

Antioxidant Activity and Sensory Profile Characterization of Herbal Tea Made of Melinjo (*Gnetum gnemon* L.) Peels and White Turmeric (*Curcuma zedoaria*)

Alifah Lailatul Rahmah^{1,✉}, Dase Hunaefi¹, Nancy Dewi Yuliana¹

¹ Department of Food Science and Technology, Faculty of Agricultural Engineering and Technology, IPB University, Bogor, INDONESIA.

Article History:

Received : 21 October 2025
Revised : 11 December 2025
Accepted : 19 December 2025

Keywords:

Flavonoids,
Melinjo peel,
RSM,
Stevia,
White turmeric.

Corresponding Author:

✉ alifahlailatulrahmah@apps.ipb.ac.id
(Alifah Lailatul Rahmah)

ABSTRACT

Melinjo peel, a by-product of melinjo cracker production, has the potential to become waste if not utilized optimally. However, it contains bioactive compounds that can be processed into herbal tea bags with health benefits. Melinjo peel has relatively low antioxidant activity; therefore, the addition of other ingredients, such as white turmeric is necessary to enhance the functional value of the herbal tea. Herbal tea bags generally have a slightly bitter and astringent taste; thus, stevia leaves were added as a natural sweetener. Formula optimization of the herbal tea was carried out using response surface methodology (RSM), with total flavonoid content and antioxidant activity as the measured responses. The optimal formula was further subjected to sensory profile characterization (RATA method and hedonic rating) to determine the selected formulation. The selected herbal tea formula consisted of 50% melinjo peel, 40% white turmeric, and 10% stevia leaves. Based on the RATA test, the herbal tea was characterized by attributes of licorice, sweet, floral, bitter aftertaste, astringency, and metallic aftertaste, with an average liking score of 3.51 (liked).

1. INTRODUCTION

As one of the most widely consumed beverages worldwide, tea is appreciated not only for its distinctive taste and aroma but also for its role in supporting health. According to the Statista Consumer Market Outlook, global tea consumption has continued to increase, rising from 6.89 million tons in 2022 to a projected 7.44 million tons by 2025 (Ardiansyah, 2024). Herbal tea is a type of tea commonly consumed, made from a single type of plant or a mixture of various herbal plant parts, such as seeds, leaves, roots, or flowers, which provide health benefits (Dusun *et al.*, 2017).

Banten Province is the fifth-largest producer of melinjo (*Gnetum gnemon* L.) in Indonesia (BPS, 2014). As of 2024, melinjo production in Banten Province reached 55,366 tons per year (BPS, 2025). The abundant melinjo plants provide an important source of income for local communities, particularly through the processing of melinjo seeds into emping crackers (traditional crackers). However, the production of emping generates solid waste in the form of melinjo peels, which, if not properly utilized, can potentially cause environmental pollution. Therefore, this waste can be processed into herbal tea with potential health benefits. Herbal tea containing antioxidant compounds plays an important role in protecting the body against free radicals, oxidative stress, and cellular damage that may lead to various diseases (Harahap *et al.*, 2016).

Ripe melinjo peel is red in color, contains anthocyanin pigments that act as antioxidants by scavenging free radicals that cause cellular damage (Adhityasmara & Advistasari, 2021). Previous studies have shown that melinjo peel has relatively low antioxidant activity, with an inhibition value of 37.35% (Fatimatuzzahroh *et al.*, 2020). This indicates the need to add other ingredients to enhance the antioxidant activity of the herbal tea, such as white turmeric (*Curcuma zedoaria*), which has high antioxidant activity with an inhibition value of 85.41% (Malipeddi *et al.*, 2010).

In general, tea products tend to have a bitter and astringent taste due to interactions between various compounds, including caffeine, certain amino acids, and polyphenols (Pratiwi *et al.*, 2024). Therefore, a sweetener is necessary to reduce this bitterness. Stevia leaves were selected as a sweetener because they are calorie-free, making them suitable for consumers who wish to limit sugar intake. Excessive use of stevia leaves can cause bitterness and an unpleasant aftertaste, so their amount must be carefully adjusted.

Traditionally, herbal tea is prepared by boiling the tea ingredients in hot water, which takes a longer time and produces residue that needs to be filtered before consumption. This method is considered less practical for consumers who prefer a quick and simple preparation process. Therefore, herbal tea bags have been developed as a more practical alternative, providing faster brewing, no need for filtration, while retaining functional benefits. This study aims to develop a practical herbal tea bag with optimal antioxidant activity and sensory characteristics acceptable to consumers. Variations in the properties of each ingredient require appropriate formulation to maintain bioactive properties and sensory quality. Furthermore, sensory profile characterization is necessary to ensure that the resulting product meets consumer preferences.

2. MATERIALS AND METHODS

2.1. Materials

The main materials used in this study were melinjo peel, white turmeric, and stevia leaves. Melinjo peel was sourced from plantations in Serang, Banten, and selected for uniform red color, freshness, and the absence of physical damage such as bruising or decay. White turmeric was sourced from a traditional market in Serang, Banten, and selected for uniform yellowish-white color, characteristic aroma, firm and dense texture, and no shriveling. Stevia leaves were obtained from an online store in whole form, dry, free from additives, and dark green in color.

2.2. Methods

2.2.1. Raw Material Preparation

The preparation of raw materials included the preparation of melinjo peel powder, white turmeric powder, and stevia leaf powder. Melinjo peel and white turmeric were first sorted, washed, cut into small pieces, and oven-dried. Melinjo peel was dried at 65 °C for 4 h (Saragih *et al.*, 2018), resulting in an antioxidant activity of 52.80% inhibition, while white turmeric was dried at 50 °C for 7 h with some modifications (Malahayati *et al.*, 2021), resulting in an antioxidant activity of 63.59% inhibition. After drying, both materials were ground into powder and sieved using a 20-mesh sieve. Commercial stevia leaves were crushed and sieved using the same mesh. All powdered materials were stored in airtight containers, weighed according to the formulation, thoroughly mixed, and packaged into tea bags with a weight of 2 g per sachet.

2.2.2. Determination of Ingredient Concentration Limits

A study by Apriliyanti *et al.* (2021) reported that the use of melinjo peel at concentrations between 30% and 60% resulted in good consumer acceptance, so this range was used as the formulation limit. Listiana & Herlina (2015) found that white turmeric at a concentration of 50% was most preferred; however, using too much white turmeric may cause a bitter taste, so a concentration of 40% was set as the upper limit. In addition, according to Sinuhaji *et al.* (2023), the addition of 10% stevia leaves gave the best taste acceptance and was thus used in the product formulation.

2.2.3. Formula Optimization

The formula optimization process was conducted using Response Surface Methodology (RSM) with a D-optimal design to determine the concentration of each variable and to obtain the optimal responses. The measured responses were total flavonoid content and antioxidant activity, and each treatment was performed in triplicate.

2.2.4. Sensory Profile Characterization of the Optimal Formula

The process consisted of three stages: focus group discussion (FGD), panelist selection, and sensory evaluation. The focus group discussion (FGD) was conducted to determine the most appropriate terms to describe sensory attributes to

untrained panelists (consumers). This method typically involves a small group of 8–12 participants (Alfiyah *et al.*, 2024). In this study, a total of 10 consumer panelists participated, consisting of five females and five males. The discussion indicated that panelists could identify nine sensory attributes in the samples, which were subsequently used in the Rate-All-That-Apply (RATA) sensory evaluation. The list of sensory attributes is presented in Table 1.

Table 1. Results of the focus group discussion (FGD)

No	Sensory Attribute	Description
1	Sweet	Sweet taste
2	Bitter	Bitter taste
3	Yellow	Yellowish color of the brewed tea
4	Astringency	Astringent or drying sensation in the mouth, especially on the tongue and palate
5	Licorice	Licorice or medicinal syrup-like taste, perceived at the back of the tongue or throat
6	Floral	Floral aroma and flavor
7	Metallic aftertaste	Metallic taste lingering in the mouth after consumption
8	Sweet aftertaste	Sweet taste lingering in the mouth after consumption
9	Bitter aftertaste	Bitter taste lingering in the mouth after consumption

Panelist selection involved 70 consumers aged 20–50 years from Banten Province. Sensory evaluation was conducted using the Rate-All-That-Apply (RATA) method with intensity ratings on a 1–5 scale, from very low to very high, as well as a hedonic rating test using a 1–6 preference scale, from “dislike extremely” to “like extremely.” This sensory evaluation process was approved by the Ethics Committee for Research Involving Human Subjects, IPB University, with approval number 1697/IT3.KEPMSM-IPB/SK/2025.

2.2.5. Data Analysis

Formula optimization was carried out using Design-Expert version 13.0. The resulting mathematical models were evaluated by significance and lack-of-fit tests at a significance level (α) of 0.05. Sensory data from the RATA and hedonic rating tests were analyzed using XLSTAT. The analysis included Principal Component Analysis (PCA) biplot graphs, spider web and sensory wheel charts, tables of hedonic test results, Agglomerative Hierarchical Clustering (AHC) panelist grouping tables, and Internal Preference Mapping (IPM) biplot graphs.

3. RESULTS AND DISCUSSION

3.1. Optimization of Herbal Tea Bag Formulation Based on Response Variables

The determination of the optimal formulation aimed to produce a herbal tea bag with high total flavonoid content and strong antioxidant activity. These parameters are important for evaluating the quality and functional benefits of herbal products, although other factors may also be considered in overall quality assessment. High flavonoid content and strong antioxidant activity can enhance the functional value of the product, as they may provide additional health benefits beyond their nutritional role. Flavonoids have the potential to act as antioxidants due to the presence of hydroxyl groups on their aromatic rings, which enable them to react with free radicals and inhibit the formation of reactive compounds during lipid peroxidation processes (Artati *et al.*, 2024). Antioxidant activity reflects the overall capacity of bioactive compounds in a food product to neutralize reactive species that can cause cellular damage.

Ripe melinjo peel contains a total anthocyanin content of 43.52 mg/L (Sani & Kunarto, 2017). Anthocyanins are flavonoid-derived compounds with antioxidant and antimicrobial activities (Nomer *et al.*, 2019). As antioxidants, anthocyanins act by donating hydrogen atoms to neutralize reactive oxygen species (ROS), including singlet oxygen, hydrogen peroxide, superoxide, hydroxyl, and peroxy radicals. This mechanism helps protect body cells from damage (Ifadah *et al.*, 2021). White turmeric contains curcumin, which acts as an antioxidant by neutralizing various reactive oxygen species (ROS), including nitric oxide (NO), hydrogen peroxide, and superoxide. In addition, curcumin inhibits lipid peroxidation processes (Sharifi-Rad *et al.*, 2020). The formula optimization process resulted in ten formulation combinations, which are presented in Table 2.

In the optimization process using Design-Expert version 13, melinjo peel and white turmeric were set with target ranges of 50–60% and 30–40%, respectively. Meanwhile, the two response variables, total flavonoid content and

antioxidant activity, were assigned a maximize goal to reach the highest values. The lower and upper limits for total flavonoid content ranged from 13.28 to 19.27 mg QE/g extract, while antioxidant activity ranged from 72.55 to 81.96% inhibition. All parameters were given equal importance, with a value of three. This indicates that all criteria were considered equally important in determining the optimal formulation of the herbal tea bags. The criteria for selecting the optimal formulation are presented in Table 3.

Table 2. Response measurements of the formulations

Run	Melinjo Peel (%)	White Turmeric (%)	Stevia Leaves (%)	Total Flavonoid Content (mg QE/g extract)	Antioxidant Activity (% inhibition)
1	52.5	37.5	10	13.28	72.55
2	56.6667	33.3333	10	15.97	77.32
3	55	35	10	15.13	76.03
4	50	40	10	19.16	81.83
5	57.5	32.5	10	15.63	76.80
6	60	30	10	17.65	80.15
7	60	30	10	17.87	80.32
8	60	30	10	17.76	80.28
9	53.3333	36.6667	10	13.61	75.77
10	50	40	10	19.27	81.96

Table 3. Criteria for optimal herbal tea bag formulation

Name	Goal	Lower Limit	Upper Limit	Importance
Melinjo peel (%)	In range	50	60	3 (+++)
White turmeric (%)	In range	30	40	3 (+++)
Total flavonoid (mg QE/g extract)	Maximize	13.28	19.27	3 (+++)
Antioxidant activity (% inhibition)	Maximize	72.55	81.96	3 (+++)

Based on the analysis of the formulation combinations, three optimal solutions were obtained, as presented in Table 4. Among these, the combination of 50% melinjo peel and 40% white turmeric showed the best results, with predicted total flavonoid content of 19.22 mg QE/g extract and antioxidant activity of 81.87% inhibition. This was due to the highest desirability value of 0.99 for this formulation. A desirability value close to 1 indicates that the optimization results closely align with the targeted responses (Engelen, 2015). Therefore, the first formulation in Table 4 was selected as the optimal formulation.

The selected optimal formulation was verified to ensure that the predicted values from the optimization process matched the actual laboratory measurements. The actual values for total flavonoid content and antioxidant activity were 19.17 mg QE/g extract and 82.93% inhibition, respectively. Both values fell within the 95% prediction interval (PI), indicating that the actual results were in agreement with the model predictions and confirming the accuracy and reliability of the selected formulation. The verification results are presented in Table 5.

Table 4. Optimal formulation solutions

No	Melinjo Peel (%)	White Turmeric (%)	Total Flavonoid (mg QE/g extract)	Antioxidant Activity (% inhibition)	Desirability	
1	50	40	19.22	81.87	0.99	Selected
2	60	30	17.76	80.26	0.78	
3	56.40	33.60	15.77	77.24	0.46	

Table 5. Verification of the selected optimal formulation

Response	Actual	Predicted	95% PI	
			Low	High
Total flavonoid (mg QE/g extract)	19.17	19.22	18.90	19.53
Antioxidant activity (% inhibition)	82.93	81.87	80.00	83.73

3.1.1. Optimization of Total Flavonoid Content in Herbal Tea Bags

Based on the test results, total flavonoid content ranged from 13.28 to 19.27 mg QE/g extract. Analysis using Design-Expert version 13 (DX13) indicated that a quartic model was most suitable for describing the total flavonoid response. ANOVA results at a 5% significance level showed a p -value of <0.0001 , indicating that the model was significant ($p < 0.05$) and adequately explained the data variation. The lack-of-fit value was 0.1919, indicating a non-significant result ($p > 0.05$); thus, the model did not significantly deviate from the experimental data and was considered acceptable.

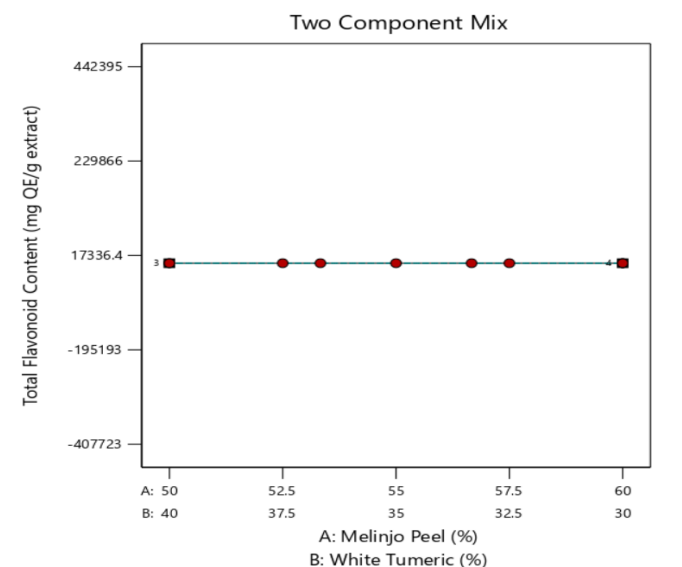


Figure 1. Total flavonoid content response of herbal tea bags

Flavonoids are naturally occurring compounds widely distributed in various parts of plants, including leaves, roots, fruits, peels, flowers, wood, and stems (Ningsih *et al.*, 2023). They belong to the phenolic group and are characterized by a basic structure consisting of a benzene ring substituted with hydroxyl ($-OH$) groups. These chemical features contribute to the biological activities of flavonoids, such as antioxidant, anti-inflammatory, antimutagenic, and anticarcinogenic effects (Khoirunnisa & Sumiwi, 2019). Due to these activities, flavonoids are considered important compounds in the development of a wide range of products, including foods, nutraceuticals, pharmaceuticals, medicines, and cosmetics.

3.1.2. Optimization of Antioxidant Activity in Herbal Tea Bags

Based on the test results, antioxidant activity ranged from 72.55 to 81.96% inhibition. Analysis using Design-Expert version 13 (DX13) indicated that a quartic model was most suitable for describing the antioxidant activity response (Figure 2). ANOVA results at a 5% significance level showed a p -value of 0.0009, indicating that the model was significant ($p < 0.05$) and adequately explained data variation. However, the lack-of-fit value of 0.0007 was significant ($p < 0.05$), suggesting that the model was not ideal for predictive purposes. Nevertheless, it could still be used for preliminary exploratory analysis to understand the patterns of relationships among variables.

Free radicals are atoms or molecules with one or more unpaired electrons, making them highly reactive and prone to stealing electrons from surrounding molecules (Najihudin *et al.*, 2017). Naturally, these compounds can be generated endogenously as by-products of various metabolic activities. Free radicals are not only produced within the body but can also be influenced by external factors, such as radiation, pesticide exposure through food, smoking, and air pollution (Mbaoji *et al.*, 2016). Excessive accumulation of free radicals can damage cells and tissues, increasing the risk of various diseases, including neurodegenerative disorders, diabetes mellitus, cardiovascular diseases, and cancer, as well as accelerating aging through oxidative stress (Phaniendra *et al.*, 2015).

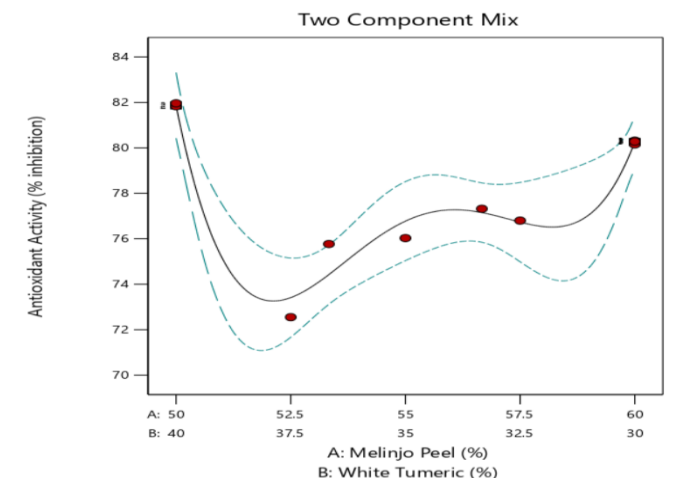


Figure 2. Antioxidant activity response of herbal tea bags (Dashed curves represent the 95% confidence interval of the predicted response)

To mitigate the negative effects of free radicals, antioxidant compounds capable of neutralization are required. Antioxidants neutralize free radicals by donating electrons, thereby stabilizing them and making them non-reactive, while also preventing chain reactions that could damage cells (Wahdaniah *et al.*, 2020). In herbal tea bags, antioxidant activity is related to the ability of bioactive compounds present in the ingredients, such as flavonoids, polyphenols, tannins, vitamin C, and other components, to neutralize free radicals. According to analysis results, the antioxidant activity of ripe melinjo peel dried at 65 °C for 4 h was 52.80% inhibition, white turmeric dried at 50 °C for 7 h showed 63.59% inhibition, and commercially dried stevia leaves exhibited 59.17% inhibition.

3.2. Sensory Profile Characterization of the Optimal Formula

Sensory profile characterization was performed on three herbal tea bag formulations: formula 144 (50% melinjo peel : 40% white turmeric : 10% stevia leaves), formula 198 (60% melinjo peel : 30% white turmeric : 10% stevia leaves), and formula 256 (56.40% melinjo peel : 33.60% white turmeric : 10% stevia leaves). These formulations were derived from the optimal solutions obtained during the formulation optimization stage using RSM. The characterization aimed to assess differences in sensory attributes resulting from the varying ingredient proportions in each formulation.

3.2.1. Panelist Profile

A total of 70 panelists residing in Banten Province participated in the sensory evaluation. The panelist group comprised 39% females and 61% males. In terms of age distribution, most panelists were between 20 and 50 years old: 54% were aged 20–30 years, 24% were 31–40 years old, and 22% were 41–50 years old.

3.2.2. Rate-All-That-Apply (RATA) Test for the Optimal Formula

Sensory profile characterization is a method used to identify and describe in detail the sensory characteristics of a food product, including taste, aroma, color, texture, and appearance. One widely used consumer-based method for characterizing sensory profiles in food products is the Rate-All-That-Apply (RATA) method (Munarko *et al.*, 2023). The RATA method not only identifies the sensory attributes perceived by consumers but also measures their intensity, providing more comprehensive and detailed information.

The sensory evaluation results obtained using the RATA method were analyzed via Principal Component Analysis (PCA) using XLSTAT software. PCA was employed to map the relationships between the samples and the sensory attributes assessed by the panelists. This analysis aimed to identify the attributes that contributed most to differentiating each herbal tea bag formulation and to examine the panelists' perceptions of each sample, as presented in the PCA biplot in Figure 3.

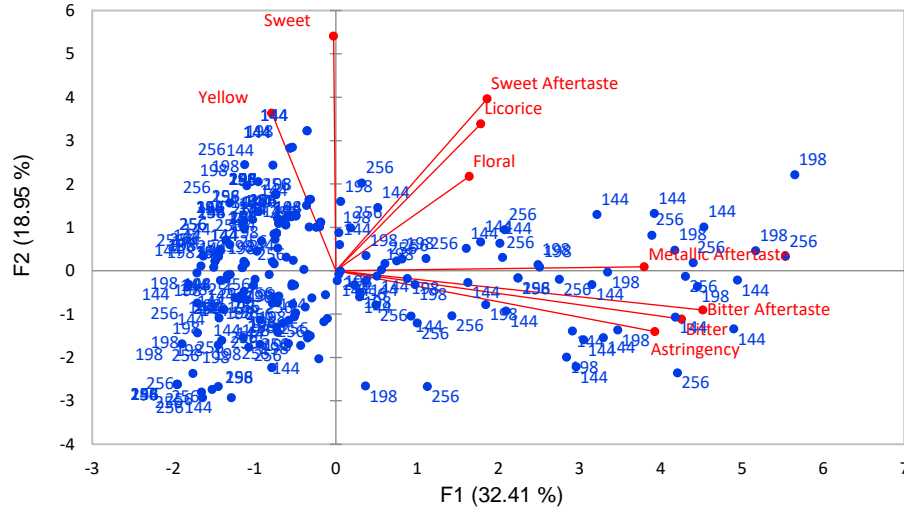


Figure 3. PCA biplot of the sensory profiles of the herbal tea bags

The positions of the attribute points in the PCA biplot reflect the correlations among the attributes. Attributes that are positioned close together and form an angle of less than 90° from the origin, or are located within the same quadrant, indicate a positive correlation. This means that an increase in the intensity of one attribute is likely accompanied by an increase in the intensity of the positively correlated attribute. Conversely, attributes that are positioned far apart and form an angle greater than 90° from the origin, or are located in different quadrants, indicate a negative correlation or no correlation. Figure 3 shows that product 144 is characterized by the attributes licorice, sweet, floral, bitter aftertaste, astringency, and metallic aftertaste. Product 198, although not having attributes within its own quadrant, is closely associated with bitter, sweet aftertaste, and yellow. Meanwhile, product 256 does not exhibit any dominant characteristic attributes.

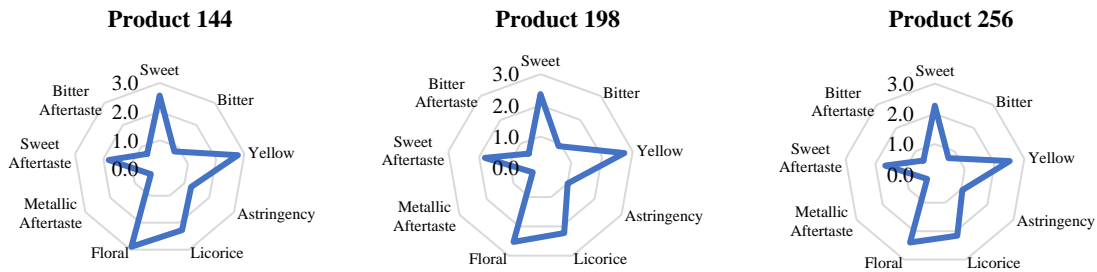


Figure 4. Spider web plot of product sensory attributes based on panelists' perceptions

The spider web chart in Figure 4 shows that product 144 exhibits prominent floral and sweet characteristics. This is influenced by its relatively high white turmeric content of 40% compared to the other products. The essential oils in white turmeric contain various monoterpenes such as eucalyptol, alpha-phellandrene, camphor, terpinolene, as well as sesquiterpenes (Siburian *et al.*, 2023). These compounds are aromatic and, at certain concentrations, can impart a light, fresh, and sweet scent. This combination is often associated with a floral aroma, contributing to the perception of the floral attribute, while the addition of stevia leaves enhances sweetness.

Product 198 showed higher values for the bitter and yellow attributes. This is due to its relatively high melinjo peel content of 60% compared to the other products. Ripe melinjo peel contains active compounds such as flavonoids, phenolics, alkaloids, saponins, and tannins (Eff *et al.*, 2016). Phenolic compounds can interact directly with bitter taste receptors on the tongue, producing a bitter sensation. White turmeric imparts a pale to bright yellow color, while

melinjo peel contains carotenoid pigments that contribute to reddish to yellow-green hues (Wahyuni *et al.*, 2017), resulting in a yellow-colored herbal tea infusion. Meanwhile, product 256 generally exhibited lower attribute values compared to the other products, particularly for sweet, floral, and licorice attributes, indicating that its formulation resulted in less pronounced taste and aroma characteristics.



Figure 5. Sensory wheel of herbal tea bags

The sensory wheel is a method used to map the various sensory attributes of a food product, making it easier to identify and describe the product’s characteristics using clear, consistent, and standardized terminology. Figure 5 illustrates four main attribute categories for the herbal tea bags: aroma (floral), color (yellow), taste (sweet, bitter, astringent, and licorice), and aftertaste (bitter aftertaste, sweet aftertaste, and metallic aftertaste).

3.2.3. Hedonic Rating Test of the Optimal Formula

In addition to identifying the intensity of each sensory attribute in a food product, information on consumer acceptance is also essential. Therefore, sensory attribute intensity assessment using the RATA method is generally conducted alongside consumer liking evaluation through the hedonic rating method. The hedonic rating test is used to measure consumers’ subjective responses regarding their level of liking or acceptance of a product (Adawiyah *et al.*, 2020). Combining these two evaluations provides insights into how each sensory attribute influences consumer perception and preference.

The parameters assessed in this study included the panelists’ overall liking, encompassing taste, aroma, infusion color, aftertaste, and mouthfeel. The results of the hedonic rating test for the herbal tea bags are shown in Figure 6. Product 144 achieved the highest mean score of 3.51, compared to product 198 (3.23) and product 256 (3.21), indicating that product 144 was the most preferred overall by the panelists. The hedonic rating is showed in Figure 6.

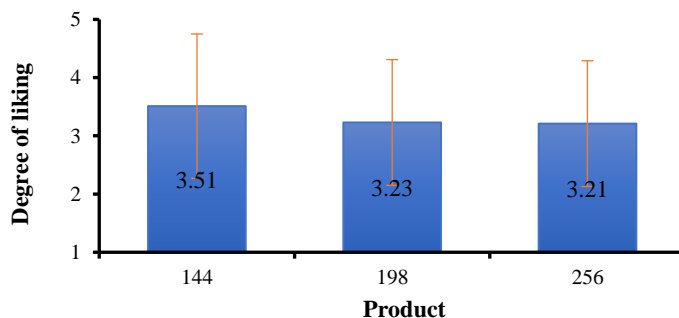


Figure 6. Hedonic rating graph of the optimal formulation

3.2.4. Panelists' Preference Map for Herbal Tea Bags

The hedonic test also aims to determine panelists' level of preference for a product by performing cluster analysis to identify patterns of liking. This method groups panelists based on similarities in their perceptions of different food products. One commonly used clustering method in sensory data analysis is hierarchical cluster analysis, which can be performed using XLSTAT software. This analysis can support product development by addressing the preferences of more specific panelist groups. The results of panelist clustering based on liking of the herbal tea bags are presented in Table 6. The panelists were divided into three clusters. Cluster 1 had the highest preference for product 256, with a score of 3.22. Cluster 2 showed the highest preference for product 144, with a score of 4.35. Meanwhile, Cluster 3 also demonstrated the highest preference for product 144, with a score of 4.14.

Table 6. Panelist clustering based on agglomerative hierarchical analysis (AHC)

Class	144	198	256
Cluster 1	2.81	3.14	3.22
Cluster 2	4.35	2.95	3.45
Cluster 3	4.14	3.86	2.86

Internal Preference Mapping (IPM) is used to visualize the position of each cluster relative to the products based on liking data. IPM relies solely on panelists' preference data, without incorporating the products' descriptive attribute data. This method can help determine the positioning of products and the direction of preference for individual panelists or groups. The results of the IPM biplot for the herbal tea bags are shown in Figure 7.

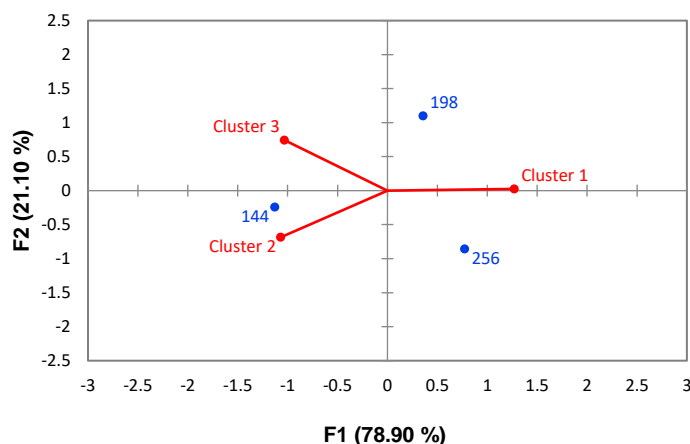


Figure 7. Biplot of internal preference mapping for herbal tea bags

Figure 7 shows that Cluster 1 is positioned very close to product 256, Cluster 2 aligns with product 144, and Cluster 3 aligns with product 144. Overall, product 144 is closest to the directions of two clusters (Cluster 2 and Cluster 3), indicating that it is preferred by the majority of panelists.

4. CONCLUSION

The selected herbal tea bag formula consists of 50% melinjo peel, 40% white turmeric, and 10% stevia leaves. This formula exhibited a total flavonoid content of 19.17 mg QE/g extract and an antioxidant activity of 82.93% inhibition. The herbal tea bag is characterized by the sensory attributes licorice, sweet, floral, bitter aftertaste, astringency, and metallic aftertaste, and achieved an average overall liking score of 3.51 (liked). Further nutritional analysis is recommended to determine the macro- and micronutrient composition of the herbal tea bag based on melinjo peel and white turmeric.

AUTHOR CONTRIBUTION STATEMENT

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
ALR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
DH	✓	✓		✓						✓		✓	✓	
NDY	✓	✓		✓						✓		✓	✓	

C: Conceptualization	Fo: Formal Analysis	O: Writing - Original Draft	Fu: Funding Acquisition
M: Methodology	I: Investigation	E: Writing - Review & Editing	P: Project Administration
So: Software	D: Data Curation	Vi: Visualization	
Va: Validation	R: Resources	Su: Supervision	

REFERENCES

- Adawiyah, D.R., Tjiptoputri, O.M., & Lince. (2020). Profil sensori sediaan pemanis dengan metode rate-all-that-apply (rata). *Jurnal Mutu Pangan : Indonesian Journal of Food Quality*, 7(1), 38–45. <https://doi.org/10.29244/jmpi.2020.7.1.38>
- Adhityasmara, D., & Advistasari, Y.D. (2021). Efek pemberian mikroenkapsulasi ekstrak kulit melinjo (*Gnetum gnemon* L.) terhadap kadar SGOT dan SPGT tikus putih jantan galur wistar yang di induksi isoniazid. *Jurnal Ilmiah Cendekia Eksakta*, 6(2), 66–71. <https://doi.org/10.31942/ce.v6i2.5521>
- Ardiansyah. (2024, January 4). *Industri teh Indonesia menuju "sunset"?*. DetikNews. Jakarta. Retrieved from <https://news.detik.com/kolom/d-7120837/industri-teh-indonesia-menuju-sunset>
- Alfiyah, Kusrina, T., & Muntoha, N. (2024). Pengaruh metode fokus group discussion dan perilaku inovatif guru paud terhadap pengembangan modul ajar kurikulum merdeka. *Journal of Education Research*, 5(1), 3003–3014. <https://doi.org/10.37985/jer.v5i3.1393>
- Apriliyanti, M.W., Ardiansyah, M., Sholehah, E., & Santoso, A. (2021). Antioxidant activity and sensory properties in packaged beverages with melinjo peel, mint leaves, and stevia leaves formulations. *IOP Conference Series: Earth and Environmental Science*, 672(1), 1–8. <https://doi.org/10.1088/1755-1315/672/1/012067>
- Artati, Widarti, Hasan, Z.A., & Askar, M. (2024). Aktivitas antioksidan dari tiga fraksi pelarut ekstrak daun dandang gendis (EDDG). *Jurnal Media Analis Kesehatan*, 15(2), 132–139. <https://doi.org/10.32382/jmak.v15i2.1159>
- Badan Pusat Statistik. (2014). *Statistik Produksi Hortikultura Tahun 2014*. BPS – Statistics Indonesia, Jakarta, Indonesia.
- Badan Pusat Statistik. (2025). *Produksi tanaman buah-buahan dan sayuran tahunan menurut kabupaten/kota dan jenis tanaman di Provinsi Banten, 2024*. BPS – Statistics Indonesia Provinsi Banten.
- Dusun, C.C., Djarkasi, G.S.S., & Tuju, T.D.J. (2017). Kandungan polifenol dan aktivitas antioksidan teh dun jamu biji (*Psidium guajava* L). *Cocos*, 9(2), 1–15.
- Eff, A.R.Y., Rahayu, S.T., & Syachfitri, R.D. (2016). Uji aktivitas penghambatan xantin oksidase secara in-vitro oleh isolat 6,4'-dihidroksi-4-metoksibenzofenon-2-O-β-D glukopiranosida (C20 H22O1) yang diisolasi dari mahkota dewa (*Phaleria macrocarpa* (Scheff.) Boerl). *Pharmaceutical Sciences and Research*, 3(1), 1–11. <https://doi.org/10.7454/psr.v3i1.3213>
- Engelen, A. (2015). Optimasi proses dan formula pada karakteristik kelengketan mi sagu. *Jurnal Technopreneur (JTech)*, 3(1), 40–47.
- Fatimatuzzahroh, D., Kunarto, B., & Pratiwi, E. (2020). Lama ekstraksi kulit melinjo merah (*Gnetum gnemon* L.) berbantu gelombang ultrasonik menggunakan pelarut etil asetat terhadap likopen, Î2-Karoten dan aktivitas antioksidan. *Jurnal Teknologi Pangan Dan Hasil Pertanian*, 15(2), 41–49. <https://doi.org/10.26623/jtphp.v15i2.2664>
- Harahap, A.D., Efendi, R., & Harun, N. (2016). Pemanfaatan ekstrak jahe merah (*Zingiber officinale* var. Rubrum) dan kulit nanas (*Ananas comosus* L. Mer) dalam pembuatan bubuk instan. *Jurnal Online Mahasiswa Faperta*, 3(2), 1–16.
- Ifadah, R.A., Wiratara, P.R.W., & Afgani, C.A. (2021). Ulasan ilmiah: antosianin dan manfaatnya untuk kesehatan. *Jurnal Teknologi Pengolahan Pertanian*, 3(2), 11–21. <https://doi.org/10.35308/jtpp.v3i2.4450>
- Khoirunnisa, I., & Sumiwi, S.A. (2019). Review artikel: peran flavonoid pada berbagai aktifitas farmakologi. *Farmaka*, 17(2), 131–142. <https://jurnal.unpad.ac.id/farmaka/article/view/21922>
- Listiana, A., & Herlina. (2015). Karakterisasi minuman herbal celup dengan perlakuan komposisi jahe merah : kunyit putih, dan jahe merah : temulawak. *AGRITEPA*, 1(2), 171–181. <https://doi.org/10.37676/agritepa.v2i1.105>

- Malahayati, N., Widowati, T.W., & Febrianti, A. (2021). Karakterisasi ekstrak kurkumin dari kunyit putih (*Kaemferia rotunda* L.) dari kunyit putih (*Curcuma domestica* Val.). *AgriTECH*, *41*(2), 134–144. <https://doi.org/10.22146/agritech.41345>
- Malipeddi, H., Ranjitha, A., Ramana, M.V., Anand, M., & Karigar, A. (2010). Phytochemical screening and antioxidant activity of rhizome part of *Curcuma zedoaria*. *International Journal of Research in Ayurveda & Pharmacy*, *1*(2), 414–417.
- Mbaoji, F.N., Ezike, A.C., Nworu, C.S., Onyeto, C.A., Nwabunike, I.A., Okoli, I.C., & Akah, P.A. (2016). Antioxidant and hepatoprotective potentials of *Stemonocoleus micranthus* harms (Fabaceae) stem bark extract. *International Journal of Pharmacy and Pharmaceutical Sciences*, *8*(7), 47–51.
- Munarko, H., Jariyah, J., & Kurnianto, M.A. (2023). Profilin atribut sensori kukis nastar menggunakan metode rate-all-that-apply (rata). *Gorontalo Agriculture Technology Journal*, *6*(2), 55–64. <https://doi.org/10.32662/gatj.v0i0.2711>
- Najihudin, A., Chaerunisaa, A., & Subarnas, A. (2017). Aktivitas antioksidan ekstrak dan fraksi kulit batang trengguli (*Cassia fistula* L) dengan metode DPPH. *Indonesia Journal of Pharmaceutical Science and Technology*, *4*(2), 70–78. <https://doi.org/10.15416/ijpst.v4i2.12354>
- Ningsih, I.S., Chatri, M., Advinda, L., & Violita. (2023). Senyawa aktif flavonoid yang terdapat pada tumbuhan. *Serambi Biologi*, *8*(2), 126–132. <https://doi.org/10.21082/jlitri.v8n2.2002.61-66>
- Nomer, N.M.G.R., Duniaji, A.S., & Nocianitri, K.A. (2019). Kandungan senyawa flavanoid dan antosianin ekstrak kayu secang (*Caesalpinia sappan* L.) serta aktivitas antibakteri terhadap *Vibrio cholerae*. *Jurnal Ilmu dan Teknologi Pangan*, *8*(2), 216–225. <https://doi.org/10.24843/itepa.2019.v08.i02.p12>
- Phaniendra, A., Jestadi, D.B., & Periyasamy, L. (2015). Free radicals: properties, sources, targets, and their implication in various diseases. *Indian Journal of Clinical Biochemistry*, *30*(1), 11–26. <https://doi.org/10.1007/s12291-014-0446-0>
- Pratiwi, Y.S., Sanjaya, Y.A., Rahmawati, Putri, L.A.H.H., & Syari, R.M. (2024). Pengaruh formulasi teh herbal perikarp manggis (*Garcinia mangostana*), kayu manis (*Cinnamon verum*), dan cengkeh (*Syzygium aromaticum*) terhadap tingkat penerimaan konsumen. *Amert Nutrition*, *8*(1), 1–7. <https://doi.org/10.20473/amnt.v8i1.2024.1-7>
- Sani, E.Y., & Kunarto, B. (2017). Ekstraksi antosianin kulit melinjo merah dan stabilitas warnanya pada berbagai lama pemanasan. *Jurnal Pengembangan Rekayasa dan Teknologi*, *1*(2), 33–36. <https://doi.org/10.26623/jprt.v13i2.928>
- Saragih, R., Husein, G.H., Tamizi, E., Yuli Amalia, & Latifa, H. (2018). Karakteristik teh kulit melinjo warna merah dan hijau. In *Prosiding Technopex-2018* (pp. 352–358). Institut Teknologi Indonesia
- Sharifi-Rad, J., El Rayess, Y., Abi Rizk, A., Sadaka, C., Zgheib, R., Zam, W., Sestito, S., Rapposelli, S., Neffe-Skocińska, K., Zielińska, D., Salehi, B., Setzer, W.N., Dosoky, N.S., Taheri, Y., El Beyrouthy, M., Martorell, M., Ostrander, E.A., Suleria, H. A.R., Cho, W.C., Maroyi, A., & Martins, N. (2020). Turmeric and its major compound curcumin on health: Bioactive effects and safety profiles for food, pharmaceutical, biotechnological and medicinal applications. *Frontiers in Pharmacology*, *11*, 1021. <https://doi.org/10.3389/fphar.2020.01021>
- Sibirian, H.N.I., Nugroho, W., & Ayuhecacia, N. (2023). Formulasi dan stabilitas mutu fisik lilin aromaterapi dari minyak atsiri kunyit putih (*Curcuma zedoaria* Rosc.) sebagai antinyamuk menggunakan pigmen warna Belawan merah (*Tristanopsis merguensis* Griff.). *Bohr: Jurnal Cendekia Kimia*, *2*(1), 15–25.
- Sinuhaji, A.K.B., Darmayanti, L.P.T., & Yusasrini, N.L.A. (2023). Pengaruh penambahan daun stevia (*Stevia rebaudiana* Bertoni) terhadap karakteristik teh celup herbal temu putih (*Curcuma zedoaria* (Berg.) Roscoe). *Jurnal Ilmu dan Teknologi Pangan (ITEPA)*, *12*(3), 480–490. <https://doi.org/10.24843/itepa.2023.v12.i03.p01>
- Wahdaniah, Erika, M., & Purwaningsih, I. (2020). Aktivitas antioksidan fraksi metanol daun jeringau merah (*Acorus* sp.) metode DPPH. *Jurnal Laboratorium Khatulistiwa*, *4*(1), 26–33.
- Wahyuni, S., Rais, M., & Fadilah, R. (2017). Fortifikasi tepung kulit melinjo sebagai pewarna alami pada pembuatan kerupuk singkong. *Jurnal Pendidikan Teknologi Pertanian*, *3*(2), 212–222.