

MORPHOLOGICAL IDENTIFICATION, PHYTOCHEMICAL ANALYSIS, AND UTILIZATION POTENTIAL OF *Gomphrena globosa* L. FROM BALI

Ni Luh Made Pradnyawathi, Rindang Dwiyani*, Ida Ayu Putri Darmawati, I Made Basma Redana, and Yuyun Fitriani

Faculty of Agriculture, Udayana University, Bali, Indonesia

* Corresponding Author. E-mail address: rindangdwiyani@unud.ac.id

ARTICLE HISTORY:

Received: 31 July 2025

Peer Review: 29 December 2025

Accepted: 24 July 2026

KEYWORDS:

Characterization, *Gomphrena globosa*, morphologica, phytochemica

ABSTRACT

This study aims to evaluate the morphological characteristics and phytochemical content of the purple phenotype of *G. globosa* growing in two different locations: Denbantas Vilage (Tabanan Regency) and Kesiman Kertalangu Vilage (Denpasar City). Samples were collected using purposive sampling, while morphological analysis was based on Tjitrosoepomo's (2013) description. Compound analysis was conducted using gas chromatography-mass spectrometry (GC-MS). Morphologically, although the flower and leaf structures are similar, notable differences were found in stem color and leaf surface texture. Phytochemical analysis revealed that the Denbantas sample contained a dominance of saturated fatty acids such as n-Hexadecanoic acid, Hexadecanoic acid ethyl ester, and Tetradecanoic acid ethyl ester, which are known to have antibacterial, anti-inflammatory, and antioxidant activities. The detection of Butylated Hydroxytoluene (BHT), a synthetic antioxidant, indicated potential protection against lipid peroxidation. Conversely, Kesiman Kertalangu samples contain volatile and phenolic compounds such as acetic acid, 2-Methoxy-4-vinylphenol, as well as heterocyclic compounds such as 2-Ethylacridine and Indolizine, which function as antitumor and antimicrobial agents. The presence of toxic compounds such as arsenous acid and tris(trimethylsilyl) ester indicates potential heavy metal contamination from the environment. These chemical polymorphic variations are influenced by genetic, geographic, and ecological factors. These findings demonstrate the potential of *G. globosa* as a source of natural bioactive compounds and cosmetics. However, further studies are needed on toxicological safety and the environmental impact on the accumulation of secondary metabolites.

1. INTRODUCTION

Gomphrena globosa L or known as ratna flower is a flowering plant from the Amaranthaceae family that is widely known as an ornamental plant and herbal drink ingredient. It grows well in various types of environments, both optimal and sub-optimal, and has various ethnopharmacological benefits and commercial potential. In Bali, this flower is not only used as a decorative element in traditional ceremonies and sacred dances, but has also begun to be studied for its use in the field of natural pharmaceuticals and cosmetics (Darma et al., 2021). *G. globosa* plants have been reported to contain active phytochemical compounds such as flavonoids, saponins, alkaloids, and betasianin that have antioxidant, antibacterial, anti-inflammatory, and hepatoprotective activities (Tang et al., 2022; Abbad et al., 2025).

The study by Kusmiati et al. (2017) showed that ethanol extract of ratna flower effectively inhibited the growth of pathogenic bacteria such as *Staphylococcus aureus* and *Escherichia coli* in concentrations as low as 1.25%. Traditionally, the plant is also used to treat asthma, headaches, and eye infections (Rahardi et al., 2019). The purple phenotype of *G. globosa* in Bali is spread in several areas such as the Denbantas area in Tabanan Regency and Kesiman Kertalangu in Denpasar City. However, until now there has been no study that systematically characterises the morphology and analyses the phytochemical content of this plant based on its growing location. Morphological studies are important for identifying the potential diversity of local varieties, while phytochemical analysis, especially by Gas Chromatography-Mass Spectrometry (GC-MS) method, enables the detection of specific bioactive compounds underlying the pharmacological activity of plants (Chandrasekar et al., 2021; Mroczek, 2015). Therefore, the present study aimed to (1) characterise the morphological traits of purple-flowered *G. globosa* populations from two contrasting locations in Bali and (2) compare the phytochemical compositions of their leaf and flower extracts using GC-MS. The results are expected to provide a scientific basis for the development of this species as a raw material for biopharmaceutical, cosmetic, and ornamental plant industries.

2. MATERIALS AND METHOD

2.1 Time and Place of Experiment

This study was conducted during the period of January to April 2025, with the sampling location conducted in two representative areas in Bali, namely desa Denbantas (Tabanan Regency) and desa Kesiman Kertalangu (Denpasar City). Phytochemical analysis of the samples was conducted at the Laboratory of Genetic Resources and Molecular Biology, Udayana University. Furthermore, instrumental testing of phytochemical compounds using *Gas Chromatography-Mass Spectrometry* (GC-MS) was carried out at the Forensic Laboratory, Bareskrim POLRI Denpasar.

2.2 Experimental Materials and Tools

This study used field tools such as hoes, knives, scissors, rulers, and digital cameras for documentation and morphological measurements. Laboratory equipment used included beakers, measuring cups, test tubes, erlenmeyers, volumetric flasks, dropper pipettes, micropipettes, and analytical scales. Blenders were used for sample homogenisation, while jars, plastic bags, filter paper were used in storage and filtration.

Morphological colour identification was aided by *The Royal Horticultural Society* (RHS) Color Chart. Phytochemical analysis was conducted using 96% ethanol solvent, and bioactive compounds were analysed by Gas Chromatography–Mass Spectrometry (GC–MS) analysis was performed using an Agilent 7890B gas chromatograph coupled with an Agilent 5977B mass selective detector (MSD), equipped with a Wakosil ODS/5C18-200 silica column (4.6 × 200 mm). Nitrogen (N₂) was used as

the carrier gas. The column temperature was programmed from 70 °C to 290 °C. The initial oven temperature was set at 70 °C and held for 3 minutes, followed by an increase at a rate of 10 °C per minute until reaching the final temperature of 290 °C. The total analysis time was 27 minutes. The injection volume was 1 mL, with a column flow rate of 1 mL/min. Samples of purple phenotype ratna (*G. globosa*) flowers were collected from two locations namely Denbantas, Tabanan and Kesiman Kertalangu, Denpasar.

2.3 Experimental Method

This experiment used a survey method to collect information and data on *G. globosa* (ratna flower) plants through a direct data collection approach, namely interviews with relevant informants. Determination of the sample area was carried out using *purposive sampling* technique, while plant sampling was carried out using *simple random sampling* method. Identification of plant morphological characters refers to the guidelines of Tjitrosoepomo (2013). Phytochemical profiling was performed using gas chromatography–mass spectrometry (GC-MS). Data were analysed qualitatively based on retention times, similarity indices, and relative peak areas. Compound identification was achieved by comparison with mass spectral libraries available in the GC-MS database.

3. RESULT AND DISCUSSION

3.1. Morphological Characterisation

Observations of the purple phenotype of *G. globosa* in the Denbantas and Kesiman Kertalangu areas show that the two populations have relatively similar morphological diversity. The main differences were found in the variables of leaf surface colour and stem colour. Based on plant morphological guidelines by Tjitrosoepomo (2013), the flower structure of *G. globosa* from both locations has an ethopus flower arrangement (cyclical and twisted), *strong purple* flower colour, cob-shaped compound flower type (*spadix*), and has compound pistils (*compositus*). This is in accordance with the general characteristics of *G. globosa* as reported in the study of Dwiyani et al. (2023), who found consistency in flower morphology in Bali at different altitudes.

Leaf morphology in both phenotypes showed a breech ovate leaf shape (*obovatus*), tapered leaf tip, blunt leaf base (*obtusus*), and pinnate leaf bones. The leaf surface is covered with fine and dense hairs (*villosus*). Notable differences are seen in the colour of the upper leaf surface. The phenotype from the Denbantas area has a *Brilliant yellowish green* lower leaf surface colour, while the phenotype from Kesiman Kertalangu has a *Vivid yellowish green* upper surface colour. This difference is thought to be closely related to the growing environment. According to Tjitrosoepomo (2013), plant leaf colour is strongly influenced by environmental factors such as water availability, nutrients, and sunlight intensity. This is reinforced by the findings of Amalia et al. (2023), which states that the expression of plant phenotypes is the result of interactions between genotypes and external environmental factors.

Another characteristic observed is the surface of the stem in both phenotypes that are both hairy (*pilosus*). However, there was a significant difference in stem colour: the phenotype from Denbantas had *Strong purplish red* stems, while the phenotype from Kesiman Kertalangu showed *Brilliant yellowish green* stem colour. Root morphology in young plants from both regions showed a mixed root type, i.e. taproot accompanied by fibrous roots (*radix primaria*), with *Dark grayish yellow* root colour. This difference may be due to variations in anthocyanin content and light conditions as described by Alidust and Sedaghathoor (2020), who reported that differences in lighting and moisture content affect the colouration of stem and leaf tissues of *Amaranthaceae* plants.

The morphological characteristics of the purple phenotypes from Denbantas and Kesiman Kertalangu are summarized in Table 1. Representative images of the phenotypes are presented in Figure 1 (Denbantas) and Figure 2 (Kesiman Kertalangu). The morphological differences between the two phenotypes can be more clearly observed in Figure 3.

Table 1. Qualitative Character Data of Purple Phenotype Ratna Flower Plants

Observation Variable	Plant Phenotype <i>Gomphrena globosa</i> L	
	Purple Denbantas	Kesiman Kertalangu Purple
Flower arrangement	stacked etopus	stacked etopus
Flower Colour	RHS 77B/218 <i>Strong purple</i>	RHS 77B/218 <i>Strong purple</i>
Flowering type	Cob-shaped compound flowers (<i>spadix</i>)	Cob-shaped compound flowers (<i>spadix</i>)
Stamen position	Stamens on flower crown	Stamens on flower crown
Pistil	Compound pistil (<i>compositus</i>)	Compound pistil (<i>compositus</i>)
Seed colour	RHS 199A/95 <i>Moderate Olive Brown</i>	RHS 199A/95 <i>Moderate Olive Brown</i>
Leaf Construct	Breech ovate (<i>obovatus</i>) build	Breech ovate (<i>obovatus</i>) build
Leaf tip shape	Pointed	Pointed
Shape of leaf base (<i>Basis folii</i>)	Blunt (<i>obtusus</i>)	Blunt (<i>obtusus</i>)
Leaf upper surface colour	RHS 40 B/130/ <i>Brilliant Yellowish Green</i>	RHS 40A/129/ <i>Vivid Yellowish Green</i>
Leaf bone arrangement (<i>Nervatio</i>)	Pinnate leaf blade	Pinnate leaf blade
Leaf surface	Smooth and tightly hairy (<i>villosus</i>)	Smooth and tightly hairy (<i>villosus</i>)
Traits	Hairy (<i>Pilosus</i>)	Hairy (<i>Pilosus</i>)
Stem surface		
Stem Colour	RHS 71C/255 <i>Strong Purplish Red</i>	RHS 140C/130 <i>Brilliant Yellowish Green</i>
Root Form	Taproot-toothed (<i>Radix Primaria</i>)	Retractable (<i>Radix Primaria</i>)
Root Colour	RHS 199D/91 <i>Dark Grayish Yellow</i>	RHS 199D/91 <i>Dark Grayish Yellow</i>

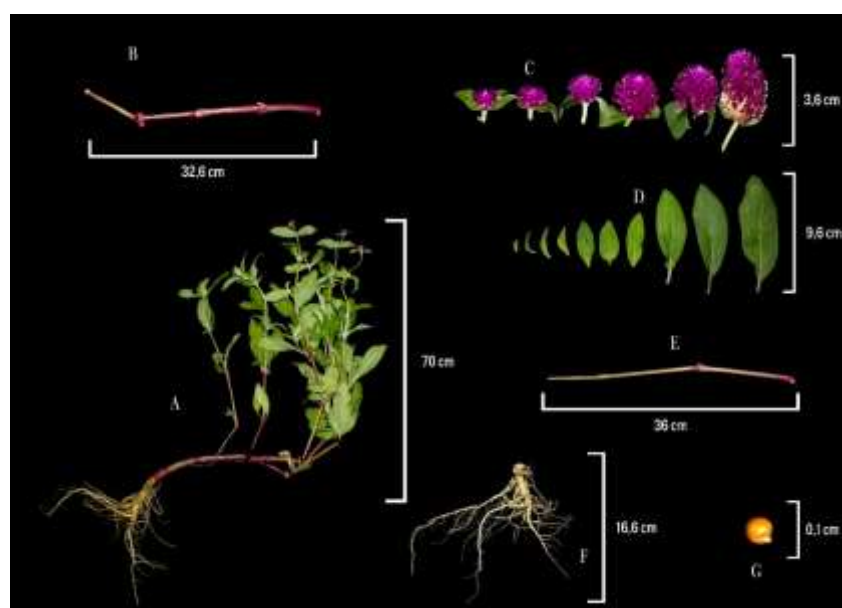


Figure 1. Characteristics of *Gomphrena globosa* Denbantas purple phenotype. (A) Habitus, (B) Stem, (C) Flower, (D) Leaf, (E) Branch, (F) Root, (G) Seed.

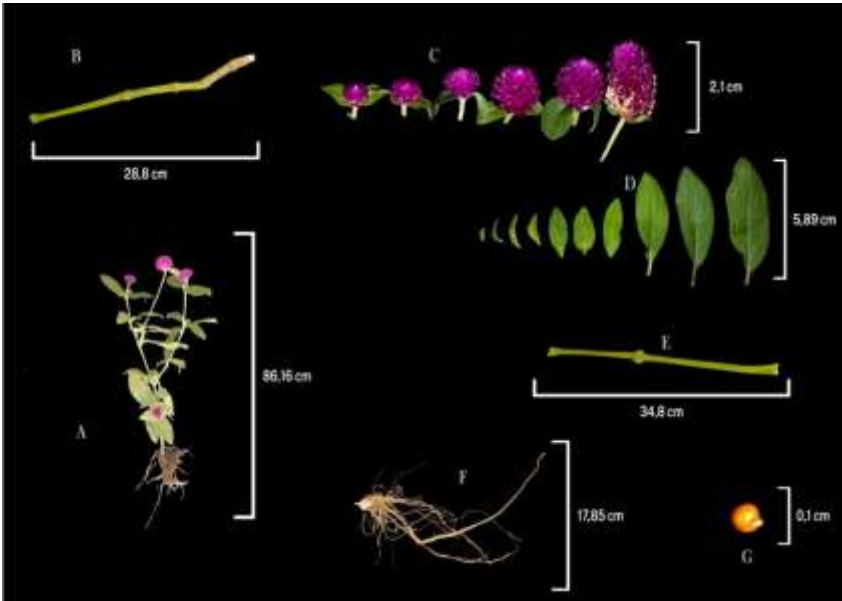


Figure 2. Characteristics of *G. globosa* Kesiman Kertalangu purple phenotype (A) Habitus, (B) Stem, (C) Flower, (D) Leaf, (E) Branch, (F) Root, (G) Seed.

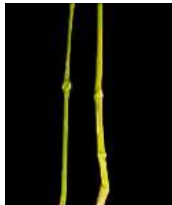
Phenotype Ratna Flower	Flower Color	Leaf Color	Stem Color	Root Color	Seed Color
Purple Denbatas					
Purple Kesiman Kertalangu					

Figure 3. Differences in Characteristics of *G. globosa* Denbantas and Kesiman Kertalangu purple phenotypes.

3.2 Phytochemical Analysis of Leaf and Flower Extracts of Pink Phenotypes Sibangede and Kesiman Kertalangu

Based on the results of phytochemical analysis of the flower extract of *G. globosa* purple phenotype of Denbantas area, it is known that the main compounds contained include n-Hexadecanoic acid (palmitic acid), Hexadecanoic acid ethyl ester, and Tetradecanoic acid ethyl ester. These compounds belong to a group of saturated fatty acids that have been widely studied to have various biological activities, such as antibacterial, antifungal, antioxidant, nematocidal, and haemolytic and hypocholesterolemic activities (Sativa and Agustin, 2018; Sukarti *et al.*, 2023). Hexadecanoic acid (palmitic acid), in particular, is known to have the potential to lower the risk of coronary heart disease and exhibit antitumour activity in vivo. In addition, this extract also contains the synthetic compound Butylated hdroxytoluene (BHT), which is widely used as a synthetic antioxidant in the food and pharmaceutical industries. Recent studies have shown that BHT has high antioxidant activity and is able to inhibit lipid peroxidation effectively, even compared to some

natural bioactive compounds. For example, a study by Al-Atbi *et al.* (2024) showed that azomethine compounds had 26% lipid oxidation inhibitory activity, while BHT showed comparable or lower inhibition ability at similar concentrations, indicating its effectiveness in inhibiting free radicals (Al-Atbi *et al.*, 2024). Meanwhile, in the flower extract of *G. globosa* purple phenotype of Kesiman Kertalangu area, besides containing fatty acid derivatives, volatile compounds such as acetic acid, a simple monocarboxylic acid with two carbons, were also found. Acetic acid has functions as a protic solvent, acidity regulator, food preservative, and natural antimicrobial which is also used as a metabolite in organisms such as *Daphnia magna* (Syarifuddin *et al.*, 2023; PubChem, 2024).

Phenol group compounds such as 2-Methoxy-4-vinylphenol were also found and known to have significant anti-inflammatory, antioxidant, analgesic, and antibacterial activities (Rubab *et al.*, 2020). The presence of these compounds strengthens the hypothesis that the purple phenotype flowers of *Gomphrena globosa* from the Kesiman Kertalangu area have potential as a natural source of bioactive compounds for herbal medicine development. GC-MS chromatogram analysis of purple phenotype flowers from Denbantas and Kesiman Kertalangu revealed distinct differences in the separation patterns of volatile compounds. In samples from Denbantas, the chromatogram exhibited several dominant peaks at intermediate to late retention times, specifically at RT 8.322 min, 15.043 min, 15.833 min, 16.559–16.930 min, as well as peaks at RT 18.089 min and 24.179 min. These peaks showed relatively high intensities, indicating the presence of major compounds with high abundance, which are presumed to contribute significantly to the phytochemical characteristics of the purple phenotype flowers from the Denbantas region. The predominance of peaks at intermediate to late retention times suggests the presence of compounds with moderate to low volatility. In contrast, the GC-MS chromatogram of purple phenotype flowers from Kesiman Kertalangu was dominated by peaks at early to intermediate retention times, with major peaks observed at RT 5.614 min, 6.934 min, 8.644 min, as well as high-intensity peaks around RT 9.353 min and 9.536 min, followed by a peak at RT 9.778 min. This pattern indicates that samples from Kesiman Kertalangu are relatively richer in volatile compounds with lower molecular weights that elute more rapidly. The phytochemical profiles and compound compositions of purple phenotype flower extracts from Denbantas and Kesiman Kertalangu are further presented in Figures 4 and 5, and comprehensively summarized in Table 2.

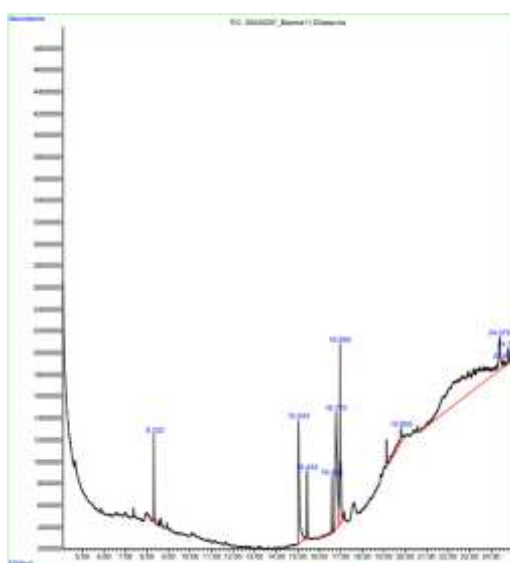


Figure 4. Chromatogram of gas separation of Denbantas purple phenotype flower.

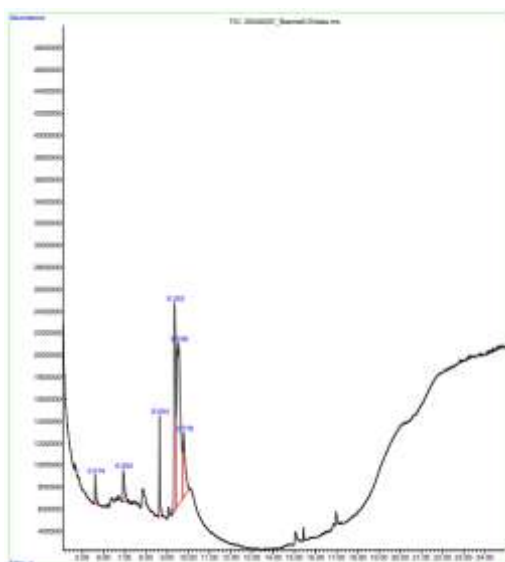


Figure 5. Gas separation chromatogram graph of purple phenotype flower of-Kesiman Kertalangu.

Table 2. Compound content of *Gomphrena globose* flower extract of purple phenotype

Region	Compound content	RT	AUC	Compound Formula	Utilisation
Denbantas	<i>Butylated Hydroxytoluene</i>	8.322	2.44	$C_{15}H_{24}O$	Antioxidant (Al-Atbi <i>et al.</i> , 2024)
	<i>Hexadecanoic acid, ethyl ester</i>	15.433	2.93	$C_{18}H_{36}O_2$	Antitumour (Sativa and Agustin, 2018)
	<i>n-Hexadecanoic acid</i>	15.044	2.29	$C_{16}H_{32}O_2$	Anti-inflammatory, antispasmodic, anticancer, antiviral (Fadillah, <i>et al.</i> , 2020)
	<i>Tetradecanoic acid, ethyl ester</i>	15.433	2.93	$C_{14}H_{28}O$	Topical drugs that require good absorption through the skin (Pubchem, 2024;
	<i>Phytol</i>	16.584	1.72	$C_{20}H_{40}O$	Colorectal anticancer (Sanora, <i>et al</i> 2019)
	<i>Linoleic acid ethyl ester</i>	16.959	9.12	$C_{20}H_{36}O_2$	Anticancer (Dutta <i>et al.</i> , 2023)
	<i>9, 12-octadecadienoic acid</i>	16.959	9.12	$C_{18}H_{32}O_2$	Anticancer (Lestari <i>et al.</i> , 2019)
Kesiman Kertalangu	<i>Carbonic acid</i>	5.614	5.614	CH_2O_3	Antibacterial, Antiproliferation, (Saputri <i>et al.</i> , 2020)
	<i>Carbamodithioic acid</i>	5.614	5.614	CH_3NS_2	Antivirus, antibacterial, and antifungal, in addition, anti-HIV and anti-tumour agent (Hoidy <i>et al.</i> , 2020)
	<i>acetic acid</i>	8.644	5.76	$C_2H_4O_2$	Antimicroorganism (Syarifuddin <i>et al.</i> , 2023)
	<i>Ethyl.alpha.-d-glucopyranoside</i>	9.353	30.34	$C_8H_{16}O_6$	Has a role as a preservative (Karuppasamy, 2016)
	<i>Pentanoic acid</i>	9.353	30.34	$C_5H_{10}O_2$	Antimicrobial (Oulaï <i>et al.</i> , 2018)
	<i>.alpha.-D-Galactopyranoside</i>	9.778	11.48	$C_7H_{14}O_6$	Antioxidant (Trang <i>et al.</i> , 2021), anti-inflammatory, hepatoprotective, and antimicrobial (Al-Snafi, 2016).

In the leaves of *G. globosa* purple phenotype, extracts from the Denbantas area contain major phytol compounds and various types of fatty acids, such as palmitic acid and tetradekanoic acid,

which have been shown to have anti-inflammatory, anticancer, antiviral, antihyperglycemic, and antibacterial activities against *Bacillus cereus* (Fadillah *et al.*, 2020). In addition, heterocyclic aromatic compounds such as 2-Ethylacridine and Indolizine were also found. 2-Ethylacridine compounds are known to have promising biological activities, including as antitumour, antimicrobial, and antioxidant. Recent research by Javaid *et al.* (2021) showed that 2-Ethylacridine identified from *Vinca major* plant extract has significant antimicrobial and antitumour properties, as well as contribution to antioxidant activity. Biochemical assays suggest this compound could act as a potential bioactive component in the development of novel therapeutic agents. Similarly, Indolizine is a widely researched heterocyclic framework compound that exhibits anticancer, antiviral, and anti-inflammatory activities through the mechanism of enzyme inhibition and interaction with target cell DNA (Muthukrishnan *et al.*, 2022).

In the leaf extract of Kesiman Kertalangu region, the main compound Z-10-Pentadecen-1-ol was found as well as pungent acidic compounds such as propanamide, and the toxic compound Arsenous acid, tris(trimethylsilyl) ester. Although arsenic compounds such as arsenous acid (H_3AsO_3) are widely known to be toxic, in controlled concentrations and specific formulations, arsenic-based compounds have been utilised in agriculture as pesticides, herbicides, and antimicrobial agents. The historical use of these compounds is extensive, especially in the form of arsenite and arsenate for pest control and weed growth. According to Genchi *et al.* (2022), arsenous acid and arsenic oxide were widely used as active components in agricultural pesticides prior to regulatory bans due to their impact on the environment and human health. Although their use is now strictly restricted in many countries, arsenic compounds are still used on a limited basis in agriculture and industry with strict toxicity control. The acetic acid found in purple leaves from the Kesiman Kertalangu area has significant benefits as a natural antimicrobial agent. Acetic acid is a monocarboxylic acid that not only functions as a protic solvent and acidity regulator in food, but also shows antimicrobial activity against various pathogenic bacteria and fungi, as reported by Li *et al.* (2016) in their toxicological study of food organic compounds. The chromatogram graphs of the phytochemical compound content of purple leaf extracts from Denbantas and Kesiman Kertalangu regions are shown in (Figures 6 and 7) (Table 3).

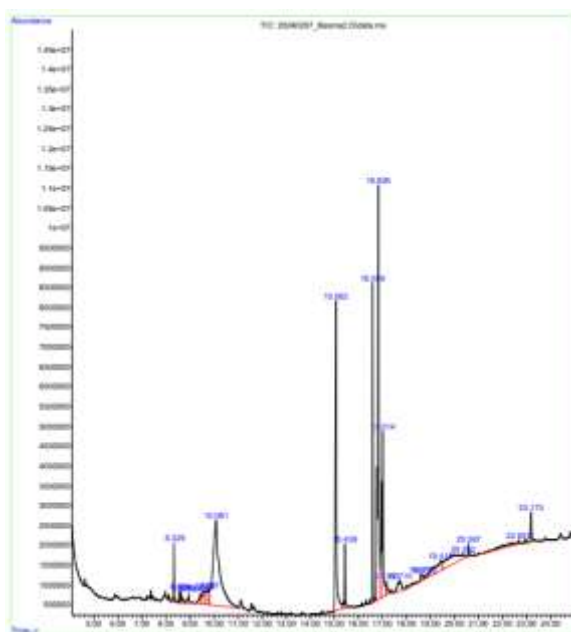


Figure 6. Gas separation chromatogram graph of purple phenotype leaves of Denbantas area

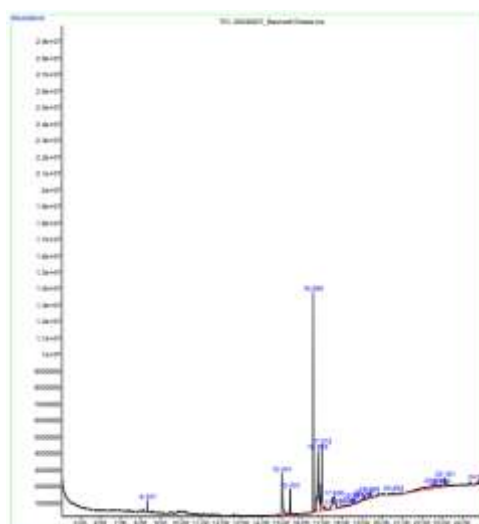


Figure 7. Gas separation chromatogram graph of purple phenotype leaves of Kesiman Kertalangu area

Table 3. Compound content of purple phenotype *Gomphrena globose* plant leaf extracts

Region	Compound Content	RT	AUC	Compound Formula	Utilisation
Denbantas	<i>Butylated Hydroxytoluene</i>	8.327	1.12	<u>C₁₅H₂₄O</u>	Antioxidant (Al-Atbi <i>et al.</i> , 2024)
	<i>n-Hexadecanoic acid</i>	15.041	9.87	C ₁₆ H ₃₂ O ₂	Anti-inflammatory, antispasmodic, anticancer, antiviral (Fadillah, <i>et al.</i> , 2020)
	<i>Hexadecanoic acid, ethyl ester</i>	15.437	3.89	<u>C₁₈H₃₆O₂</u>	Antitumour (Sativa and Agustin, 2018)
	<i>Tetradecanoic acid, ethyl ester</i>	15.437	3.89	C ₁₄ H ₂₈ O	Topical drugs that require good absorption through the skin (Pubchem, 2024; Chemeurope, 2024).
	<i>Phytol</i>	16.586	25.09	<u>C₂₀H₄₀O</u>	Colorectal anticancer (Sanora, <i>et al</i> 2019)
	<i>9,12,15-Octadecatrienoic acid</i>	16.818	16.74	C ₁₈ H ₃₀ O ₂	Antidiabestes (Linn <i>et al.</i> , 1989).
	<i>Ethyl 9,12,15-octadecatrienoate</i>	17.012	12.12	C ₂₀ H ₃₄ O ₂	Antioxidant, antimicrobial, anti-inflammatory, (Aldakheel <i>et al.</i> , 2020)
Kesiman Kertalangu	<i>Hexadecanoic acid, ethyl ester</i>	15.451	1.26	<u>C₁₈H₃₆O₂</u>	Antitumour (Sativa and Agustin, 2018)
	<i>Undecanoic acid, ethyl ester</i>	15.451	1.26	C ₁₃ H ₂₆ O	Treatment of dermatophytosis in humans (Muflihunna <i>et al.</i> , 2021)
	<i>Z-10-Pentadecen-1-ol</i>	16.862	1.13	C ₁₅ H ₃₀ O	Adsorption ability to air pollutants and mild pharmacological effects due to its high lipophilic nature (Azizi <i>et al.</i> , 2023)
	<i>9, 12-octadecadienoic acid</i>	16.973	2.54	C ₁₈ H ₃₂ O ₂	Anticancer (Lestari <i>et al.</i> , 2019)
	<i>Linoleic acid ethyl ester</i>	16.973	2.54	C ₂₀ H ₃₆ O ₂	Anti-inflammatory, antioxidant (Calderón-Martínez <i>et al.</i> , 2024)
	<i>Arsenous acid, tris(trimethylsilyl) ester (arsenic acid)</i>	22.631	33.62	C ₉ H ₂₇ AsO ₃ Si ₃	As herbicide, pesticide, and rodenticide (Alhazmi <i>et al.</i> , 2019)
	<i>acetic acid</i>	8.644	5.76	C ₂ H ₄ O ₂	Antimicroorganism (Syarifuddin <i>et al.</i> , 2023)

Differences in the type and content of phytochemical compounds between flower and leaf samples of the purple phenotype of plants in the Denbantas and Kesiman Kertalangu areas indicate the existence of chemical polymorphism that is closely related to genetic, geographic, and ecological factors (Casiglia *et al.*, 2017). This variation reflects the complex dynamics between the environment and plant secondary metabolism. Plant genotypes serve as the foundation for metabolite expression, but the environment exerts significant selective pressure and physiological influence on the biosynthesis of these active compounds.

Environmental stresses in the form of abiotic stresses such as extreme temperatures, drought, salinity, or biotic stresses such as pathogen infection or pest attack can trigger changes in gene expression in secondary metabolite biosynthetic pathways, which ultimately result in differences in phytochemical content between organs and locations. Mahajan and Tuteja (2005) explained that unfavourable environmental conditions are referred to as stress, and this can inhibit growth, metabolism, and accelerate the production of protective compounds by plants. A recent study by Singh and Mina (2025) showed that variations in phytochemical content in *Withania somnifera* plants exposed to temperature stress were accompanied by an increase in antioxidant activity, especially in leaf and root organs, proving that the plant's response to the environment is very specific to its body parts. Similarly, the study by Ogwu *et al.* (2025) emphasised that environmental stress also affects the concentration and diversity of bioactive compounds, depending on the plant organ and stage of physiological development.

These two studies support the conclusion that phytochemical variation not only reflects differences in geographical location, but is also the result of dynamic interactions between plant genetics and the ecological stresses it experiences. Therefore, understanding environmental stress and its effect on secondary metabolite biosynthesis is important in the exploration of plants as natural sources of bioactives for pharmaceutical, food and cosmetic applications.

4. CONCLUSIONS

This study demonstrates that purple-flowered *Gomphrena globosa* populations from Denbantas and Kesiman Kertalangu exhibit both morphological and phytochemical variation associated with local environmental conditions. While floral structures and leaf morphology were largely conserved, significant differences in stem pigmentation and leaf surface colour were observed. GC-MS profiling revealed marked chemical polymorphism between sites and plant organs. Denbantas accessions were characterised by high levels of saturated fatty acids and antioxidant-related compounds, whereas Padang Galak samples contained greater proportions of volatile acids, phenolics, and heterocyclic metabolites with antimicrobial and antitumour potential. The occurrence of arsenic-derived compounds in some samples highlights the importance of environmental monitoring and toxicological evaluation prior to pharmaceutical or cosmetic exploitation. Overall, these findings support the potential of *G. globosa* as a valuable natural resource while underscoring the strong influence of ecological factors on secondary metabolite biosynthesis.

5. REFERENCES

- Abbad, S., Aissaoui, N., & Gana, F. Z. (2025). Marrubium vulgare leaf extract-assisted green synthesis of silver nanoparticles: Optimization, characterization and in vitro exploration of their antimicrobial, antioxidant and anti-inflammatory potential. *Pharmacognosy Journal*, 17(1), 7–21. <https://doi.org/10.5530/pj.2025.17.2>

- Al-Atbi, H. S., Al-Salamia, B. K., & Al-Assadi, I. J. (2025). Synthesis, characterization, antimicrobial and antioxidant studies of azomethine compounds derived from sulfa drugs. *Chemical Interactions*, 2(1), 1–6. <https://doi.org/10.64354/ofon.ci.2.1.34>
- Aldakheel, R. K., Rehman, S., Almessiere, M. A., Khan, F. A., Gondal, M. A., Mostafa, A., & Baykal, A. (2020). Bactericidal and in vitro cytotoxicity of Moringa oleifera seed extract and its elemental analysis using laser-induced breakdown spectroscopy. *Pharmaceuticals*, 13(8), 193. <https://doi.org/10.3390/ph13080193>
- Alhazmi, H. A., Khalid, A., Sultana, S., Abdelwahab, S. I., Ahsan, W., Oraiby, M. E., & Bratty, M. A. (2019). Determination of phytocomponents of twenty-one varieties of smokeless tobacco using gas chromatography-mass spectroscopy (GC-MS). *South African Journal of Chemistry*, 72, 47–54. <https://doi.org/10.17159/0379-4350/2019/v72a7>
- Alidust, J., & Sedaghatthoor, S. (2020). The physiological parameters of three Cordyline terminalis cultivars as influenced by substrate and deficit irrigation. *Air, Soil and Water Research*, 13, 1–9. <https://doi.org/10.1177/1178622120948079>
- Al-Snafi, A. E. (2016). Medical importance of Cichorium intybus: A review. *IOSR Journal of Pharmacy*, 6(3), 41–56.
- Azizi, M., Abdulrahman, Y. J., Abdessamad, N.-H., Azzaz, A. A., & Naguib, D. M. (2023). Valorization and characterization of bio-oil from Salvadora persica seed for air pollutant adsorption. *Environmental Science and Pollution Research*, 30(18), 53397–53410. <https://doi.org/10.1007/s11356-023-25566-9>
- Calderón-Martínez, P., Yam-Puc, A., Ramón-Sierra, J., Hernández-Bolio, G., Hernández-Núñez, E., Zamora-Bustillos, R., & Ortiz-Vázquez, E. (2024). Antioxidant and antibacterial properties of ethanolic pot-pollen extracts of Melipona beecheii and determination of the major components by GC-MS. *Chemistry & Biodiversity*, 21(12), e202401355. <https://doi.org/10.1002/cbdv.202401355>
- Casiglia, S., Bruno, M., Bramucci, M., Quassinti, L., Lupidi, G., Fiorini, D., & Maggi, F. (2017). Kundmannia sicula (L.) DC: A rich source of germacrene D. *Journal of Essential Oil Research*, 29(6), 437–442. <https://doi.org/10.1080/10412905.2017.1338625>
- Chandrasekar, A., Vasantharaj, S., Jagadeesan, N. L., Shankar, S. N., Pannerselvam, B., Bose, V. G., Arumugam, G., & Shanmugavel, M. (2021). Studies on phytomolecules mediated synthesis of copper oxide nanoparticles for biomedical and environmental applications. *Biocatalysis and Agricultural Biotechnology*, 33, 101994. <https://doi.org/10.1016/j.bcab.2021.101994>
- Darma, I. D. P., Sutomo, S., Hanum, S. F., Iryadi, R., & Rahayu, A. (2021). Flowers and value of conservation in the culture of Hindu community in Bali. *Biosaintifika: Journal of Biology & Biology Education*, 13(1), 34–40. <https://doi.org/10.15294/biosaintifika.v13i1.27054>
- Dwiyani, R., Sanjaya, I. P. W., Darmawati, I. A. P., Laksmiani, N. P. L., Redana, I. M. B., Yuswanti, H. (2023). The evaluation of vitamin C and β -carotene of globe amaranth (*Gomphrena globosa*), a local germplasm of Bali (Indonesia) from two different altitudes. *Bali Medical Journal*, 12(3), 3448–3452. <https://doi.org/10.15562/bmj.v12i3.5040>
- Fadillah, U. F., Hambali, E., & Muslich, M. (2020). Identifikasi senyawa aktif ekstrak daun pulutan (*Urena lobata* L.) dengan GC-MS [Identification of active compound in pulutan (*Urena lobata* L.) leaf extract sing GC-MS]. *Jurnal Sains dan Kesehatan*, 2(3), 217–221. <https://doi.org/10.25026/jsk.v2i3.155>
- Genchi, G., Lauria, G., Catalano, A., Carocci, A., & Sinicropi, M. S. (2022). Arsenic: A review on a great health issue worldwide. *Applied Sciences*, 12(12), 6184. <https://doi.org/10.3390/app12126184>

- Javaid, A., Ferdosi, M. F. H., Khan, I. H., Shoaib, A., Saeed, H. M., & Ul Hassan, M. A. (2021). Biochemical analysis of flowers of *Vinca major*, a medicinal weed plant of hilly areas of Pakistan. *Pakistan Journal of Weed Science Research*, 27(4), 537–546. <https://doi.org/10.28941/pjwsr.v27i4.1014>
- Kusmiati, Priadi, D., & Rahayu, R. K. (2017). Antibacterial activity test, evaluation of pharmacognosy and phytochemical screening of some extracts of globe amaranth (*Gomphrena globosa*). *The Journal of Pure and Applied Chemistry Research*, 6(1), 27–33. <https://doi.org/10.21776/ub.jpacr.2017.006.01.288>
- Lestari, D., Kartika, R., Marliana, E., & Syamsul, E. S. (2019). Analisis fragmentasi GC-MS senyawa aktif antikanker leukemia fraksi kloroform umbi bawang tiwai (*Eleutherine bulbosa* (Mill.) Urb). *Jurnal Ilmiah Manuntung*, 5(1), 1–7.
- Li, Y., Ye, F., Wang, A., Wang, D., Yang, B., Zheng, Q., Sun, G., & Gao, X. (2016). Chronic arsenic poisoning probably caused by arsenic-based pesticides: Findings from an investigation study of a household. *International Journal of Environmental Research and Public Health*, 13(1), 133. <https://doi.org/10.3390/ijerph13010133>
- Mahajan, S., & Tuteja, N. (2005). Cold, salinity and drought stresses: An overview. *Archives of Biochemistry and Biophysics*, 444(2), 139–158. <https://doi.org/10.1016/j.abb.2005.10.018>
- Mroczek, A. (2015). Phytochemistry and bioactivity of triterpene saponins from *Amaranthaceae* family. *Phytochemistry Reviews*, 14(4), 577–605. <https://doi.org/10.1007/s11101-015-9394-4>
- Muflihunna, A., Mu'Nisa, A., & Hala, Y. (2021). Gas chromatography-mass spectrometry (GC-MS) analysis and antioxidant activity of sea-cucumber (*Holothurian atra* and *Holothurian edulis*) from Selayar Island. *Journal of Physics: Conference Series*, 1752(1), 012057. <https://doi.org/10.1088/1742-6596/1752/1/012057>
- Muthukrishnan, S., Prakathi, P., Sivakumar, T., Thiruvengadam, M., Jayaprakash, B., Baskar, V., Rebezov, M., Derkho, M., Zengin, G., & Shariati, M. A. (2022). Bioactive components and health potential of endophytic micro-fungal diversity in medicinal plants. *Antibiotics*, 11(11), 1533. <https://doi.org/10.3390/antibiotics11111533>
- Ogwu, M. C., Izah, S. C., & Joshua, M. T. (2025). Ecological and environmental determinants of phytochemical variability in forest trees. *Phytochemistry Reviews*, 24, 5109–5137. <https://doi.org/10.1007/s11101-025-10066-0>
- PubChem. (2024). Acetic acid. National Center for Biotechnology Information. <https://pubchem.ncbi.nlm.nih.gov/compound/Acetic-acid>
- PubChem. (2024). Palmitic acid (n-hexadecanoic acid). National Center for Biotechnology Information. <https://pubchem.ncbi.nlm.nih.gov/compound/985>
- PubChem. (2024). Palmitic acid; linoleic acid; hexadecanoic acid—Compound summary. National Center for Biotechnology Information. <https://pubchem.ncbi.nlm.nih.gov/>
- Rahardi, R. K., Setyaningsih, Y., & Dewi, R. P. (2019). Iconic meanings of traditional herbs and shrubs: Culture-specific based envirolinguistic perspective. *International Journal of Engineering and Advanced Technology*, 9(2), 1986–1992. <https://doi.org/10.35940/ijeat.B2530.129219>
- Rubab, M., Chelliah, R., Saravanakumar, K., Barathikannan, K., Wei, S., Kim, J. R., Yoo, D., Wang, M. H., & Oh, D. H. (2020). Bioactive potential of 2-methoxy-4-vinylphenol and benzofuran from *Brassica oleracea* L. var. capitata f. rubra (red cabbage) on oxidative and microbiological stability of beef meat. *Foods*, 9(5), 568. <https://doi.org/10.3390/foods9050568>
- Sanora, G. D., Mastura, E. Y., Handoyo, M. O. M., & Purnama, E. R. (2019). Identification of anticancer active compound from GC-MS test results of zodia leaves (*Evodia suaveolens*) ethanol extract. *Jurnal Biota*, 5(2), 89–95. <https://doi.org/10.19109/Biota.v5i2.3374>
- Sativa, N., & Agustin, R. (2018). Analisis uji kadar senyawa dan uji antioksidan ekstrak propolis coklat dari lebah *Trigona* sp. *JAGROS: Jurnal Agroteknologi dan Sains*, 2(2), 61–68.

- Singh, A., & Mina, U. (2025). Temperature stress and its effects on phytochemical dynamics and antioxidant activity in *Withania somnifera* (L.) Dunal. *Physiology and Molecular Biology of Plants*, 31(4), 675–692. <https://doi.org/10.1007/s12298-025-01594-2>
- Sukarti, S., & Illing, I. (2023). Analisis kandungan senyawa kimia dari ekstrak kloroform daun akar bulu (*Merremia vitifolia*) menggunakan GC-MS. *Journal of Chemical Science*, 5(2), 30–38.
- Syarifuddin, K. A., Burhamin, Y., & Saleha, R. (2023). Analisis kadar asam asetat dan alkohol pada apel manalagi (*Malus sylvestris* Mill.) berdasarkan variasi waktu fermentasi. *Jurnal Kesehatan Yamsi Makassar*, 7(2), 46–53. <https://doi.org/10.59060/jurkes.v7i2.291>
- Tang, S.-R., Sun, Y.-X., Gu, T.-T., Cao, F.-F., Shen, Y.-B., He, J.-P., Xie, Z.-X., & Li, C. (2022). Phenolic compounds from *Gomphrena globosa* L.: Phytochemical analysis, antioxidant, antimicrobial, and enzyme inhibitory activities in vitro. *Journal of Food*, 20(1), 218–227. <https://doi.org/10.1080/19476337.2022.2125584>
- Tjitrosoepomo, G. (2013). Taksonomi umum: Dasar-dasar taksonomi tumbuhan (Cet. 5). Gadjah Mada University Press.
- Trang, N. T. Q., Long, D. T., & Hong, H. T. K. (2021). Phytocomponents and antioxidant activity in the methanol extract of seed lotus (*Nelumbo nucifera* Gaertn.) from Viet Nam. *Research Journal of Biotechnology*, 16(12), 38–44. <https://doi.org/10.25303/1612rjbt3844>
- Ogwu, M. C., Izah, S. C., & Joshua, M. T. 2025. Ecological and environmental determinants of phytochemical variability in forest trees. *Phytochemistry Reviews*, 1-29.
- PubChem. 2024. Acetic Acid. National Center for Biotechnology Information. <https://pubchem.ncbi.nlm.nih.gov/compound/Acetic-acid>
- PubChem. 2024. Palmitic acid (n-Hexadecanoic acid). National Center for Biotechnology Information. Retrieved from <https://pubchem.ncbi.nlm.nih.gov/compound/985>.
- PubChem. 2024. Palmitic acid; Linoleic acid; Hexadecanoic acid – Compound Summary. National Center for Biotechnology Information. <https://pubchem.ncbi.nlm.nih.gov>
- Rahardi, R. K., Setyaningsih, Y., & Dewi, R. P. 2019. Iconic meanings of traditional herbs and shrubs: culture-specific based enviro-linguistic perspective. *International Journal of Engineering and Advanced Technology*. 9(2): 1986- 1992.
- Rubab, M., Chelliah, R., Saravanakumar, K., Barathikannan, K., Wei, S., Kim, J. R., Yoo, D., Wang, M. H., & Oh, D. H. 2020. Bioactive Potential of 2-Methoxy-4-vinylphenol and Benzofuran from *Brassica oleracea* L. var. *capitata* f. *rubra* (Red Cabbage) on Oxidative and Microbiological Stability of Beef Meat. *Foods (Basel, Switzerland)*, 9(5), 568. <https://doi.org/10.3390/foods9050568>
- Sanora, G. D., Mastura, E. Y., Handoyo, M. O. M., & Purnama, E. R. 2019. Identification of anticancer active compound from GC-MS test results of Zodia Leaves (*Evodia suaveolens*) ethanol extract. *Jurnal Biota*, 5(2), 89-95.
- Sativa, N., & Agustin, R. 2018. Analisis uji kadar senyawa dan uji antioksidan ekstrak propolis coklat dari Lebah Trigona SP. *JAGROS: Jurnal Agroteknologi dan Sains (Journal of Agrotechnology Science)*, 2(2), 61-68.
- Singh, A., & Mina, U. 2025. Temperature stress and its effects on phytochemical dynamics and antioxidant activity in *Withania somnifera* (L). dunal. *Physiology and Molecular Biology of Plants*, 31(4), 675-692.
- Sukarti, R., & Illing, I. 2023. Analisis kandungan senyawa kimia dari ekstrak kloroform daun akar bulu (*Merremia vitifolia*) Menggunakan Gc-Ms, 5(2):30-38.
- Syarifuddin, K. A., dan Saleha, R. 2023. Analisis kadar asam asetat dan alkohol pada apel manalagi (*malus sylvestris* mill.) Berdasarkan variasi waktu fermentasi. *Jurnal Kesehatan Yamsi Makassar*, 7(2), 46-53.

- Tang, S. R., Sun, Y. X., Gu, T. T., Cao, F. F., Shen, Y. B., He, J. P., & Li, C. 2022. Phenolic compounds from *Gomphrena globosa* L.: phytochemical analysis, antioxidant, antimicrobial, and enzyme inhibitory activities in vitro. *CyTA-Journal of Food*, 20(1), 218-227.
- Tjitrosoepomo, G. 2013. Dasar - Dasar Taksonomi Tumbuhan. Yogyakarta: Gadjah Mada University Press.
- Trang, N. T. Q., Long, D. T., & Hong, H. T. K. 2021. Phytocomponents and antioxidant activity in the methanol extract of seed lotus (*Nelumbo nucifera* Gaernt.) from Viet Nam. *Research Journal of Biotechnology Vol*, 16, 12.