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Nutritional Investigation, LC-MS-Based Phytochemical Profiling, and Antioxidant Assay of Two Edible Flowers

Kuswati Kuswati[1*], Aliza Zahro[1], Nadhiratuzzahra Alifiah Daud[1], Erlia Narulita[1], Yayuk Fatmawati[2]

[1]*Biology Education Study Program, Faculty of Teacher Training and Education, University of Jember, Jember 68121, Indonesia*
[2]*College of Bioscience and Biotechnology, Chungnam National University, Daejeon 34134, South Korea*

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ABSTRACT

Two commonly consumed, yet under-researched, edible flowers—*Malvaviscus arboreus* (Topi Turki) and *Acmella paniculata* (Jotang)—were comprehensively analyzed to assess their potential as functional food sources. This study investigated their nutritional content, phytochemical profiles, antioxidant activity, and organoleptic properties. Our methodology, conducted between July and December, 2024, involved a multi-faceted approach—proximate analysis quantified ash, moisture, protein, fat, fiber, carbohydrates, and total energy. Freeze-dried samples underwent LC-MS for phytochemical identification, and antioxidant activity was determined using the DPPH assay. Organoleptic preferences were evaluated through a hedonic test where 30 panelists rated color, aroma, taste, and overall acceptance. Key findings revealed distinct differences. *A. paniculata* presented higher protein (18.75%), fat (21.71%), and fiber (24.10%), leading to a greater total energy (213.84 kcal/50g). In contrast, *M. arboreus* showed higher moisture (21.22%) and carbohydrates (48.12%). Phytochemical profiling by LC-MS indicated that *M. arboreus* contained 51 phytochemicals, primarily phenolics (13.52%), while *A. paniculata* had a remarkable 170 phytochemicals, dominated by alkaloids (2.94%). Importantly, *M. arboreus* demonstrated superior antioxidant activity (IC_{50} 92.74 µg/mL, strong) compared to *A. paniculata* (IC_{50} 156.95 µg/mL, weak) in the DPPH assay. Organoleptically, *M. arboreus* was preferred for its color, taste, and overall acceptability, with no significant difference in aroma. Overall, both *M. arboreus* and *A. paniculata* exhibit promising nutritional value and bioactive potential for functional food applications. This research highlights the significant potential of these edible flowers to diversify plant-based diets and contribute to the development of novel health-promoting products. Future research should focus on optimizing processing techniques and exploring diverse food applications to maximize their utilization.

1. Introduction

Edible flowers (EFs) offer more than just beauty; they possess significant nutritional value and bioactive compounds (Kumari & Bhargava 2021). For centuries, EFs have been integral to culinary and medicinal practices, serving as natural colorants and flavor enhancers. They are safe to consume, whether fresh or processed (Takahashi *et al*. 2020; Kresnapati *et al*. 2022; Bayyinah *et al*. 2022). Notably, the array of phytochemicals found in EFs—including flavonoids,

*Corresponding Author
E-mail Address: kuswati.fkip@unej.ac.id.

phenolics, alkaloids, and terpenoids—has spurred considerable research investigating their potential antioxidant, anti-inflammatory, and anticancer properties (Takahashi *et al*. 2020; Kumari & Bhargava 2021).

Indonesia's rich biodiversity presents significant potential for exploring local edible flowers (EFs). Past research highlights the versatile use of various EF species in dishes like vegetables, beverages, infused water, and salads (Prabawati *et al*. 2021; Saputra *et al*. 2022; Zen *et al*. 2022). Specifically, Jember District is home to wild EFs, such as Topi Turki (*Malvaviscus arboreus*) and Jotang (*Acmella paniculata*) (Figure 1), that are currently underutilized. These species are particularly interesting due to their abundance and the presence of diverse bioactive compounds with pharmacological properties. For example, Topi Turki is reported to contain flavonoids, tannins, coumarins, phenolic compounds, terpenoids, emodin, and anthocyanins (Gazwi *et al*. 2022), while Jotang is rich in monoterpene hydrocarbons, oxygenated monoterpenes, and sesquiterpene hydrocarbons (Subashree *et al*. 2024).

Growing awareness of healthy lifestyles has increased interest in using edible flowers (EFs), particularly *Malvaviscus arboreus* (Topi Turki) and *Acmella paniculata* (Jotang), as ingredients in functional foods. Utilizing EFs holds significant potential to diversify local plant-based food sources, thereby enhancing food security and facilitating the development of bioresource-derived products (Fernandes *et al*. 2020; Das *et al*. 2024). Nutritional analysis, also known as proximate testing, is crucial for assessing the feasibility of using EFs in functional foods (Prabawati *et al*. 2021; Hegde *et al*. 2023). The tea market offers a substantial opportunity for EFs; as the second most popular drink globally after water, the rising demand for natural, healthy lifestyles has made flower teas (also known as herbal products) a hot commodity. Comprehensive analysis and test data can provide empirical evidence to support the efficacy of these flowers and generate new market opportunities (Kong *et al*. 2024; Maciejewski *et al*. 2024). Consequently, sensory evaluation of Topi Turki and Jotang flower teas is essential for market acceptance (García-Gómez *et al*. 2022).

To scientifically determine the potency and safety of edible flowers (EFs), an in-depth understanding of their phytochemical profile is crucial. Metabolite profiling using liquid chromatography-mass spectrometry (LC-MS) is an ideal method for comprehensively identifying and characterizing these compounds (Zeki *et al.* 2020; Raza 2022). LC-MS particularly aids in identifying bioactive compounds like flavonoids and polyphenols, which studies have shown are involved in various biological activities. The cornerstone of sustainable EF use lies in the nutrients and active compounds they provide that contribute to health. Therefore, integrating nutritional and phytochemical analysis methodologies offers a comprehensive perspective on their nutritional potential and safety, facilitating the development of functional food products from EFs. Utilizing untargeted metabolomics with LC-MS will enable the determination of the distribution and relative abundance of metabolites in flower samples, establishing a foundation for substantial bioactivity

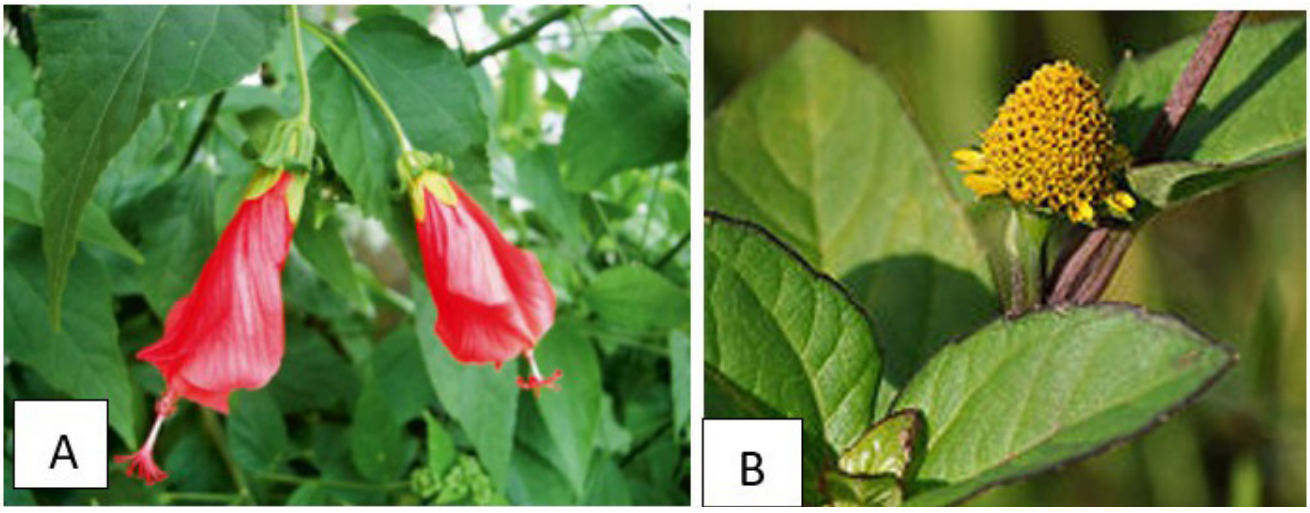

Figure 1. Edible flowers (A) *Malvaviscus arboreus*, (B) *Acmella paniculata*

testing. For instance, the antioxidant bioactivity of both flowers was confirmed using the DPPH method.

Against this background, the present study aims to investigate the nutritional content of *Malvaviscus arboreus* (Topi Turki) and *Acmella paniculata* (Jotang), profile their phytochemicals using LC-MS, and analyze their antioxidant activity. Specifically, using a metabolomics approach, we will identify and compare the phytochemical compounds and antioxidant activity in both flowers. The study will also analyze their nutritional content through proximate testing and evaluate organoleptic preference when brewed as tea. The findings are expected to provide comprehensive information on the nutritional value, health potential, and consumer acceptance of these two types of local edible flowers, particularly as tea from Jember Regency.

2. Materials and Methods

2.1. Flower Collection and Sample Preparation

Topi Turki (*M. arboreus*) and Jotang (*A. paniculata*) flowers were collected from several locations across Jember Regency. To ensure freshness, we harvested only flowers in full bloom, characterized by their bright color and visible pistils and stamens, and immediately stored them in ice boxes. Upon collection, the flowers were sorted, separating only the petals for processing. These petals were then thoroughly washed. The freeze-drying process began by freezing the samples at -20°C for 24 hours, followed by drying at 30°C. Next, we pulverized and sieved the dried samples (50 mesh, ASTM standard) to achieve a fine powder with a particle size of less than 300 µm. We prepared 50g of powder from each sample and stored it in an airtight container at 4°C (Navarro-González *et al*. 2014; Hegde *et al*. 2023).

2.2. Proximate Analysis

We subjected the fine powder samples to proximate testing at the DUDRG (Drug Utilization Discovery Research Group) Lab, Faculty of Pharmacy, University of Jember. These tests, adhering to AOAC (2016) standards, provided comprehensive nutritional information, including ash content, moisture content, crude protein, crude fat, crude fiber, carbohydrates, and total energy.

2.2.1. Ash Content

We determined Ash content by weighing a 2g sample in a pre-dried and pre-weighed porcelain cup. The sample was then oven-dried at 105°C for four hours. After cooling in a desiccator for 15 minutes, the cup and residue were re-weighed. The final moisture content was calculated from the weight difference before and after drying (AOAC 2016 2.7.08, 967.05; Das *et al*. 2024).

$$\text{Ash content} = \frac{\text{Weight of ash residue}}{\text{Weight of original samples}} \times 100\%$$

2.2.2. Moisture Content

To quantify moisture content, we first oven-dried an aluminium cup for about 30 minutes and then weighed it. We then precisely weighed a 3-gram sample and transferred it to the cup. The sample was baked in an oven at 105°C for four hours, cooled in a desiccator for 15 minutes, and then the final weight was measured, following AOAC (2016, 2.7.03, 967.03) protocols. Moisture content was estimated using the following equation (AOAC 2016; Das *et al*. 2024).

$$\text{Moisture content} = \frac{\text{Dried samples weight}}{\text{Intial weight}} \times 100\%$$

2.2.3. Crude Protein

The Kjeldahl method (IKA-B.005) is used to determine protein content. First, 0.2 g of the dried flower powder sample is placed in a Kjeldahl flask. Then, 0.25-0.50 g of selenium mixture and 5 mL of concentrated sulfuric acid (H_2SO_4) are added. The decomposition process was carried out gradually at a temperature between 150 and 350°C for 3 to 3.5 hours, until the solution became clear. After cooling, the solution was analyzed using the Vapodest 50s tool (Gerhardt) with the following parameters: H_2O, 22 mL; addition of NaOH, 57 mL; reaction time, 30 seconds; distillation time, 4 minutes; steam power, 100%; addition of H_3BO_3, 37 mL; suction sample, 30 seconds; suction receiver, 30 seconds; titration and calculation, automatic. The analysis results were used to calculate the total nitrogen content, which was then converted to protein content.

$$\%\ \text{Nitrogen} = \frac{(V\text{-}Vb) \times C\ HCl \times 14.008 \times 100}{\text{Sample weight}}$$

V : Volume of titrant for sample;
Vb : Volume of titrant for blank sample;
14.008 : Atomic weight of nitrogen

The crude protein percentage was calculated using the following equation (AOAC 2016).

$$\% \text{ Protein} = \% \text{ Nitrogen} \times 6.25$$

2.2.4. Crude Fiber

We determined crude fiber content using the Chesson-Datta method. First, 1 gram of the fine powder sample was reacted with 50 mL of a 1.25% H_2SO_4 solution and heated at 200°C for 30 minutes. Then, 50 mL of a 3.25% NaOH solution was added, and the mixture was heated for another 30 minutes. The mixture was subsequently filtered using a Büchner funnel. The remaining residue was then successively washed with dilute H_2SO_4, warm distilled water, and 96% alcohol. Finally, the residue was dried in an oven at 105°C for four hours, cooled in a desiccator for 15 minutes, and weighed to determine the crude fiber content (Das *et al*. 2024).

$$\text{Crude Fiber} = \frac{\text{Dry weight}}{\text{Sample weight}}$$

2.2.5. Crude Fat

We determined crude fat content using the Soxhlet method with a 6-place Soxhlet tool (Gerhardt), following SNI 06-6989.10-2014 standards. To do this, one gram of dried flower powder was wrapped in filter paper and placed in an extraction sleeve. We then extracted the fat using heated petroleum benzene solvent, which cyclically flowed through the sample at temperatures from 350°C to boiling for 4-6 hours. After extraction, the solvent in the flask was distilled off. The flask was then dried in an oven at 105°C for 30 minutes, cooled in a desiccator, and weighed until it reached a constant weight. This constant weight determined the crude fat content. The fat content percentage was calculated using the following formula (Hegde *et al*. 2023; Das *et al*. 2024).

$$\text{Crude fat Percentage} = \frac{\text{Final fat weight} - \text{Initial flask weight}}{\text{Sample weight}}$$

2.2.6. Carbohydrate

Carbohydrate content was calculated using the difference method. This involved subtracting the proportions of water, ash, crude fat, and crude protein content from the total dry matter of each flower sample. The results were then used in the following equation (AOAC 2016; Rachkeeree *et al*. 2018).

$$\text{Carbohydrate Content} = 100 - (\% \text{ water} + \% \text{ ash} + \% \text{ crude protein} + \% \text{ crude fat})$$

2.2.7. Total Energy

We determined the total energy of each flower sample by summing the energy contributions from crude protein, fat, and carbohydrates, expressed in kcal/100 g. The conversion factors used were: protein = 4 kcal/g; fat = 9 kcal/g; and carbohydrates = 4 kcal/g. This calculation followed the equation provided by AOAC (2016) and Rachkeeree *et al*. (2018).

$$\text{Total Energy} = (\text{crude protein} \times 4) + (\text{crude fat} \times 9) + (\text{carbohydrate} \times 4)$$

2.3. Phytochemical Profiling

Both flower samples were extracted using 70% methanol at a 1:15 sample-to-solvent ratio (Hegde *et al*. 2023). The resulting solution sat in the dark for 30 minutes before being centrifuged at 4,500 rpm for 15 minutes (Hegde *et al*. 2023), yielding pellet and supernatant fractions. The supernatant was then separated from the pellet and stored at 4°C for subsequent analysis. Phytochemical compounds were identified using a UHPLC-Q Exactive Plus Orbitrap MS (LC-MS) instrument equipped with biphenyl reversed-phase LC columns. The mobile phase consisted of UHPLC-grade deionized water with 0.1% formic acid and acetonitrile with 0.1% formic acid. We set the column temperature at 30°C to enhance compound separation stability and reproducibility, and the autosampler temperature was maintained at 8°C to stabilize the sample before injection. HRMS analysis was performed using predetermined parameters to acquire high-accuracy mass data. Compound identification was achieved by comparing the mass spectra against three digital libraries: ChemSpider, Metabolica, and mzCloud.

2.4. Hedonic Test

Organoleptic surveys are crucial for evaluating the attractiveness and quality of edible flowers for tea brewing. This assessment uses a hedonic test to gauge consumer preferences (Ana *et al.* 2017). For the test, 1 gram samples of fine powder from both *M. arboreus* (Topi Turki) and *A. paniculata* (Jotang) were packed into separate tea bags. Each tea bag was brewed with 250 mL of water at 75°C for 9 minutes (Kushargina *et al*. 2022). Consumers then assessed the tea based on taste, aroma, color, and overall acceptability (Table 1). The assessment involved 30 healthy panelists, aged 18-33 years, who were potential consumers capable of providing hedonic evaluations (Qamariah *et al.* 2022; Wangiyana & Triandini 2022; Firmansyah *et al*. 2024).

Each panelist received two types of tea (Figure 2), drinking water for palate cleansing, and a rating sheet (Noviatri *et al.* 2020). A 5-level hedonic scale was used for evaluation: (1) strongly dislike, (2) moderately dislike, (3) neutral, (4) moderately like, and (5) strongly like (Lim 2011; Kushargina *et al*. 2022; Triandini & Wangiyana 2022).

2.5. Antioxidant Assay

We assessed antioxidant activity using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. This involves reacting the samples with a DPPH solution and then measuring the absorbance at the maximum wavelength using UV-Vis spectroscopy. DPPH produces a dark purple color with maximum absorption at 517 nm. This method relies on the reaction between the DPPH solution and antioxidant compounds, where the antioxidant compounds donate hydrogen atoms to the DPPH solution (Kaneko *et al*. 2022).

In this study, extract samples were tested at volumes of 10, 20, 30, and 40 µL. Ascorbic acid (20 ppm) was used as the positive control. A 0.1 mM DPPH solution in methanol was mixed with each extract concentration and incubated in the dark at room temperature for 30 minutes. The absorbance was then measured at 517 nm using a UV-Vis spectrophotometer. Antioxidant activity was expressed as the percentage of DPPH radical inhibition, and IC_{50} values were calculated based on regression analysis (Rahman *et al*. 2025). All step-by-step diagrammatic procedures are shown in Figure 4.

3. Results

3.1. Nutritional Contents of Two Edible Flowers

Proximate analysis, a fundamental method for determining food composition, provides essential preliminary data on the nutritional potential of ingredients, including their ash, water, protein, fat, fiber, carbohydrate, and total energy content. Our study applied this analysis to two local edible flowers, *Malvaviscus arboreus* (Topi Turki) and *Acmella paniculata* (Jotang), with the results detailed in Table 2. *A. paniculata* and *M. arboreus* exhibit

Table 1. Organoleptic survey assessment instrument

Name/ age :
Product : Brewed Tea from Edible Flower
Methods : A sample of brewed-water from 2 different types of edible flowers will be served. Evaluation is done by giving a score for each parameter aroma, colour, taste, and overall acceptance, using the attached rating scale.

Tea brewed	Parameter				Total score
	Color	Taste	Aroma	Overall acceptenace	
Malvaviscus arboreus					
Acmella paniculata					

Rating scale, 1 : strongly dislike; 2 : moderately dislike; 3 : neutral; 4 : moderately like; 5 : strongly like. (Modified form Cempaka *et al*.2020)

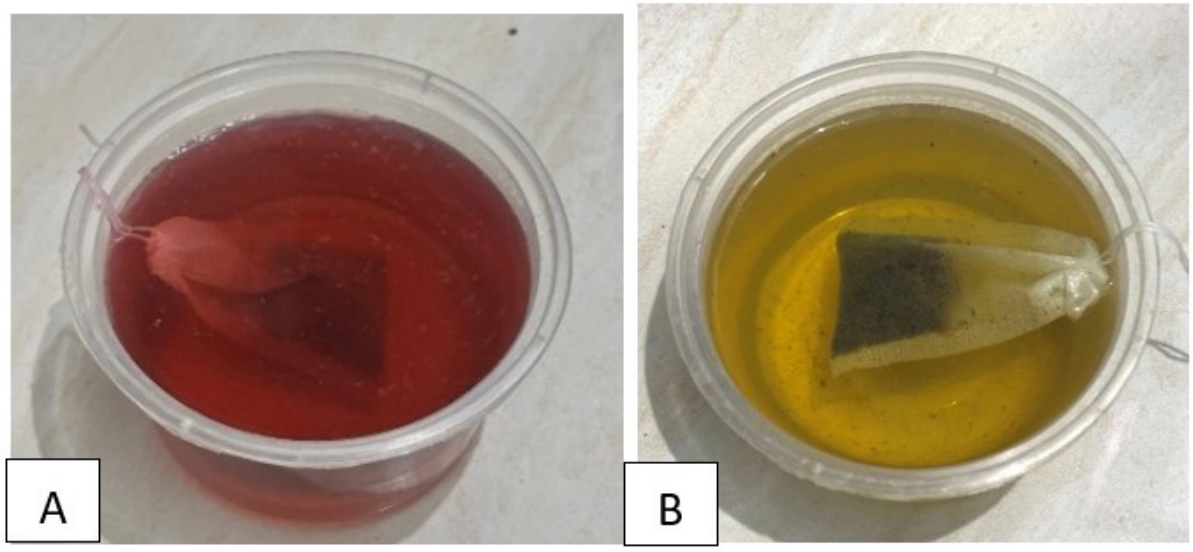

Figure 2. The tea of edible flowers (A) *Malvaviscus arboreus*, (B) *Acmella paniculata*

distinct nutritional profiles. *A. paniculata* consistently showed higher levels of ash, protein, fat, and fiber, surpassing some National Indonesian Standards (SNI), which contributes to its higher energy value. Conversely, *M. arboreus* contained higher moisture and carbohydrate levels, with its moisture content exceeding established standards. These differences suggest that *A. paniculata* is better suited for high-protein and fiber applications, while *M. arboreus* is more appropriate for beverages. The strategic combination of these two flowers holds potential for developing novel functional foods.

3.2. LC-MS-Based Phytochemical Profiling

The phytochemical profiles of both edible flowers revealed a diverse array of components, with 51 metabolites identified in *M. arboreus* flowers and 170 in *A. paniculata*. Table 3 summarized a detailed categorization of these metabolites. Phenolic compounds were the most abundant in *M. arboreus*, while organic compounds predominated in *A. paniculata*. A comparative analysis of secondary metabolite (phenolic, terpenoid, alkaloid) shows that *M. arboreus* flowers contain 20 phytochemicals, closely comparable to the 19 phytochemicals found in *A. paniculata* (Jotang) flowers (Table 4).

3.3. Survey Organoleptic

An organoleptic test using hedonic scaling was conducted to assess consumer preference for tea *M. arboreus* and *A. paniculata* (Jotang) (Figure 3). *M. arboreus* scored highest in color (4.53 vs. 3.60 for Jotang), while both teas received a similar mean score of 3.63 for aroma. Consumers significantly preferred *M. arboreus* in taste (3.63 vs. 2.90 for Jotang), primarily due to its natural sweetness, contrasting with Jotang's inherent bitterness. Consequently, *M. arboreus* achieved a higher overall acceptance score (4.23 vs. 3.07 for Jotang), underscoring the importance of color and taste in influencing preferences for herbal drinks. While *M. arboreus* shows more immediate potential as a herbal drink, *A. paniculata*, despite its lower acceptance due to bitterness and color, could be strategically positioned as a health supplement given its nutrient content. This suggests that both flowers possess distinct market potential with appropriate product development and marketing strategies.

Table 2. Proximate analysis result

Nutritions	*Malvaviscus arboreus* (%)	*Acmella paniculata* (%)
Ash content (3g)	7.23±0.08[a]	8.85±0.09[b]
Water Content (3g)	21.22±0.04[a]	11.36±0.01[b]
Protein (0.2g)	12.60±0.09[a]	18.75±0.24[b]
Fat (1g)	10.82±0.20[a]	21.71±0.18[b]
Fiber (1g)	17.86±0.29[a]	24.10±0.81[b]
Carbohydrate (%)	48.12±0.41[a]	39.33±0.50[b]
Total energi (kcal)	170.14±0.28[a]	213.84±0.29[b]

Data are expressed as percentages from 2 repetitions (mean ± sd). Letters a and b in the data indicate a significant difference ($p<0.05$) within the same row

3.4. Antioxidant Activities

The DPPH assay revealed that Topi Turki (*M. arboreus*) flower extract possesses more potent antioxidant activity (IC_{50} 92.74 ± 0.68 µg/mL, classified as strong) compared to Jotang (*A. paniculata*) flower extract (IC_{50} 156.95 ± 2.49 µg/mL, classified as weak) (Table 5). This difference is likely attributable to Topi Turki's significantly higher phenolic content (12.35%) compared to Jotang's (1.34%), although Jotang's alkaloids and terpenoids also contribute to its antioxidant properties. While one study reported moderate activity for Topi Turki (IC_{50} 115.6 ± 16.9 µg/mL), variations in extraction methods and solvents can significantly impact results. For instance, another study demonstrated powerful antioxidant activity for Jotang (IC_{50} 25.61 µg/mL) using a different extraction approach. These findings confirm that both flowers are potential natural antioxidants, but their overall effectiveness is highly dependent on their specific phytochemical content and the chosen extraction techniques.

4. Discussion

Proximate analysis reveals that Topi Turki (*M. arboreus*) and Jotang (*A. oleracea*) possess distinct nutritional profiles, making them suitable for different applications. *M. arboreus* are notable for their high

Table 3. Summary of compounds identified by LC-MS

Edible flowers	Secondary metabolites				Primary metabolites				Total
	P	T	A	C	P	F	Ac	O	
Topi Turki (*Malvaviscus arboreus*)	14	4	2	2	6	11	-	12	51
Jotang (*Acmella paniculata*)	7	3	9	3	11	13	4	120	170

(P) Phenolic; (T) Terpenoid; (A) Alkaloid; (C) Carbohidrate; (P) Protein; (L) Fat; (Ac) Alcohol; (O) Organic

Table 4. Secondary metabolites of edible flowers

Metabolites	Chemical formula	Area %	
		Topi turki	Jotang
Phenolic			
Kaempferol	$C_{15}H_{10}O_6$	2.599874918	-
Astragalin	$C_{21}H_{20}O_{11}$	2.553133044	-
3,5-di-tert-Butyl-4- hydroxybenzaldehyde	$C_{15}H_{22}O_2$	2.135615509	-
3,4-Dihydroxybenzaldehyde	$C_7H_6O_3$	1.938661386	-
Trifolin	$C_{21}H_{20}O_{11}$	0.77280436	-
Luteolin	$C_{15}H_{10}O_6$	0.543304534	-
4-Vinylphenol	C_8H_8O	0.384522613	-
2,4,6-Trihydroxy-2-(4- hydroxybenzyl)-1-benzofuran3(2H)-one	$C_{15}H_{12}O_6$	0.311856363	-
Genistin	$C_{21}H_{20}O_{10}$	0.248823126	-
Phloretin	$C_{15}H_{14}O_5$	0.365260633	-
Pelargonidin	$C_{15}H_{10}O_5$	0.249465147	-
Afzelin	$C_{21}H_{20}O_{10}$	0.119435829	-
Quercetin	$C_{15}H_{10}O_7$	0.098348787	-
o-Acetylphenol	$C_8H_8O_2$	0.03684961	-
2-(Dimethylamino)-4,6-bis(2- methyl-2-propanyl) phenol	$C_{16}H_{27}NO$	-	0.63663666
9-(4-Dimethylamino-but-1-ynyl)-9H-fluoren-9-ol	$C_{19}H_{19}NO$	-	0.384953068
Trans-caffeic acid	$C_9H_8O_4$	-	0.09914826
Rutin	$C_{27}H_{30}O_{16}$	-	0.078912975
Chlorogenic acid	$C_{16}H_{18}O_9$	-	0.100514332
4-Hydroxybenzoic Acid	$C_7H_6O_3$	-	0.028263437
Octylphenol	$C_{14}H_{22}O$	-	0.016174731
	Total abundance (%)	12.35795586	1.344603463
Terpenoid			
2-[(2R,4aR,8R,8aR)-8-hydroxy4a,8-dimethyldeca-hydronaphthalen-2-yl]prop2-enoic acid	$C_{15}H_{24}O_3$	0.360200109	-
2-[(2S,4aR,8aS)-2-Hydroxy-4amethyl-8-methyl-enedecahydro-2- naphthalenyl]acrylic acid	$C_{15}H_{22}O_3$	0.530078972	-
Abietic acid	$C_{20}H_{30}O_2$	0.04809206	-
Oxylubimin	$C_{15}H_{24}O_3$	0.027599918	-
Styrene	C_8H_8	-	0.053306275
Geranyl acetate	$C_{12}H_{20}O_2$	-	0.051207133
Glutaric Acid	$C_5H_8O_4$	-	0.025570316
	Total abundance (%)	0.965971059	0.130083724
Alkaloid			
Betaine	$C_5H_{11}NO_2$	52.54862533	-
Trigonelline	$C_7H_7NO_2$	2.651948815	-
6-Methyl-5,6,6a,7-tetrahydro-4H dibenzo[de,g] quinoline-1,2-diol	$C_{17}H_{17}NO_2$	-	1.111075938
7S,8R)-7-(Dipropylamino)-8- methyl-5,6,7,8-tetrahydro-1- naphthalenol	$C_{17}H_{27}NO$	-	0.906058739
1S,2S,8R,9S,11S)-8-Propyl-7- azatricyc-lo[7.2.1.0~2, 7~]dodecan-11-ol	$C_{14}H_{25}NO$	-	0.161576474
(8aR,9S,10R,12aS)-10-Hydroxy9-methyldeca-hydro-1H,5Hpyrrolo[2,1-k][1]benzazepin-5-one	$C_{14}H_{23}NO_2$	-	0.121060875
Azacyclonol	$C_{18}H_{21}NO$	-	0.090131252
(−)-Ecgonine methyl ester	$C_{10}H_{17}NO_3$	-	0.083870886
Meptazinol	$C_{15}H_{23}NO$	-	0.036163146
Stachydrine	$C_7H_{13}NO_2$	-	0.030884375
Dextromethorphan	$C_{18}H_{25}NO$	-	0.686870289
	Total abundance (%)	55.20057415	3.227691974

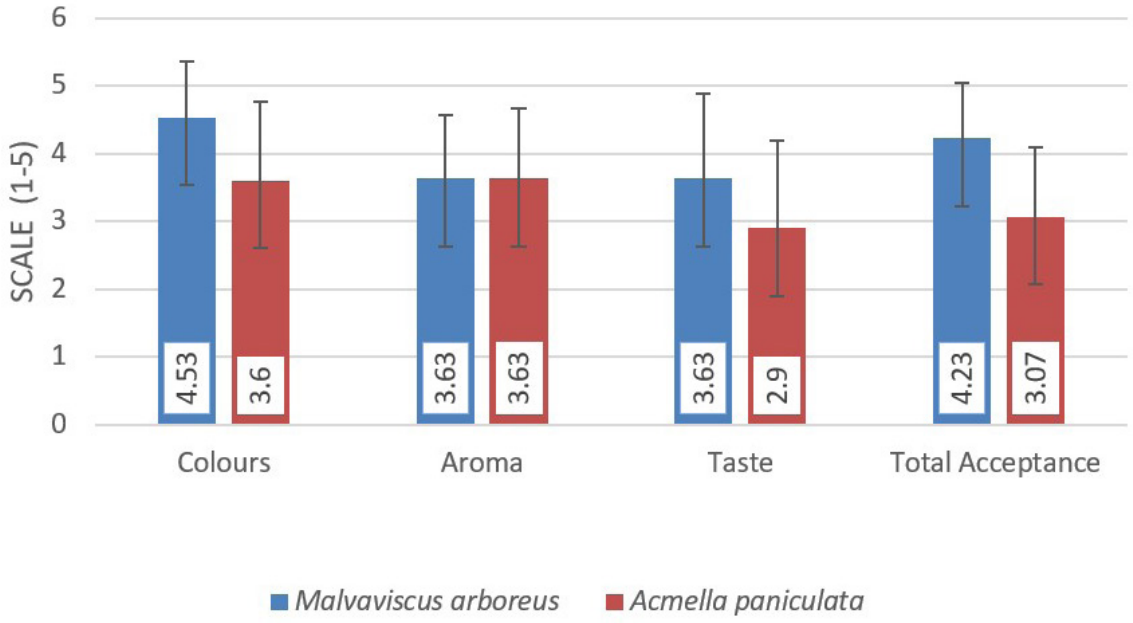

Figure 3. Hedonic test value of two flower-teas

Table 5. IC_{50} score of edible flowers

Edibel flowers	Mean	Unit	Group
Topi Turki (*Malvaviscus arboreus*)	92.74 ± 0.68	µg/mL	Strong
Jotang (*Acmella paniculata*)	156.95 ± 2.49	µg/mL	Weak

carbohydrate (48.12%) and water content (21%). This composition is influenced by their soft, mucilage-rich structure and hydrophilic properties, which help them retain water and contribute to their carbohydrate content (Abdelhafez *et al*. 2020). In contrast, *A. oleracea* flowers are rich in ash (8.85%), protein (18.75%), fat (21.71%), and crude fiber (24%). They also offer a significant energy content of 213 kcal/50g. The denser structure of *A. oleracea* flowers, along with a high content of non-polar compounds like essential oils and lipids, accounts for their high fat and fiber content and lower water content (Abdul Rahim *et al.* 2021). These unique compositions suggest specific uses for each flower: *A. oleracea* flowers are ideal for products needing an energy boost and high macronutrient content, such as solid supplements or energy-boosting powdered drinks. *M. arboreus* flowers are best used where a natural sweetness is desired, such as in herbal teas, garnishes, or functional soft drinks (Jakubczyk *et al*. 2022).

Phytochemical profiling identified a diverse array of metabolites in both flowers (Table 3). *M. arboreus* was rich in phenolic compounds (e.g., kaempferol, astragalin) and alkaloids (e.g., betaine, trigonelline), compounds known for their antioxidant, antimicrobial, cardioprotective, and potential anticancer properties (Jan *et al*. 2022; Gazwi *et al*. 2022; Yuan *et al*. 2022; Chen *et al*. 2023; Dobrijević *et al*. 2023; Mohammed *et al.* 2023; Oliveira *et al*. 2023; Makiso *et al*. 2024; Rahman *et al*. 2024). *A. paniculata* predominantly contained alkaloids, such as tapentadol and 8-OH-DPAT, recognized for their analgesic and anxiolytic effects, respectively (Purwaningsih *et al.* 2023; Onofre-Campos *et al*. 2023; Christoph *et al*. 2025). Trace amounts of bioactive terpenoids were also detected (Sivaraj *et al*. 2024). While both flowers contain beneficial bioactive compounds, *M. arboreus* exhibits a higher diversity and concentration of secondary metabolites (Table 4), particularly phenolics. The DPPH assay demonstrated that *M. arboreus* extract possesses significantly stronger antioxidant activity compared to *A. paniculata* (Table 5). This difference is largely attributed to the substantially higher phenolic content in Topi Turki (12.35%) compared to Jotang (1.34%). Although alkaloids and terpenoids in Jotang contribute to its antioxidant properties, the phenolic group in Topi Turki appears to be more dominant. Variations in extraction methods and solvents can significantly impact these results, as evidenced by previous studies (Gazwi *et al*. 2022; Kaneko *et al*. 2022; Rahman *et al*. 2025). Both flowers are thus potential natural antioxidant sources, with their efficacy influenced by phytochemical composition and extraction techniques.

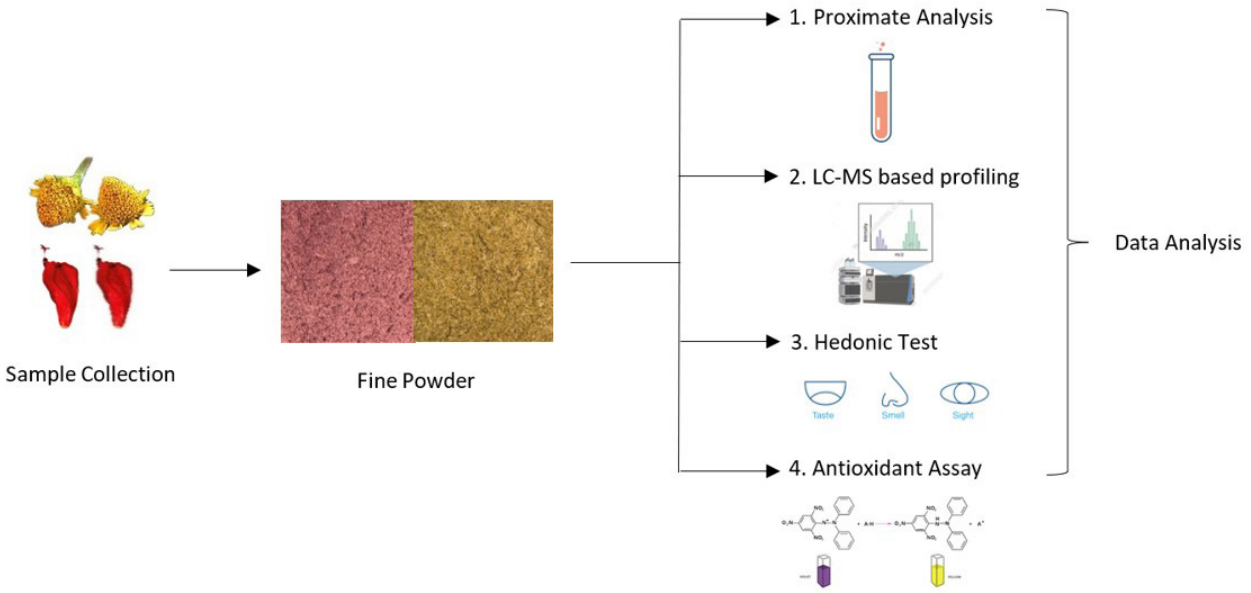

Figure 4. Graphical illustration of used-methods

Organoleptic evaluation using a hedonic test revealed distinct consumer preferences for the teas. *M. arboreus* brew scored higher in color preference, likely due to its bright red hue derived from betaine, kaempferol, and pelargonidin, which enhances visual appeal (Wangiyana & Triandini 2022; Daud *et al*. 2024). Its naturally sweet taste, linked to higher sucrose and glucose content and overall carbohydrate levels, also contributed to its preference (Henao Toro *et al*. 2022; Daud *et al.* 2024). In contrast, *A. paniculata* tea, with its yellow-green color (from quercetin and luteolin) and bitter taste (associated with phenolic acids), received lower acceptance (Vollmannová *et al*. 2021; Qiao *et al*. 2024). Aroma perception was similar for both, attributed to low volatile compound content (Kushargina *et al.* 2022; Yamasaki *et al*. 2022 Daud *et al.* 2024; Guo *et al*. 2025). Consequently, overall acceptance was significantly higher for Topi Turki brew, driven by its attractive color and palatable taste, aligning with findings that these attributes strongly influence herbal drink preference (Rahardjo *et al*. 2023). This suggests *M. arboreus* has greater immediate potential as a base for edible flower herbal drinks, while *A. paniculata* may require reformulation to improve consumer acceptance (Kurniadi *et al.* 2024). Despite differing preferences, both brews hold potential in the growing natural health drink market, leveraging their unique characteristics and visual appeal (Fernandes *et al*. 2020; Hegde *et al.* 2023).

This study provides a comprehensive understanding of the nutritional and bioactive potential of *M.arboreus* and *A.paniculata*. Topi Turki demonstrates promising potential as a palatable herbal tea with significant antioxidant properties, supported by its favorable sensory profile and rich phenolic content. In contrast, Jotang, despite lower sensory acceptance in tea form, offers a richer nutritional profile and diverse bioactive compounds (notably alkaloids) that could be leveraged in other food applications or as a health supplement. Both local edible flowers represent valuable, underexplored resources for diversifying plant-based food options and developing functional food products in Indonesia. Future research should focus on optimizing processing methods (e.g., alternative drying techniques to address high moisture content and preserve bioactives), exploring diverse food matrices beyond tea to enhance *A. paniculata*'s consumer acceptance, and conducting in vivo studies to validate the pharmacological activities and bioavailability of the identified compounds. Further investigation into the synergistic effects of the diverse phytochemicals present in both flowers could also lead to enhanced functional food formulations for preventing oxidative stress-related diseases.

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