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Antioxidant Based Functional Drink Formulation as an Alternative Diet Drink for Diabetes and Cholesterol

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Abstract

Indonesian people's awareness of health has led to a trend of seeking for alternative food or drink to prevent degenerative diseases such as cardiovascular, atherosclerosis, and diabetes mellitus. Functional drinks enriched with antioxidants from natural ingredients have emerged as a promising solution to adress these issues. Previous studies have focused more on antioxidant drinks derived from a single source, such as herbal infusions or plant extracts. However, limited research has been conducted on the combination of local herbs and tropical plants in one functional drink, especially those sourced from Indonesian biodiversity. This study aims to determine the chemical characteristics and sensory quality of functional drinks formulated as instant tea bags using pigeon pea, cinnamon, and lime peel. The parameters tested in this study were functional groups of organic compounds using FTIR, moisture content using the thermogravimetric method, pH value, sugar content using the Luff Schoorl method, antioxidant activity using the DPPH method, and organoleptic tests using the scoring method to assess the sensory quality of tea. The results showed that the highest moisture content was obtained in F4 at 8.56% and the lowest value in F1 at 6.97%. The highest pH value was in F4 with a value of 6.76 and the lowest in F5 at 5.72. Antioxidant compound analysis confirmed that all tea formulations have a very strong antioxidant capacity for all formulas with the highest IC_{50} value obtained in F1 at 1.29 ppm. In terms of total organoleptic score for color, aroma and flavor, the most preferred formula is F1> F2> F4> F5> F3 with scores respectively of 4.16; 4.17; 3.40; 3.28; and 3.07. Based on all the chemical and sensory characteristics of the antioxidant tea products, formulations F1and F2 has the potential for further development.

Keywords: Antioxidants; Cajanus cajan; Cinnamomum burmannii; Citrus aurantifolia; Functional drinks

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INTRODUCTION

The current lifestyle of society has led to an increase in metabolic disorders, which potentially raises the incidence of degenerative diseases, one of which is diabetes mellitus (Kesetyaningsih et al., 2020). Lifestyle, dietary patterns, physical activity, and environmental factors influence the overall health of the population. The convenience of modern technology has led to a decrease in physical activity, and the promotion of various types of new foods on social media. Especially fast food and junk food, has resulted in unhealthy eating habits. This contributes to a lifestyle that increases the likelihood of developing symptoms of degenerative diseases such as hypercholesterolemia, dyslipidemia, hypertension, obesity, and hyperglycemia, which can eventually lead to degenerative diseases such as cardiovascular disease, atherosclerosis, and diabetes mellitus (Fridalni et al., 2019).

According to the International Diabetes Federation (IDF), the prevalence of diabetes mellitus (DM) cases in 2021 was 537 million people, with an estimated increase to 643 million by 2030, and continuing to rise to 783 million by 2045. In Indonesia, as of 2022, there were

41.8 thousand recorded cases of type-1 DM. In West Nusa Tenggara (NTB), there were 63,488 recorded DM cases in 2022, with 47,483 patients receiving standard healthcare services (Lestiani et al., 2023; Tajiwalar et al., 2023).

As the possibility of developing degenerative diseases increases and the cost of treatment tends to be high, people are becoming more aware of the importance of maintaining a healthy lifestyle, one of which is by preventing the onset of symptoms associated with such diseases. One way to do this is by seeking alternative medicines or health products that are relatively affordable yet effective. This has led to a growing trend in the use of natural ingredients for maintaining health (Sihombing, 2022).

Functional beverages are drinks that contain food components that do not harm the body and have positive effects on health (Chairiyah Batubara[1] & Pratiwi[2], 2018). Antioxidants are one of the food components that play a role in fighting oxidative stress, which is the main cause of degenerative diseases (Gazali et al., 2018). Antioxidants can be obtained from fruits, vegetables, spices and other natural plants (Fortin et al., 2021).

In previous research it was stated that pigeon peas, cinnamon and lime peel have good antioxidant activity. In sequence, they are 2.03 ppm (very strong); 3.24 ppm (very strong); and 71.16 ppm (strong). The antioxidant capacity of these three ingredients is suspected to originate from secondary metabolite compounds such as alkaloids, saponins, flavonoids, phenolics, steroids, terpenoids and tannins (Y. K. Dewi, 2023). In addition, based on Ariviani's research, it is known that administration of 30g/day of powdered pigeon pea drink has been proven to reduce plasma glucose and total cholesterol levels in diabetic-hypercholesterolemia rats (Ariviani et al., 2018).

There has been previous research conducted on antioxidant drinks, but focused more on antioxidant drinks derived from a single source, such as herbal infusions or plant extracts. However, limited research has been conducted on the combination of local herbs and tropical plants from Indonesian biodiversity. Moreover, no research has been conducted to assessed sensory and antioxidant characteristics of pigeon pea-based tea bags. This research aims to develop a functional drink formulation that utilizes pigeon pea powder, supplemented with cinnamon powder as a natural sweetener, and lime peel as a flavoring agent into an antioxidant-based functional drink in the form of instant tea bags that can serve as an alternative dietary drink for diabetics. The formulation of pigeon pea, cinnamon and lime peel was carried out to obtain the best quality antioxidant tea that meets the standards in both chemical and sensory characteristics that can be accepted by consumers.

METHOD

This research utilized natural ingredients including pigeon peas, cinnamon, and lime peel which were prepared into simplicia, then made into powder and packaged in the form of tea bags. Furthermore, the tea infusion bag were analyzed for chemical characteristics and sensory quality including the content of functional groups of organic compound, moisture content, pH value, sugar content, antioxidant activity and sensory values of color, aroma and flavor. The research design used in this study is a Completely Randomized Design with three replications. The functional group data obtained from FTIR results were processed using Origin software. The water content, pH value, and sugar content data were statistically analyzed using ANOVA with Duncan's post-hoc test. Meanwhile, the organoleptic test was analyzed using the Kruskal-Wallis non-parametric statistical test.

Tools and Materials

The tools used are a grinder (Vipoo V-830), knife, sieve, oven (Memmert UN55), a set of glassware (Pyrex), reflux set, dropper pipette, stirring rod, micropipette (Eppendorf), analytical balance (Kern ABS 220-4), pH meter probe (Thermo Scientific Orion Star A211) desiccator (Duran), UV-Vis spectrophotometer (Thermo scientific Genesys 150) and Fourier Transform Infrared (FTIR) Spectrometer (Spectrum Two Perkin Elmer). The materials used are cinnamon, pigeon peas (Lebui), lime peel, starch (Merck), Luff Schoorl Reagent, Phenolphthalein (Merck), Sodium thiosulfate (Merck), Hydrogen chloride 37% (Merck), (Sodium hydroxide (Merck), sulfuric acid 95-97% (Merck), Glacial acetic acid (Merck), Potassium Iodide (Merck), distilled water, dip bag for tea, DPPH (Sigma Aldrich), Vitamin C (Merck), methanol (Merck) and distilled water.

Tea Preparation Procedure

Cinnamon, pigeon pea seeds, and lime peel that have been separated from the fruit flesh, cut into small pieces, sorted and washed using running water are then dried in indirect sunlight until dry. Once dry, the three ingredients are blended separately to obtain simplicia powder. Antioxidant tea bags are made by mixing the simplicia of the three ingredients with the formulation according to Table 1 into a tea bags. The tea formulation consists of five formulas: F1 uses only pigeon pea, F2 includes cinnamon and lime peel as additives, F3 uses equal amounts of all ingredients, while F4 and F5 test cinnamon and lime peel as the main ingredients, respectively.

Table 1. Antioxidant Tea Formulation

Material	Antioxidant Tea Formulation (grams)				
	F1	F2	F3	F4	F5
Pigeon pea	3	2	1	0.5	0.5
Cinnamon	0	0.5	1	1.5	1
Lime Peel	0	0.5	1	1	1.5
Total	3	3	3	3	3

Functional Group Testing of Organic Compounds with FTIR

The dried simplicia as much as 1-3 miligrams was tested for the functional group content of its organic compounds using an FTIR instrument at a wavenumber of 4000-550 cm-1 (Annisa & Cahyaningrum, 2022).

Determination of Moisture Content

The moisture content was determined using the thermogravimetric method with three replications. The sample was dried using an oven at 105°C for 1 hour, and cooled in a desiccator for 15 minutes. Drying was continued until it reached a stable weight. The initial weight of the sample before drying and after drying was recorded to calculate the percentage of moisture content. (Syahidah et al., 2022).

Determination of pH Value

The brewed tea is cooled to room temperature, then its pH value is measured using a pH meter probe or a digital pH meter. The test was repeated 3 times.

Sugar Content Test

Total sugar content analysis was carried out using the Luff schoorl method with three replications. 1) The determination of sugar content before inversion is carried out by taking 2 grams of sample, dissolved in a volumetric flask up to 100 ml. 10 ml of the solution was added with distilled water and luff schoorl reagent for the test sample. The blank solution is prepared in the same steps without the test substance. Heat the test sample and blank until boiling. After cooling, add H2SO4 and KI. The next solution is titrated using sodium thiosulfate and starch indicator. The endpoint titration was marked with a blue to white solution. 2) The determination of sugar content after inversion is carried out by taking a sample from the sugar content before inversion, adding distilled water and 25% HCl. Then heated at a temperature of 70-80°C for 15 minutes. The solution is then dropped with phenolphthalein indicator and neutralized with 30% NaOH and 1% acetic acid. Next, Luff schoorl reagent was added and refluxed. After reflux, H2SO4 6N solution was added and titrated with thiosulfate until it turned light yellow.

1% starch indicator was added and titration was continued until the blue color disappeared. The invert sugar content and total sugar content were calculated (Nissa et al., 2019; Putri, 2022).

Antioxidant Activity Test With DPPH Method

Antioxidant activity was tested using a UV-Vis spectrophotometer at a wavelength of 515 nm with three replications. The first step is to prepare a 100 ppm DPPH stock solution with methanol as the solvent. Furthermore, a 1000 ppm tea stock solution is made by boiling distilled water, and the temperature is lowered to 90°C to brew the tea sample for 6 minutes. The solution is filtered, and the resulting filtrate is used to make standard solutions with concentrations of 20, 40, 60, 80 ppm. Into the standard and blank solutions, 1 ml of DPPH solution is added and made up to 4 ml with methanol. The solution was then incubated for 30 minutes in the dark, then the absorbance is measured (Aji, 2014).

Organoleptic Test

This test aims to measure the acceptance score of the flavor, aroma and color characteristics of antioxidant tea using 25 panelists. The assessment criteria use the numbers 1 (Very dislike), 2 (Dislike), 3 (Normal), 4 (Like), and 5 (Very like). Organoleptic tests have obtained approval from 25 untrained panelists, both male and female, aged over 35 years.

RESULTS AND DISCUSSION

Determination of Functional Groups of Organic Compounds

In preliminary research, it was found that the phytochemical tests results of the raw materials used for antioxidant tea showed that Cajanus cajan powder contains saponins, flavonoids, phenolics and tannins. Citrus aurantifolia peel positively contains compounds of the alkaloid, phenolic, terpenoid/steroid and tannin groups, while Cinnamomum burmanni positively contains all groups of compounds tested, namely alkaloids, saponins, flavonoids, phenolics, steroids/terpenoids and tannins (Y. K. Dewi, 2023).

To confirm the presence of these compound groups, an analysis of the functional groups of organic compounds can be conducted through FTIR testing. The FTIR test results on the simplicia powder of the three raw materials from the antioxidant tea are presented in Figure 1. For the absorption bands from the FTIR test results of the tea raw materials are presented in Table 2.

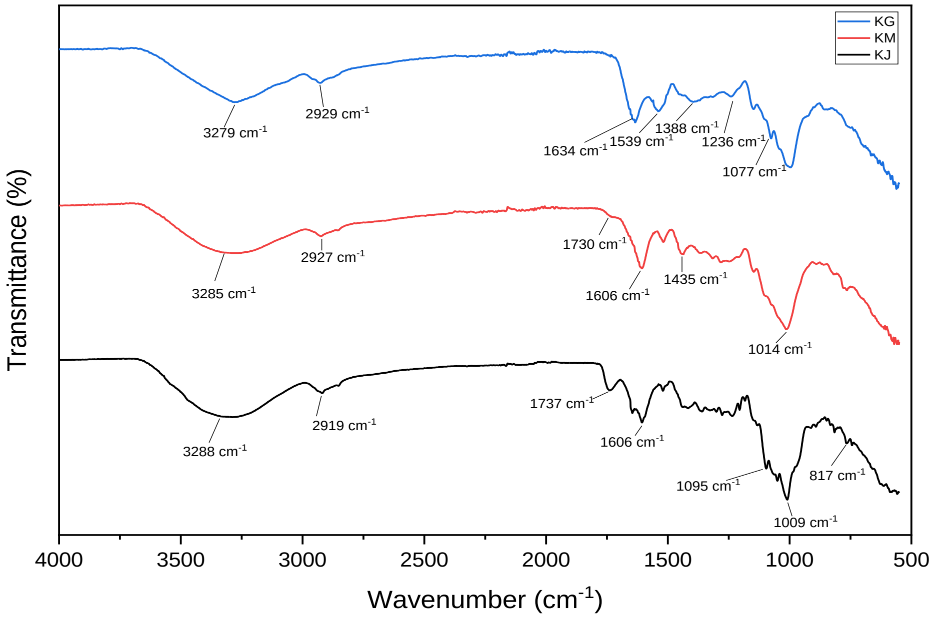

Figure 1. FTIR Test Results of Pigeon Pea Powder (KG), Cinnamon (KM), and Lime Peel (KJ).

Based on Figure 1, the O-H functional group appears in the absorption band around the region of 3200. This peak indicates the presence of stretching vibrations from O-H of phenol or alcohol compounds, thus confirming the presence of phenolic compounds [17], [22]. Absorption in the 2900 and 1388 areas indicates the presence of C-H bonds from alkanes or lipids. The absorption band in the area around 1600 is related to the C=O amide bonds and C=C aromatics. Absorption in the region around 1700 indicates the presence of C=O stretching which is commonly found in carbonyl compounds. This further strengthens the suspicion of the presence of phenolic compounds due to the appearance of several bonds and functional groups such as O-H, C=C, C=O and C-H. Flavonoids and tannins are compounds that belong to the group of phenolic compounds (Maidawati, 2022; Olii et al., 2013).

Table 2. FTIR Absorption Bands of Antioxidant Tea Raw Materials

Wavenumber (cm-1)			**Functional Group**	**Compound**
KG	**KM**	**KJ**		
3279	3285	3286	O-H stretch	Phenol, alcohol monomer
2929	2923-2855	2919-2852	C-H stretch	Alkane, aromatic compound
	1740	1737	C=O stretch	Carbonyl compounds (Aldehyde, ketone, carboxylic acid, ester, etc.)
1634	1606	1606	C=O amida, C=C aromatik	Unsaturated fatty acids, protein
1539,	1606-1518	1606-1520	N-H bend	Amide, Protein
1388	1440		C-H bend	Alkane or Lipid
1236			C-O stretch	Ester, Phenol
1077	1013	1095, 1009	C-O stretch	Carbohydrat
858			C-O-C	Ether
		817	C=C bend	Alkene

* This table referring to (A'yuni et al., 2021; Papayrata et al., 2024) for KG, (Bedjaoui et al., 2023; Lad et al., 2024) for KM, and (Luque et al., 2020; Oyinloye et al., 2024) for KJ.

The absorption band in the region of 1500-1600 shows the bending vibrations of the N-H bond, and stretching vibrations of C-O at 1236, thus the presence of alkaloids is strengthened by the presence of functional groups N-H, C=O, C-O, and C-H (Damayanti et al., 2020; Gamah et al., 2023). The presence of saponins is reinforced by the presence of functional groups O-H, C-H, C=O, C-O (Bintoro et al., 2017). As for terpenoids, their presence can be confirmed by the presence of functional groups O-H, C=C, C-O, C-O-C, and C-H (Wardani et al., 2020). Secondary metabolite compounds such as flavonoids, tannins, phenolics, alkaloids, saponins and terpenoids have the ability to act as antioxidants (Chaudhary & Khan, 2024; Hardiningtyas et al., 2014; Kumaradewi et al., 2021).

Determination of Moisture Content, pH Value, and Total Sugar Content

The results of the chemical characteristic tests, which include moisture content, pH value and sugar content in this study are presented in Table 3. The measurement of moisture content in a food ingredient is closely related to the quality of the product to be produced because it will affect the product's properties, the durability and stability of the product, chemical changes and resistance to microbes. The moisture content in a material can affect the quality and characteristics of the material in terms of appearance or freshness, texture, flavor and shelf life. The presence of water in food ingredients can be used as a growth medium for microbes, accelerate the occurrence of chemical changes and physical properties of the ingredients, and affect the texture and appearance of the food (Naway et al., 2023; Prasetyo et al., 2019).

The National Standardization Agency (BSN) of Indonesia, has established the quality requirements for packaged dried tea in Standar Nasional Indonesia (SNI) 3836:2013, where the moisture content in packaged dried tea meets the requirements if it is does not exceed 8%. (Badan Standardisasi Nasional, 2013). Therefore, in this study, moisture content is an important parameter to measure in the production of food products to maintain their shelf life.

Table 3. Results of Moisture Content, pH Value, and Sugar Content

Formula	Average Value		
	Moisture Content (%)	**pH Value**	**Sugar Content (%)**
F1	6.97 ± 0.03^{a}	6.76 ± 0.03^{e}	39.54 ± 0.08^{e}
F2	7.80 ± 0.08^{b}	6.55 ± 0.01^{c}	34.18 ± 0.07^{d}
F3	8.14 ± 0.05^{c}	6.15 ± 0.01^{b}	25.61 ± 0.39^{c}
F4	8.56 ± 0.03^{e}	6.63 ± 0.01^{d}	20.58 ± 0.15^{b}
F5	8.37 ± 0.02^{d}	5.72 ± 0.01^{a}	19.67 ± 0.29^{a}

* Different letter notations indicate a statistically significant difference based on Duncan's tets.
** Values are presented as mean ± standard deviation

When compared to the quality standard for moisture content in packaged dried tea according to SNI, which has a maximum moisture content value of 8%, the moisture content values of F1-F2 meet the quality standards. However, the moisture content values of F3-F5 do not meet the quality standards. This could happen due to the drying process not being optimal using indirect sunlight. The choice of using indirect sunlight drying is to maintain and minimize damage to secondary metabolite compounds due to high temperatures. Flavonoids are a group of compounds that are easily damaged and experience a decrease in concentration at high temperatures (Chaudhary & Khan, 2024). However, this problems can be overcome by using the oven drying method at low temperatures. In line with the research results of Arif Dwi Utomo, the total flavonoid content in sambiloto herbs with indirect sunlight drying has the highest content compared to oven drying and direct sunlight drying (Utomo et al., 2009).

Measurement of pH value in beverage products is carried out to ensure the safety of the consumed drinks. Food and beverages that enter the body with a certain pH value will affect the regulation of the body's acid-base balance. Under normal conditions, the pH value of body fluids is generally around 7.35-7.45, and this condition can decrease or increase due to external influences such as food or beverages (Fathul et al., 2008). The pH value test results of the tea products are presented in Table 3.

The lowest pH value was 5.72 in F5 and the highest value is 6.76 in F1. Pigeon peas themselves have a pH value of 6.76, but experience a change in pH when mixed with lime peel and cinnamon. The addition of cinnamon will increase the pH value of the drink, because cinnamon is classified as an alkaline material with a pH above 8, while the addition of lime peel will decrease the pH of the drink. The pH value of the drink can also be related to the antioxidant potential of the ingredients. Nanjo in Siagian stated that antioxidant activity will increase when the pH value increases because there will be an increase in redox potential. In addition, an increase in pH value towards the alkaline also tends to enhance the antioxidant capacity of the phenolic compound (Siagian et al., 2020).

If referring to the pH value in packaged drinking water according to SNI 01-3553-2006, the quality requirement for the pH value in packaged drinking water is 6.0-8.5 (Badan Standardisasi Nasional, 2006), then the pH value in formulation F7 is outside the criteria range. However, it does not mean that the formulation cannot be consumed, because the pH of fermented drinks is generally acidic. Currently, there is no specific SNI that establish a standard pH value for tea.

The determination of total sugar content in a food ingredient can be done using the Luff Schoorl method. Total sugar is the amount of carbohydrate compounds present in a substance, either in the form of monosaccharides (glucose, fructose, galactose) or disaccharides (sucrose) which can provide a sweet taste and supply calories in a food ingredient. In Table 3, it can be seen that the highest total sugar content is in the F1 formulation which consists of only 3 grams of pigeon peas with a value of 39.54%. While the lowest value is in the F5 formulation where the composition of pigeon peas is the lowest at 0.5 grams with a total sugar of 19.67%.

The results of the total sugar content obtained in Table 3, for all formulas meet the standard requirements for the quality of traditional beverage powder, where the total sugar required is a maximum of 85%. This result is quite good, because the total sugar in the formulated drink is significantly lower than the required number. The higher the total sugar content in a subtance, the higher the calories or energy will be, and it will also affect blood sugar levels.

Determination of Antioxidant Activity

The results of the antioxidant activity test involved 5 drink formula and vitamin C as a positive reference. The results of the antioxidant activity test are presented in Table 4 and Figure 2.

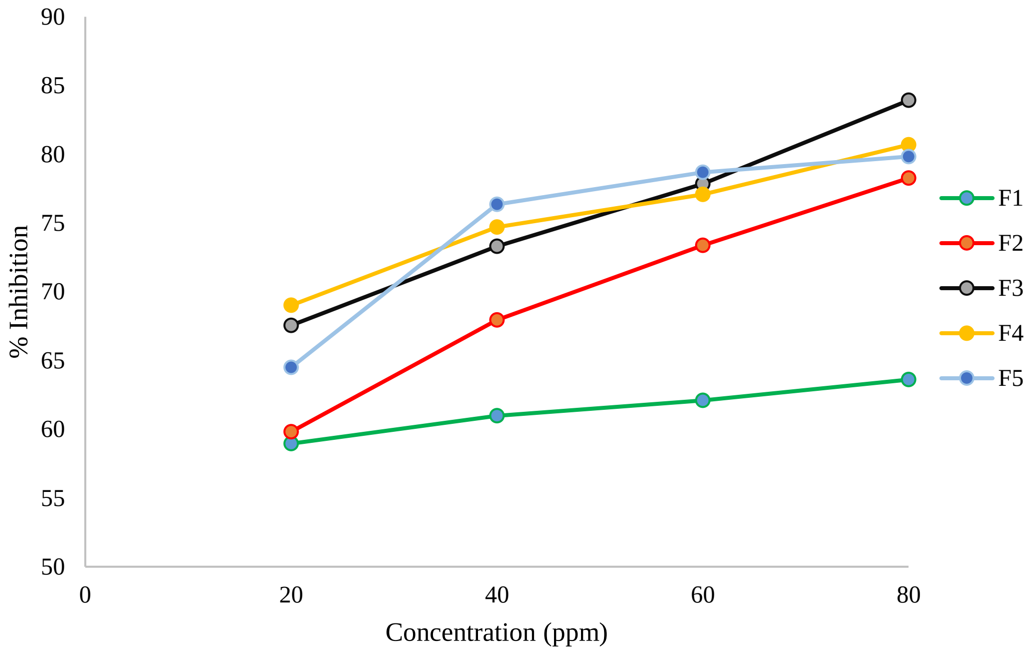

Figure 2. Plot graph of % inhibition vs concentration on Antioxidant activity of tea samples

Table 4. Antioxidant Activity Test

Sample	Antioxidant Activity	
	% Inhibition	**IC_{50} (ppm)**
F1	61.41 ± 0.01	1.29
F2	69.85 ± 0.00	9.76
F3	75.65 ± 0.08	4.55
F4	75.36 ± 0.05	1.93
F5	74.84 ± 0.05	4.86
Vitamin C	89.77 ± 0.03	0.14

*Inhibition values are presented as mean ± standard deviation

The percentage of inhibition indicates the ability of a compound in a material or sample to capture free radicals at a certain concentration. Generally, the lower the absorbance value, the higher the inhibition percentage value. The higher the inhibition value, the better the sample's ability to suppress free radical activity. (Membri et al., 2021). Based on the results above, it can be seen that the overall tea formulation has antioxidant activity with a percentage of inhibition or free radical scavenging percentage above 0%, with an IC50 value entering the category of very strong antioxidant capacity. This result approaches the antioxidant activity value of Vitamin C, which has been proven to have very strong antioxidant capacity. These results are in accordance with previous studies related to several Cajanus cajan extracts that produce strong antioxidants ranging from 0.52 to 0.66 mg/ml [40].

This is closely related to the content of secondary metabolite compounds from tea ingredients. The ability of the sample or test material to inhibit the oxidation process of radical DPPH in a solvent can be seen or observed through the color changes that occur. The process of reducing DPPH radicals causes the deep purple color (from the parent DPPH solution) to change to yellow. It can be seen in Figure 3 that there is a change in the purple color at a concentration of 20 ppm, slowly fading until it turns yellow as the concentration of the solution increases. The higher the concentration of compounds with potential antioxidants properties, the stronger its ability to reduce DPPH radicals (C. E. Dewi et al., 2024).

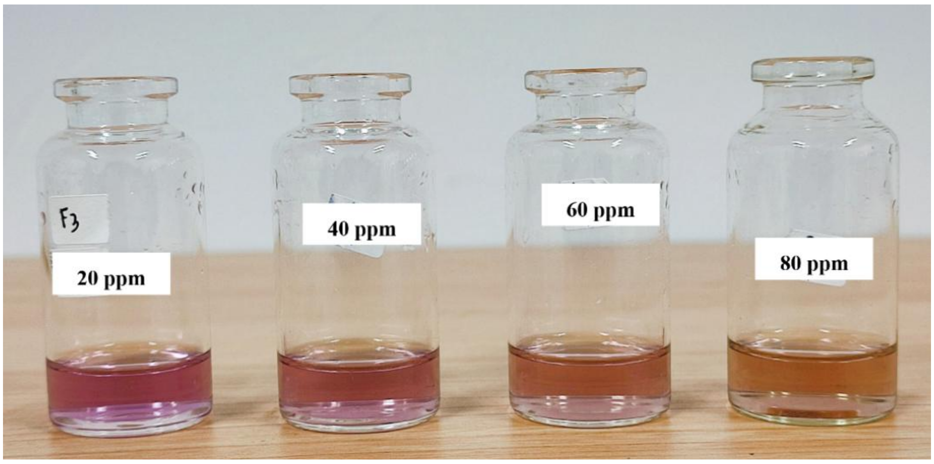

Figure 3. Color change of DPPH during oxidation using antioxidant tea

Samples containing antioxidants scavange free radicals by donating hydrogen atoms (H^+) to DPPH radical, forming more stable compound DPPH-H with lower absorbance (Nurmazela et al., 2022). This reaction cause decolorization, changing DPPH from purple to yellow due to increased electron donation (Baliyan et al., 2022). Figure 4 ilustrates the mechanism of DPPH radical scavenging reaction.

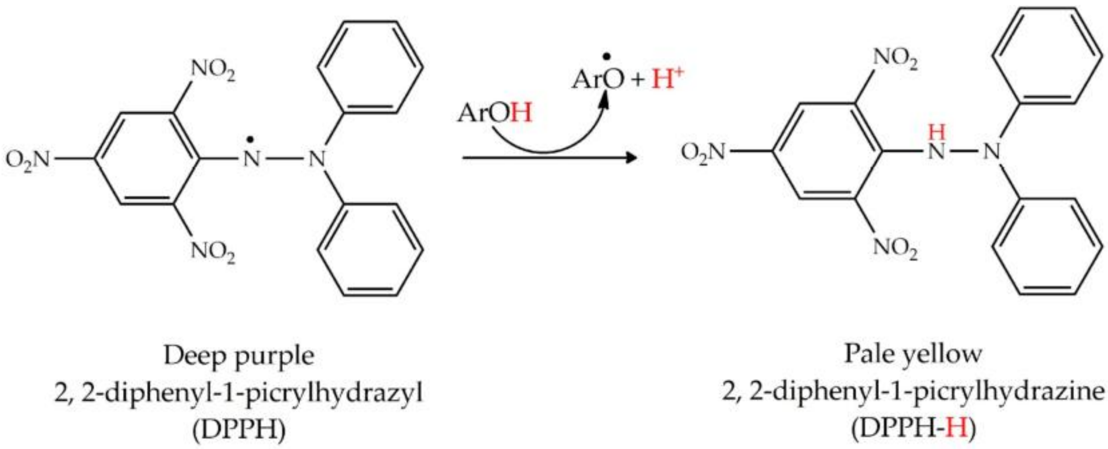

Figure 4. DPPH free radical scavenging mechanism (Sadeer et al., 2020)

While endogenous antioxidants are widely recognized for their effectiveness, the health benefits of exogenous dietary antioxidants remain uncertain. Several studies have evaluated the effects of exogenous antioxidants on human health. Polyphenolic antioxidants are exogenous antioxidants that protect cells by preventing oxidative stress and neutralizing free radicals. Their intracellular activity contributes to increased antioxidant defense (Bešlo et al., 2023). Flavonoids, for example, undergo structural changes in vivo, affecting their antioxidant activity. Enzymatic removal of sugar groups may enhance their effect, while methylation and glycosylation can reduce their prooxidant behavior (Kotha et al., 2022).

Consuming natural antioxidants through whole foods is considered healthier than taking dietary supplements or pills. However, food processing significantly affects their nutritional properties. A study on four sweet potato varieties showed that heat treatments, especially baking and microwaving, increased total phenolic, anthocyanin, and antioxidant levels. On the contrary, boiling negatively impacted individual phenolic acids (Toydemir et al., 2022).

Organoleptic Test

Furthermore, organoleptic tests were conducted to determine the level of panelist acceptance of the tea product. The organoleptic test conducted using 5-point hedonic scale (1=dislike very much; 2=dislike slightly; 3=neither like nor dislike; 4=like slightly, 5=like very much)(Zhi et al., 2016). Parameters tested in this study are color, aroma and flavor. The panelists used for this test were untrained panelists over 30 years of age, both male and female. The results of the organoleptic test on 25 panelists are presented in Table 5.

Tabel 5. Organoleptic Test Result

Parameter	Average Score				
	F1	**F2**	**F3**	**F4**	**F5**
Color	4.20^{b}	4.16^{b}	3.08^{a}	3.48^{a}	3.56^{a}
Aroma	4.24^{b}	4.08^{b}	3.28^{a}	3.56^{ab}	3.28^{a}
flavor	4.04^{b}	4.08^{b}	2.84^{a}	3.16^{a}	3.00^{a}
Average	4.16	4.11	3.07	3.40	3.28

* Different letter notations indicate a statistically significant difference based on Kruskal Wallis's test.

Based on the results of statistical analysis, it was concluded that there is a significant difference in the variation of the formula. The lowest preference value was in F3 with a score of 3.07 and the highest value was in F1 with a score of 4.16. If we look at the color produced by the tea infusion, the panelists tend to prefer the color of tea with a higher content of pigeon peas where pigeon peas give a purplish-brown color. The addition of high amount lime peel is preferred compared to the addition of high amount cinnamon to the resulting color.

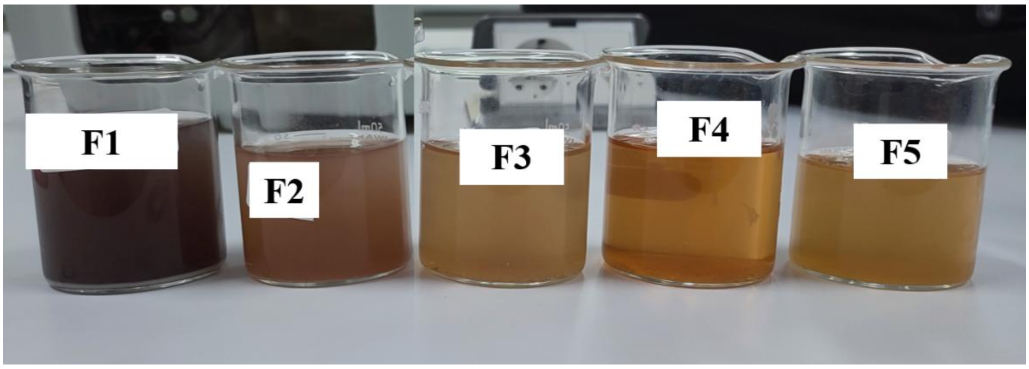

Figure 5. The Color of The Antioxidant Tea Infusion

Based on Figure 5, it can be seen that F1 has a purplish-brown color because it only contains pigeon peas. While in other formulations, pigeon peas are combined with cinnamon and lime peel, where cinnamon will give a clear brown color typical of tea and lime peel will contribute a yellowish color although with a rather pale yellow color.

The purplish-brown color of pigeon peas comes from natural color pigment called anthocyanins. Anthocyanins are color pigments that generally provide red, magenta, purple or blue colors depending on the variety and ripeness of the material. Anthocyanins themselves belong to the group of flavonoid compounds. This causes anthocyanins to be used not only as natural dyes in the food processing process, but also as a source of antioxidants in food (Enaru et al., 2021; Swami et al., 2020).

The yellow brown color of cinnamon comes from essential oil cinnamaldehyde. Cinnamaldehyde generally exists in liquid form and has a yellow color (Saksina, 2020). Similarly with lime peel, the yellow color comes from the essential oil content with colors ranging from colorless to greenish yellow.

The tea produced has a more dominant aroma, which is a mixture of lime and cinnamon only, because pigeon peas tend to lack a distinctive aroma. The preferred tea formula generally contains more pigeon peas and not too much cinnamon and orange peel. The distinctive aroma of tea is contributed by essential oils from cinnamon and lime. Cinnamon contains cinnamaldehyde which has a very strong distinctive aroma like spices that not all panelists necessarily like the aroma. While lime peel has a distinctive aroma like oranges which tends to be fragrant and fresh which comes from the compounds β-pinene dan d-limonene, β-phellandrene, β-citral, β-bisabolene, and geranial (Pandiangan et al., 2021; Wibaldus et al., 2016).

The value of the flavor parameters of the produced tea received the lowest preference score when compared to the preference score for aroma and color. This could be influenced by the absence of sugar addition when the tea infusion was served to the panelists. The tea formulation with a fairly high content of lime peel and cinnamon lower the panelists' preference score because it is associated with the bitterness and astringency that increase along with the addition of cinnamon in the tea formulation. Based on the overall average total score of each tea formulation, it can be concluded that the panelist’s preference value for tea products in order from the lowest is F3 <F5 <F4 <F1 <F2. Scores for F1 and F2 fall into the like category, indicating higher acceptance, while the other formulation fall into the nuetral category.

CONCLUSION

Based on the results and discussion, it can be concluded that the produced tea has a pH value and total sugar content that suitable for consumption. However, the moisture content values in formulations F3, F4, and F5 slightly above the standard, thus requiring a longer drying treatment. In terms of chemical compounds and antioxidant activity, all tea formula contain antioxidants compounds and exhibit very strong activity. Overall, F1 and F2 are recommended for further development based on their chemical and sensory characteristics. Future work should focus on identifying specific active compound contributing to this activity as antioxidant. This study has several limitations, including the use of a single drying method, which may have influenced the moisture content. The drying method used may not have been optimal for achieving standard moisture levels, particularly in formulations F3, F4, and F5. Additionally, the sensory evaluation involved a limited number of panelists from a narrow demographic range, which may not represent broader consumer preferences.

RECOMMENDATION

For future research, it is recommended to identify the specific compounds responsible for the antioxidant activity in the product. In vivo testing should also be conducted to evaluate the product’s potential in inhibiting or treating diabetes and cholesterol. If possible, the product should be tested on diabetic consumers to assess its practical effectiveness.

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