drink, so that a total of 9 stiffeners were obtained. The functional drink was then homogenized and put into sterile glass bottles. The glass bottle containing the Moringa leaf juice functional drink was pasteurized at 70°C for 30 min.

2.4. Analysis Procedure

Tests for the quality characteristics of Moringa leaf functional drinks included physical characteristic test, namely total dissolved solids tests (SNI 3719:2014), antioxidant activity tests (SNI 8623:2018). Hedonic and organoleptic test was performed for color, taste, and flavour to measure the satisfaction or preference of consumers towards a product through sensory assessment (SNI ISO 11056:2021). Supporting tests were carried out only for the best treatment include heavy metal contamination tests (SNI 6989.46:2009), Total Plate Number microbiology tests (SNI 3719:2014) and Yeast Mold Number (SNI 2332.7:2015).

2.5. Data Analysis Techniques

The research design used in this study was a factorial Completely Randomized Design (CRD) (red ginger juice and sucralose concentration) with 3 levels (differences in red ginger juice and sucralose concentrations) and two replications. The analysis technique used was two-factor analysis of variance (ANOVA) with two repetitions at α = 0.05. ANOVA was used to see significant effect from the different treatments, and then continued with DMRT (Duncan Multiple Range Test) at α = 0.05. The DMRT test was carried out to find out at what level of treatment results in differences in quality.

3. RESULTS AND DISCUSSION

3.1. Total Dissolved Solids (TDS)

TDS is a test carried out with the aim of interpreting the amount of sugar contained in ingredients (Bayu *et al*., 2017). TDS testing uses a refractometer whose units are expressed in °Brix. The refractometer works by refraction of light in the solution (Rahman *et al*., 2022). The TDS test results for the Moringa leaf juice functional drink with the addition of red ginger juice and sucralose can be seen in Table 1. The average TDS value obtained ranges from 4.55-5.37°Brix with the lowest value being in the treatment with the addition of red ginger juice with a concentration of 30% and sucralose 100 ppm (4.55°Brix) and the value the highest was in the treatment with the addition of red ginger juice with a concentration of 50% and sucralose 200 ppm (5.37°Brix). Based on the results of the ANOVA data on the TDS value, it was found that the addition of red ginger juice and sucralose and their interaction had a significant effect on the total soluble solids value of the Moringa leaf functional drink (α = 0.05). The DMRT for TDS (Table 1) reveals interaction of 50% of ginger extract and 200 ppm sucralose resulte in the highest TDS with 5.37 °Brix.

The results of this research show that the TDS value is greater resulting from increasing the concentration of added red ginger juice and sucralose. This is in line with Likumahua *et al*., (2022) stating that the higher the concentration of a sweetener added, there will be an increase in the total value of TDS which is caused by free water being bound by

Table 1. Total soluble solids (°Brix) of Moringa leaf juice functional drink with the addition of red ginger juice and sucralose

Sucralose	Red Ginger Extract		
	30%	40%	50%
100 ppm	4.55 ± 0.07 a	4.91 ± 0.02 c	5.25 ± 0.04 e
150 ppm	4.76 ± 0.01 b	4.97 ± 0.01 c	5.31 ± 0.01 e
200 ppm	4.82 ± 0.02 b	5.06 ± 0.04 d	**5.37** ± 0.02 f

Note = superscript letter in the table states that there is a significant difference (α = 0.05)

sugar, which in this case is sucralose, causing the concentration of dissolved will also increase. In a drink with a non-thick (dilute) solution consistency, the free water contained in the drink can be bound by sugar because sugar has hydrophilic properties from the presence of hydroxyl groups (OH) which will then interact with water molecules through attractive forces. The more free water bound by sugar, the higher the sugar concentration. This occurs due to water molecules surrounding the sugar molecules, forming a sugar solution which then increase the amount of sugar in the solution so that the sugar concentration will increase.

The large number of sugar particles bound by sucralose causes the TDS value to increase and is followed by reduced precipitate formation. The TDS indicates the content of dissolved ingredients (Anggoro *et al*., 2018). The functional drink Moringa leaf juice is produced by precipitate from the addition of red ginger juice, where one of the ingredients contained in red ginger is starch. The formation of precipitate from the Moringa leaf juice functional drink can be reduced due to the nature of sucralose as a sugar which interacts with water molecules to form a solution so that the precipitate formed is reduced.

According to Chasparinda *et al*., (2014), the higher the concentration of red ginger juice that is added and not balanced with the addition of sweeteners, it can result in a decrease in TDS. In Table 1, it can be seen that the increasing concentration of sucralose added to the same concentration of red ginger will increase the TDS value. This result was obtained because of the influence of the addition of sucralose which was able to reduce sediment from the addition of red ginger juice so that the TDS of the Moringa leaf functional drink would increase along with the addition of sucralose at the same concentration of red ginger juice. This research is in line with previous research that if the addition of red ginger juice is not balanced by the addition of sweeteners, the TDS decrease as indicated by the large amount of sediment from the added red ginger juice. Based on the results of the TDS test in the Moringa leaf juice functional drink, the one with the highest TDS value was the functional drink treated with a sucralose concentration of 200 ppm and 50% red ginger juice, namely 5.37°Brix. The results of the best treatment obtained did not meet the minimum requirements for fruit juice drinks referring to SNI 3719:2014, about 16°Brix.

3.2. Antioxidant Activity

Cells in the human body can be exposed to free radicals resulting from internal factors such as body metabolism or external factors. This free radical oxidation process can be inhibited by a substance called an antioxidant (Halliwell, 1995 in Maesaroh *et al*., 2018). According to research conducted by Salimi (2016), the antioxidant activity value obtained from Moringa leaf extract was 121.05 mg AEAC/g with the IC50 value obtained being 128.69, which means that the level of antioxidant strength is at a medium to strong level. The results of the IC50 antioxidant activity test on the Moringa leaf juice functional drink with the addition of red ginger juice and sucralose can be seen in Table 2. The average total value of the IC50 antioxidant activity test ranges from 38-77 ppm with the lowest value being in the treatment with the addition of red ginger juice with a concentration of 30% and sucralose 200 ppm (77 pm) with the meaning that the value has strong antioxidant activity and the value The highest was in the treatment with the addition of red ginger juice with a concentration of 50% and sucralose 100 ppm (38 ppm), meaning it had very strong antioxidant activity. Based on the ANOVA results of the IC50 antioxidant activity test value data, results were obtained which showed that the presence of added red ginger juice and sucralose had a significant effect on the IC50 antioxidant activity test value of the Moringa leaf functional drink with the significance level used being 95%. Based on the significant ANOVA results obtained, a significant difference test was needed using the DMRT test, while the interaction between the two did not show significant effect results so no further testing was needed. The results of further DMRT tests revealed that each treatment was significantly different in the IC50 antioxidant activity test value except for the treatment with the addition of 40% red ginger juice.

Table 2. IC50 antioxidant activity (ppm) of Moringa leaf juice functional drink with the addition of red ginger juice and sucralose

Sucralose	Red Ginger Sari		
	30%	40%	50%
100 ppm	53 ± 2.83	44 ± 2.12	38 ± 2.12
150 ppm	67 ± 0.71	46 ± 4.24	44 ± 5.66
200 ppm	77 ± 3.54	56 ± 6.36	50 ± 0.71

The results of this research show that with the addition of a greater concentration of red ginger juice, the IC50 antioxidant activity test will be lower, which means it has stronger antioxidant activity. This is in line with research by Chasparinda *et al*., (2014) which states that ginger contains gingerol compounds which have antioxidant activity and research by Noaman *et al*., (2022) which states that the addition of red ginger juice to Moringa leaf tea can increase the sensory score of functional drinks in terms of aroma and taste as well as antioxidant activity. Apart from that, in Table 2 it can also be seen that increasing the concentration of sucralose added to the same concentration of red ginger will increase the IC50 antioxidant activity value, which is interpreted as having weaker antioxidant activity.

The antioxidant activity decreases as the concentration of sucralose as a sweetener increases, due to the presence of moringa which has flavonol compounds in it (Dias *et al*., 2021), its solubility is easily disturbed if there is interaction with sugar molecules (Andriani *et al*., 2012). Flavonol compounds such as querecetin, kaempferol and myricetin have the property of easily binding to sugar so that their antioxidant activity will decrease as the interaction of flavonols with sugar molecules increases. Based on the results of the IC50 antioxidant activity test on the Moringa leaf juice functional drink, the functional drink which had the lowest IC50 value, namely 38 ppm, was produced when the sucralose concentration was 100 ppm and 50% red ginger juice was treated. The IC50 value of 38 ppm indicates very strong antioxidant activity.

3.3. Hedonic Test and Quality Score

3.3.1. Color

Color is actually able to cause a sensation from visual stimulation. However, color itself is not a substance (Likumahua *et al*., 2022). Based on the tests carried out, the results of the hedonic test and color quality score for the Moringa leaf juice functional drink with the addition of red ginger juice and sucralose can be seen in Table 3. Based on Table 3, the average score for the hedonic test was 2.23-4.23 (dislike-slightly) with the lowest score being in the treatment with the addition of 30% concentration of red ginger juice and 100 ppm sucralose (2.23 (not like)) and the highest score was in the treatment with the addition of red ginger juice with a concentration of 40% and sucralose 150 ppm (4.23 (slightly like)). The results of testing the color quality score parameters obtained an average score of 2.45-3.97 (not red-slightly red) with the lowest value being in the treatment with the addition of red ginger juice with a concentration of 30% and sucralose 100 ppm (2.45 (not red)) and the highest value was in the treatment with the addition of red ginger juice with a concentration of 50% and sucralose 200 ppm (3.97 (slightly red)). The color of the Moringa leaf juice functional drink itself is deep dark green which is produced from the chlorophyll contained in Moringa leaves (Telehala & Sinay 2017).

Table 3. Hedonic score and color quality of Moringa leaf juice functional drink with the addition of red ginger juice and sucralose

Hedonic preference for color				Quality score for color			
Sucralose	Red Ginger Sari			Sucralose	Red Ginger Sari		
	30%	40%	50%		30%	40%	50%
100 ppm	2.23	4.10	3.22	100 ppm	2.45	3.33	3.73
150 ppm	2.28	**4.23**	3.35	150 ppm	2.53	3.27	3.88
200 ppm	2.33	4.08	3.33	200 ppm	2.62	3.28	**3.97**

Description for hedonic score: 1 = Very dislike; 2 = Dislike; 3 = Slightly dislike; 4 = Slightly like; 5 = Like; 6 = Very like
Description for color quality score: 1 = Very not red; 2 = Not red; 3 = Slightly not red; 4 = Slightly red; 5 = Red; 6 = Very red

Based on the ANOVA results of the color hedonic test value data, results were obtained which showed that the addition of red ginger juice had a significant effect on the color hedonic test value of the Moringa leaf functional drink with the significance level used being 95%. Based on the significant ANOVA results obtained, a significant difference test was needed using the DMRT test, while the addition of sucralose and the interaction between the two had no significant effect so no further testing was needed. The results of further DMRT tests showed that each treatment had significant differences in the color hedonic test value. Meanwhile, the results of the ANOVA on the color quality score value data showed that the presence of added red ginger juice and sucralose had a significant effect on the color quality score value of the Moringa leaf functional drink with the significance level used being 95%. Based on the significant Based on ANOVA results, the DMRT test was needed, while the interaction between the two had no

significant effect so no further testing was needed. The results of DMRT tests showed that each treatment had significant differences in the color quality score test value except for the addition of 150 ppm sucralose. This explains that the color of Moringa leaf functional drink is influenced by the addition of red ginger juice. The results of the research showed that the greater the concentration of red ginger juice, the better the level of liking and the color of the Moringa leaf functional drink became redder. Based on the results of the hedonic test and the quality score of the Moringa leaf juice functional drink, the one with the best acceptance value in terms of color is the functional drink treated with a sucralose concentration of 200 ppm and 50% red ginger juice with a score of 4.23 (somewhat like) and a slightly red color (3.97).

3.3.2. Taste

Taste is an important factor that naturally comes from a food ingredient or is made by adding a substance during the processing process which can later produce a distinctive taste of a food product. Rasa (Likumahua *et al*., 2022). Taste is also a determining variable in the panelists' level of acceptance of a product. The Moringa leaf functional drink has a natural taste that is dominantly astringent due to the tannin content in it, making it less attractive to consume. The addition of red ginger juice and sucralose sweetener is thought to improve the organoleptic quality of the Moringa leaf functional drink. Sucralose is a low-calorie artificial sweetener which, according to research conducted by Andarini *et al*., (2018), the addition of sucralose is able to cover most of the sour taste of mundar bark extract so that the product is more acceptable. In addition, sucralose does not cause a bitter taste like other artificial sweeteners. Red ginger itself has a natural spicy taste that comes from oleorosin. Based on the tests carried out, the results of the hedonic test and taste quality scores for the Moringa leaf juice functional drink with the addition of red ginger juice and sucralose can be seen in Table 5. The average score for the hedonic test was 2.42-4.87 (dislike) with the lowest score in the treatment with the addition of 30% concentration of red ginger juice and 100 ppm sucralose (2.42 (dislike)) and the highest value was in the treatment with the addition of red ginger juice with a concentration of 40% and sucralose 150 ppm (4.87 (like)). The quality score testing parameter has an average test score of 2.90-4.65 (somewhat not sweet) with the lowest value being in the treatment with the addition of red ginger juice with a concentration of 30% and sucralose 100 ppm (2.90 (somewhat not sweet)) and the highest value was in the treatment with the addition of red ginger juice with a concentration of 40% and sucralose 200 ppm (4.65 (sweet)).

Table 5. Hedonic score and taste quality of Moringa leaf juice functional drink with the addition of red ginger juice and sucralose

Level of Hedonic Taste Likeability				Taste Quality Score			
Sucralose	Red Ginger Sari			Sucralose	Red Ginger Sari		
	30%	40%	50%		30%	40%	50%
100 ppm	2.42^{a}	4.18^{b}	4.38^{bc}	100 ppm	2.90^{b}	2.82^{b}	2.30^{a}
150 ppm	2.52^{a}	**4.87^{d}**	4.47^{c}	150 ppm	3.70^{c}	4.47^{d}	2.43^{a}
200 ppm	3.43^{b}	4.48^{c}	4.58^{c}	200 ppm	4.52^{d}	**4.65^{d}**	3.58^{c}

Note: Hedonic score and aroma quality score were described similarly as in bottom notes of Table 3

Based on the ANOVA results of the hedonic taste test value data, it was found that the addition of red ginger juice, sucralose and the interaction of the two had a significant effect on the hedonic taste test value of the Moringa leaf functional drink with the significance level used being 95%. Based on the significant ANOVA results obtained, a significant difference test is needed using the DMRT test. The results of further DMRT tests showed that each treatment had significant differences in the hedonic taste test value. Meanwhile, the results of the ANOVA on the taste quality score data showed that the addition of red ginger juice, sucralose and the interaction of the two had a significant effect on the taste quality score of the Moringa leaf functional drink (α = 0.05), so further testing was needed using the DMRT. and it is known that each treatment is significantly different in the taste quality score test value except for the addition of red ginger juice with a concentration of 30% and 200 ppm sucralose and red ginger juice with a concentration of 40% and sucralose 200 ppm. This explains that the taste of the Moringa leaf functional drink is influenced by the addition of red ginger juice and sucralose. The greater the concentration of red ginger juice and sucralose added, the better the level of liking and the more acceptable the taste of the Moringa leaf functional drink, namely the astringent taste of the Moringa leaf drink is disguised by the sweet taste of sucralose and spicy red

ginger. However, with the addition of the highest concentration of red ginger juice, namely 50%, the panelists preferred functional drinks less when compared to the addition of red ginger juice with a concentration of 40%. This is due to the added concentration of 50% red ginger juice, the spicy taste of ginger is more dominant than the taste of Moringa leaf juice which is the main ingredient in the drink. Based on the results of the hedonic test and the quality score of the Moringa leaf juice functional drink with the best acceptance for taste parameters, namely the functional drink treated with a sucralose concentration of 150 ppm and 40% red ginger juice with a score of 4.87 (like).

3.3.3. Flavour

Flavour is the smell of a food product. Flavour can be interpreted as a response when volatile compounds from a food enter the nasal cavity and are felt by the olfactory system (Virdayanti *et al*., 2022). Flavour plays an important role in assessing the quality of a food ingredient (Likumahua *et al*., 2022). Based on the tests carried out, the results of the hedonic test and flavour quality scores for the Moringa leaf juice functional drink with the addition of red ginger juice and sucralose can be seen in Table 6. The average score for the hedonic test was 3.08-5.42 (somewhat disliked) with the lowest score being in the treatment with the addition of red ginger juice with a concentration of 30% and sucralose 100 ppm (3.08 (somewhat don't like)) and the highest score was in the treatment with the addition of red ginger juice with a concentration of 40% and sucralose 150 ppm (5.42 (like)). Meanwhile, the average value of the quality score test obtained was 3.25-5.32 (slightly not red ginger-scented) with the lowest value being in the treatment with the addition of red ginger juice with a concentration of 30% and 100 ppm sucralose (3.25 (slightly not scented with red ginger)) and the highest value was in the treatment with the addition of red ginger juice with a concentration of 50% and sucralose 150 ppm (5.32 (scented with red ginger)). Moringa leaves which are processed into a beverage product themselves have a pleasant flavour due to the activity of the lipoxygenase enzyme which breaks down unsaturated fatty acid chains and produces a number of compounds with smaller molecular weights such as aldehydes and ketones (Mukarromah *et al*., 2021).

Table 6. Hedonic score and flavour quality of Moringa leaf juice functional drink with the addition of red ginger juice and sucralose

Hedonic Flavour Liking Level				Flavour Quality Score			
Sucralose	Red Ginger Sari			Sucralose	Red Ginger Sari		
	30%	40%	50%		30%	40%	50%
100 ppm	3.08	5.18	4.47	100 ppm	3.25	4.28	5.22
150 ppm	3.32	**5.42**	4.58	150 ppm	3.28	4.50	**5.32**
200 ppm	3.43	5.22	4.50	200 ppm	3.35	4.42	5.27

Based on the ANOVA results of the flavour hedonic test value data, results were obtained which showed that the addition of red ginger juice had a significant effect on the flavour hedonic test value of the Moringa leaf functional drink with the significance level used being 95%. Based on the significant ANOVA results obtained, a significant difference test was needed using the DMRT test, while the interaction between the two had no significant effect so no further testing was needed. The results of further DMRT tests showed that each treatment had significant differences in the color hedonic test value except for the addition of 200 ppm sucralose. Meanwhile, the results of the ANOVA on the color quality score value data showed that the added red ginger juice had a significant effect on the flavour quality score value of the Moringa leaf functional drink with the significance level used being 95%. Based on the significant ANOVA results obtained, a significant difference test was needed using the DMRT test, while the addition of sucralose and the interaction between the two had no significant effect so no further testing was needed. The results of further DMRT tests revealed that each treatment had significant differences in the flavour quality score test value. Red ginger has a high content of essential oils, gingerol and oleoresin or substances that give a higher bitter and spicy taste compared to the other two types of ginger (Herlina, 2004 in Lallo *et al*., 2018). The greater the concentration of red ginger juice added, the better the level of liking and the flavour of the Moringa leaf functional drink becomes more ginger-flavored and disguises the unpleasant flavour of the Moringa leaves. Based on the results of the hedonic test and the quality score of the Moringa leaf juice functional drink which had the best acceptance value in terms of flavour, namely in the treatment with a sucralose concentration of 150 ppm and 40% red ginger juice with a resulting score of 5.42 (like).

3.4. Determining the Best Treatment

Based on the research carried out on functional Moringa leaf juice drinks, the following is a recapitulation of the best results for each parameter which can be seen in Table 7. The best treatment for each parameter was selected by comparing it to the quality standards or best results according to the panelists for hedonic testing and quality scores. Based on Table 7, it can be seen that the treatment with the addition of 150 ppm sucralose concentration and 40% red ginger juice produces more dominant values, so that this concentration is the best treatment in terms of physical, chemical and organoleptic quality. The functional drink with the best treatment will then be followed by supporting tests for metal contamination and microbiological tests in the form of total plate numbers and yeast mold numbers.

Table 7. Recapitulation results of research on Moringa leaf juice functional drinks

Quality parameters	Treatment	Results	Reason
Physics			
Total Dissolved Solids	A3B3	5,37°Brix	This is the highest °Brix value which is close to the minimum requirement (SNI 3719:2014) of 16°Brix
Chemistry			
Antioxidant Activity	A3B1	IC50 38 ppm	Has very strong antioxidant activity value
Hedonic			
Color	A2B2	Slightly Like	
Aroma	A2B2	Like	Based on the panelists' level of liking
Flavor	A2B2	Like	
Quality Score			
Color	A3B3	Slightly Red	
Aroma	A3B2	Smells of red ginger	Able to cover up the unpleasant aroma of Moringa leaves
Flavor	A2B3	Sweet	Able to improve the astringent taste of Moringa leaves

3.5. Supporting Tests

Supporting tests were carried out on the Moringa leaf juice functional drink with the best treatment, namely the treatment with the addition of 40% red ginger juice and 150 ppm sucralose which produced the highest or dominant value among the other treatments. The best results obtained from the treatment were total dissolved solids content of 4.97˚Brix, IC50 antioxidant activity of 46 ppm which showed very strong results, hedonic test score values were in the score range of 4-5 (slightly like-like), and test score values color quality 3.27 (slightly not red), flavour 4.50 (scented of ginger), taste 4.47 (slightly sweet). Supporting tests carried out in the research consisted of metal contamination tests and microbiological tests (total plate number and yeast mold number).

3.5.1. Heavy Metal Contamination Test

Testing for heavy metal contamination in this study aims to determine the presence of dangerous heavy metal contamination such as As, Hg, Cd and Pb in the Moringa leaf juice functional drink. Heavy metal contamination of processed food is one type of pollution that is often found in the environment. Sources of metal contamination can come from industrial, mining, agricultural and household waste (Dewi, 2022). The main potential for heavy metal contamination of the Moringa leaf juice functional drink with the addition of red ginger juice and sucralose is the growth medium for Moringa and red ginger plants, namely soil. Growing plants can absorb heavy metals and heavy metals that accumulate continuously can cause decreased fertility and soil quality and trigger contamination in the food chain (Sari & Ngibad, 2023). Soil quality decreases if it is contaminated with heavy metals because heavy metals reduce the level of soil fertility and disrupt the activity of microbes in the soil, where microbes play a role in maintaining the soil ecosystem. Based on the experiments carried out, the results of heavy metal testing on the best treated Moringa leaf juice functional drink can be seen in Table 8. The test results for all heavy metal parameters in the best treated Moringa leaf juice functional drink are below the threshold according to BPOM Regulation Number 9 of 2022 concerning Requirements for Heavy Metal Contamination in Processed Food. Based on these results, the Moringa leaf juice functional drink was declared safe for consumption.

Table 8. Test results for heavy metal contamination as supporting tests

Parameter	Test Results (ppm)	Maximum limit (ppm) (PerBPOM No. 9 of 2022)
Arsenic (As)	0.00	1.00
Lead (Pb)	0.00	2.00
Cadmium (Cd)	0.00	0.20
Mercury (Hg)	0.00	0.03

3.5.2. Microbiology Test

3.5.2.1. Yeast Mold Numbers

One way to guarantee that the product does not contain fungi at predetermined limits which can affect stability and reduce quality is by carrying out a Yeast Mold Number (AKK) test. Certain types of mold, such as *Apergillus species* (sp), produce dangerous aflatoxin poisons. is toxic because it can cause cirrhosis and liver carcinoma (Jirna *et al*., 2019). The yeast mold number is calculated based on the growth of the mold after the sample is inoculated. The samples that have been inoculated then go through an incubation process where the mold growth is observed starting from the third to the fifth day at a temperature of 20-25°C. The results of observations on the AKK value of the best treated Moringa leaf juice functional drink can be seen in Table 9.

Table 9. Results of the yeast mold number test as a supporting test

Dilution	Test 1	Test 2	Average	AKK (colony /mL)	Max. limit (ppm) (PerBPOM No. 13 of 2019) m (good quality limit)	M (poor quality limit)
10-Jan	2	0	1	$<1x10^2$	10^2 colony/g	10^3 colony/g
10-Feb	0	0	0			
10-Mar	0	0	0			

Based on the results obtained in Table 9, it can be seen that mold and yeast contamination was only found in the 10^{-1} dilution cup, then in subsequent dilutions, no yeast mold was found. The principle of calculating bacterial colonies is that the higher the dilution level, the lower the number of bacterial colonies (Abna *et al*., 2021). Dilution aims to reduce the population of microorganisms. Without dilution, the colonies that grow will accumulate and make it difficult to calculate the number of colonies. Based on the calculation results, the AKK value for the Moringa leaf juice functional drink was $<1\times10^2$, with this result being below the threshold for good quality (m) and bad quality (M) according to BPOM Regulation Number 13 of 2019 so that the Moringa leaf juice functional drink was declared safe for consumption.

3.5.2.2. Total Plate Numbers

One test that can be carried out to detect microbial contamination is the Total Plate Number (ALT) test. ALT testing can indicate the quality of a food product including the handling process and condition of the ingredients during the process. The ALT value is expressed as the result of the number of bacterial colonies growing on the media which is calculated multiplied by the dilution factor value (Nasir *et al*., 2022). Based on the experiments carried out, the results obtained were obtained from observations of the ALT value of the functional drink Moringa leaf juice with the best treatment which can be seen in Table 10.

Based on the table, it can be seen that in the first dilution, namely 10-3, the growth of microbial colonies was found on the test plates. The principle of calculating bacterial colonies is that the higher the dilution level, the lower the number of bacterial colonies (Abna *et al*., 2021). Dilution aims to reduce the population of microorganisms. The results of the experiment are in accordance with this principle which can be seen that at a dilution level of 10^{-4} there was no growth of microbial colonies after incubation for 72 hours compared to a lower retail level. Based on the calculation results, the ALT value obtained for the Moringa leaf juice functional drink is $<1x10^3$, with this result being below the threshold for good quality (m) and bad quality (M) according to BPOM Regulation Number 13 of 2019 so that the Moringa leaf juice functional drink is declared safe for consumption.

Table 10. Total plate number test results as a supporting test

Dilution	Test 1	Test 2	Average	AKK (colony /mL)	Max. limit (ppm) (PerBPOM No. 13 of 2019) m (good quality limit)	M (poor quality limit)
10-Jan	9	5	7	$<1x10^3$	10^3 colony/g	10^4 colony/g
10-Feb	0	0	0			
10-Mar	0	0	0			

4. CONCLUSIONS

Based on research that has been carried out on making functional drinks from Moringa leaf juice with the addition of red ginger juice (30%, 40% and 50%) and sucralose (100 ppm, 150 ppm and 200 ppm), the ANOVA test shows the results have a significant effect at $\alpha = 0.05$ on total dissolved solids, antioxidant activity and organoleptic parameters in the form of hedonic value and hedonic quality of color, aroma and taste. The best treatment was obtained by adding a concentration of 40% red ginger and 150 ppm sucralose based on the results of physical, chemical and organoleptic tests with a total dissolved solids content of 4.97˚Brix, IC_{50} antioxidant activity of 46 ppm which showed very strong results, the hedonic test score was at score range 4-5 (rather like-like), and color quality score test value 3.27 (rather not red), aroma 4.50 (smells of ginger), taste 4.47 (slightly sweet). The results of supporting tests in the form of heavy metal contamination Cd, Pb, As and Hg were below the limit for heavy metal contamination and microbiological supporting tests produced a total plate number < $1x10^3$ colonies/ml and the yeast mold number <$1x10^2$ colonies/ml.

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