

Bridging Local Wisdom and Modern Science: An Analysis of *Bawing*'s Multidimensional Significance

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ABSTRACT

Bawing, globally known as lemon basil (*Ocimum Basillicum*) is a culturally revered and scientifically significant herb native to Borneo, particularly Sabah of East Malaysia. This paper investigates the binary role of *bawing* in local wisdom and contemporary scientific research. Drawing on a mixed-method and multidisciplinary literature review, comprising of content analysis, participant observation, interviews, and laboratory analyses, the study examines *bawing*'s traditional significance in terms of cultural, spiritual and medicinal as well as its pharmacological potential. Beyond its culinary use, *bawing* is also regarded as a symbol of purification, protection, therapeutic healing and balance within indigenous communities. The qualitative data is reinforced by modern gas chromatography–mass spectrometry (GC-MS) analysis which also reveals that *bawing* is rich in bioactive compounds, including citral, caryophyllene, humulene, linalool, limonene, and estragole-substances known for their antimicrobial, antifungal, anti-inflammatory, anticancer, antibacterial, antiviral, and antistress properties. This multidisciplinary study highlights the potential of integrating local knowledge with scientific research to support the sustainable use of local herbal resources and promote innovation in products for beauty, aromatherapy, and therapeutic applications, in tandem with the RDCI and HGHV strategies of RMK-13.

Keywords: *Bawing*; Sabah lemon basil; local wisdom; modern science; phytochemical; cultural significance; spiritual significance; medicinal significance

INTRODUCTION

Since the paleolithic era, humans have used herbs for their ability to alleviate pain and promote healing. Across centuries, cultures worldwide have developed distinctive traditions to understand and harness the therapeutic potential of medicinal plants. While some of these practices may appear mystical or unconventional, and others more rational and evidence-based, they all share the same underlying purpose: to combat illness, relieve suffering, and improve quality of life. Each nation maintains its own beliefs and cultural practices concerning medicinal herbs. In Malaysia, located in Southeast Asia, such plants occupy a significant place in both traditional and contemporary healthcare. The state of Sabah, in East Malaysia on the island of Borneo, is particularly notable for its abundance of indigenous herbs and its rich repository of traditional or local healing knowledge. Among these, the local lemon basil, commonly known as *bawing* stands out for its aromatic, therapeutic, and cosmetic properties. However, its potential remains widely undeveloped due to the limited studies, documentation, and minimal youth engagement in herbal-based agro-entrepreneurship.

Taxonomically, *bawing* belongs to the family Lamiaceae (mint family). In Sabah, two commonly found basil species are *Ocimum basilicum* L. and *Ocimum tenuiflorum* L. Naturally *bawing* itself is a hybrid basil, often identified as *Ocimum africanum* Lour. or *Ocimum citriodorum*. Botanical classification often changes with new genetic data (DNA sequencing) and different interpretations by taxonomists. What was once classified as a separate species (*O. citriodorum*) is now often considered a hybrid (*O. × africanum*), and this leads to both names appearing in the literature. Generally, it is classified as *Ocimum basilicum*. It is characterized by a distinctive lemon scent attributed to citral in its essential oil. Originating from East Africa, it is now widely cultivated across

Asia, including India and Southeast Asia. Recent taxonomic studies have distinguished it from *O. americanum* and *O. basilicum* by providing detailed morphological keys for accurate identification. Locally, the herb is known as *selasih* in West Malaysia, while in East Malaysia, particularly in Sabah, it is referred to as *bawing*, *baing*, *siwot*, or *limpodos*, depending on geographic location.

Scientific studies at the global level, together with local wisdom, characterize *bawing* as a plant with multiple functions that can be categorized into various dimensions, including gastronomy and culinary arts, medicine, pharmaceuticals and nutraceuticals, cosmetics and personal care, as well as agritourism and environmental applications. Furthermore, this herb is also associated with spiritual and religious roles, particularly among Indian communities, where it is closely linked to the concept of Ayurveda (Sanjay Kumar Rao et al., 2023), and among Western societies, where it is connected to the legend of the Orthodox Church (Teodora Ivanova et al., 2023).

Customarily, *bawing* is widely used as an aromatic and flavor-enhancing ingredient in traditional cuisines, especially among the Bajau and Dusun communities. Internationally, basil enjoys global recognition as a culinary herb with distinctive qualities. Beyond gastronomy, *bawing*'s medicinal value and economic potential have been documented in literature. Its bioactive composition and pharmacological activities confer antibacterial, antioxidant, anti-aging, anti-inflammatory, antiseptic, antistress, anticancer, and cardioprotective properties (Kalita & Devi, 2023; Sari et al., 2022; Yuliani et al., 2022; Adithya Guntur et al., 2021; Fri Rahmawati & Silaban, 2021; Junita et al., 2020; Sholichah Rohmani & Muhammad, 2019; Lindawati et al., 2014). It has also been reported to exhibit anticancer potential (Sri Rahayu et al., 2017) and antiviral activity against the COVID-19 virus (Walton, 2021). Local wisdom and scientific evidence associate *bawing* with treating or alleviating ailments such as asthma, cold, cough, fever, headaches, constipation (Carynn Tanbuda et al., 2025; Wiart, 2024; Awang Kanak et al., 2021;2018; Foo et al., 2016;) diarrhea, warts, scabies, kidney disorders, cardiovascular disease, and stress (Harianja et al., 2021; Shaari et al., 2021; Septianawati et al., 2020; Junita et al., 2020). Additionally, it is valued in skincare for treating blemishes and acne (Ramadanti et al., 2021).

Despite its broad range of benefits, many Sabahans remain unaware that *bawing* is globally recognized as basil and possesses considerable commercial potential. In light of these circumstances, this multidisciplinary study aims to bridge the gap between local wisdom or cultural heritage and scientific validation by addressing the following objectives:

- i. To examine the traditional uses of *bawing* in cultural, spiritual, and medicinal contexts.
- ii. To analyse chemical composition and pharmacological potential of *bawing*.

METHODOLOGY

This study integrates qualitative and quantitative approaches, specifically content analysis, semi-structured interviews, and laboratory experimentation. Data sources included ethnobotanical and pharmacological journals, oral histories, and literature from local archives and indigenous knowledge repositories. Literature searches employed keywords such as *bawing*, *basil*, *tulsi*, *lemon basil*, *ritual healing*, *indigenous medicine in Borneo*, *bio-active compound of basil*, and *pharmacological properties of basil*, using databases including Scopus, ScienceDirect, and MyJurnal. Semi-structured interviews analysed local knowledge of *bawing* and its uses across Sabah ethnic groups, with primary themes classified into spiritual, cultural and medicinal significances. Eight key informants from the Dusun, Bajau, Murut, and Bisaya ethnic groups in Sabah (aged 40–76 years) participated in the study. Informants were selected for their expertise, including a traditional massage centre owner, a cosmetic manufacturer, a herb farmer, a lecturer and experienced homemakers. Interviews were conducted in both semi-formal and casual settings.

The interview session followed a flexible guide of open-ended questions exploring informants' knowledge, experiences, and uses of *bawing* that progressed from general background to specific cultural, medicinal, and spiritual applications, with probing to deepen responses. Each session lasted approximately 30 to 60 minutes and was conducted in Malay or in the informants' preferred language, where proficiency was available within the research team. The session was also audio-recorded with consent alongside field notes. Participants were recruited through purposive sampling based on community membership and recommendation, relevant

experience, and recognised knowledge, with occupational diversity ensuring varied perspectives. Interview data were transcribed verbatim and analysed using thematic content analysis, where coding identified recurring patterns grouped into spiritual, cultural, and medicinal themes. Quantitative laboratory data were analysed descriptively to support qualitative findings, and triangulation across literature, interviews, and experiments enhanced validity. Ethical standards were observed through informed consent, voluntary participation, confidentiality, and cultural sensitivity in handling indigenous knowledge, with appropriate permissions obtained and respectful representation ensured.

To validate literature findings and obtain primary data on *bawing*'s phytochemical composition, gas chromatography–mass spectrometry (GC–MS) was performed using an Agilent Technologies system (Santa Clara, CA, USA). The setup comprised a 7890A network gas chromatograph, 5975 inert mass selective detector, 7683B series autosampler injector (10 μ L), G1701DA GC/MSD ChemStation, and HP-5MS capillary column (30 m \times 0.25 mm i.d. \times 0.25 μ m film thickness) coated with 5% phenyl and 95% methylpolysiloxane. A 2 μ L chloroform-diluted essential oil sample was injected and analyzed under the following conditions: initial temperature 55 $^{\circ}$ C to 120 $^{\circ}$ C at 20 $^{\circ}$ C/min, ramp to 150 $^{\circ}$ C at 1.5 $^{\circ}$ C/min, then to 250 $^{\circ}$ C at 20 $^{\circ}$ C/min, held for 10 min; solvent delay 3 min; transfer line at 280 $^{\circ}$ C; helium carrier gas at 1 mL/min; split ratio 100:1. Injector, quadrupole, and detector temperatures were 220 $^{\circ}$ C, 150 $^{\circ}$ C, and 250 $^{\circ}$ C, respectively. Mass spectra were recorded in electron ionization mode at 70 eV, scan range 50–500 amu, scan rate 0.5 s, ion source at 230 $^{\circ}$ C. Compounds were identified by retention time (tR), mass fragmentation patterns, and comparison with published spectral data. Peak integration and quantification used Hewlett Packard ChemStation software (G1701BA Version B.01.00).

FINDINGS

Bawing Traditional Uses in Cultural, Spiritual and Medicinal Contexts

Based on interviews conducted with representatives of the Bajau, Bisaya, Dusun, and Murut ethnics in Sabah, the data pertaining to the local wisdom or traditional significance of *bawing* can be categorised into cultural, spiritual and medicinal perspectives. In terms of cultural function, *bawing* is dominantly considered as a domestic herb for culinary uses. It is utilized as a flavoring and aromatic enhancer in traditional ethnic cuisines, particularly among the Bajau and Dusun communities. It is incorporated into a variety of dishes, including *ikan masak ampap*, *hinava*, various types of soups, as well as vegetable preparations and fresh herb salads (*ulam-ulaman*). In addition, it is globally recognized as a culinary herb distinguished by its unique characteristics and inherent medicinal properties.

Beyond its culinary function, *bawing* is also considered as a sacred or holy plant affiliated with human life-cycle practices and customary rites. Its utilisation manifests the continuity of local wisdom, cultural tradition, belief and world view as well as the protection of social solidarity and equilibrium. Ritual practitioners and healers regard *bawing* as soul calmer (*penyejuk semangat dan jiwa raga*) highlighting its cooling and calming spiritual properties. It manifests primarily in symbolic rituals and social norms such as postnatal purification or maternal care, funeral ceremony and ancestral blessings as well as spiritual cleansing of human physical and spatial horizon.

In terms of protection, purification and spiritual cleansing, the aromatic plant is believed to safeguard household from evil spirits (makhluk halus) and shield individuals from harmful supernatural force (angin jahat), jinn, ghost or demon (jin/hantu/syaitan), or other negative energies. The *bawing* plant (leaves, seeds, stems or flowers) is normally prepared by boiling, burning or infusing it in water and sometimes it is combined with other herbs such as lime, lemongrass, betel leaf etc to purify and protect homes especially new houses, newborns, women in confinement (berpantang), or the sick and the recovering individuals. The herb is also used during and after the funeral ceremony. In those circumstances, shamans, traditional healer or village elders sprinkle *bawing* water or wave bundles of *bawing* plants to 'sweep' away harmful spirit or negative energies. According to a Murut informant, in the past, the villagers frequently traveled on foot within the village to reach relatively remote destinations. Customarily, they were provided with a decoction of *bawing*, which was consumed or kept as a remedy to protect themselves from disturbances by malevolent spirits or winds along the journey. For the same

reason, *bawing* leaves or plants were placed at each corner of the house or planted at the backyard or around the house as a means of spiritual protection and purification.

Furthermore, *bawing* is revered as a symbol of equilibrium that can restore energetic balance. In animism and paganism belief systems, plants possessing aromatic and binary sensory qualities (such as sweet-sour or cool-hot) are viewed as comprising healing equilibrium. In this understanding, the fragrance and cooling properties of *bawing* are believed to harmonize both bodily and spiritual energies, reinforcing its significance as a medium of purification, protection, and balance.

Apart from its cultural and spiritual importances, *bawing* also holds traditional medicinal significance and is employed for therapeutic healing and the management of minor ailments. All respondents indicated that *bawing* is traditionally utilised in the treatment of conditions associated with cough and the respiratory system. Furthermore, it functions as a hygienic agent for body cleansing and the elimination of body odour. Village midwives (bidan kampung) frequently incorporate *bawing* in recovery or confinement tonics and postpartume therapeutic practices (bertangas, berurut and berpilis), attributing its function as cooling and stabilising agents. Respondents also reported that *bawing* is utilised to alleviate bloating and nerve pain. Typically, the leaves are heated and the resulting steam is applied to the affected areas, particularly hands or feet. Additionally, it is employed in body treatment and massage therapy to relax or ease muscular and bodily discomfort. The empirical data concerning the local wisdom of *bawing*'s medicinal benefit is supported by findings from the existing literature. For example, studies conducted by scholars such as Carynn Tanbuda et al., (2025); Wiart (2024); Lin (2022); Awang Kanak et al., (2018; 2021), Foo et al., (2016) emphasised that *bawing* is associated with medicinal plant that can treat fever among the Lundayeh; coughs, gastric ulcer among the Brunei; asthma, cold, coughs, fever, headaches, constipation among the Bajau; and convulsion among the Bonggi and Molbog.

‘Bawing’ Chemical and Pharmacological Potential

The chemical composition of *Bawing* essential oil was analyzed using Gas Chromatography–Mass Spectrometry (GC–MS), revealing a complex mixture of bioactive compounds dominated by citral (~43.93%), caryophyllene (7.20%), and humulene (6.48%). These constituents indicate that *Bawing* belongs to the group of monoterpenoid- and sesquiterpenoid-rich aromatic plants. The presence of such compounds suggests diverse biological and pharmacological activities, including antimicrobial, anti-inflammatory, and antioxidant potential (Boulares et al. 2024; Ahmad et al. 2024).

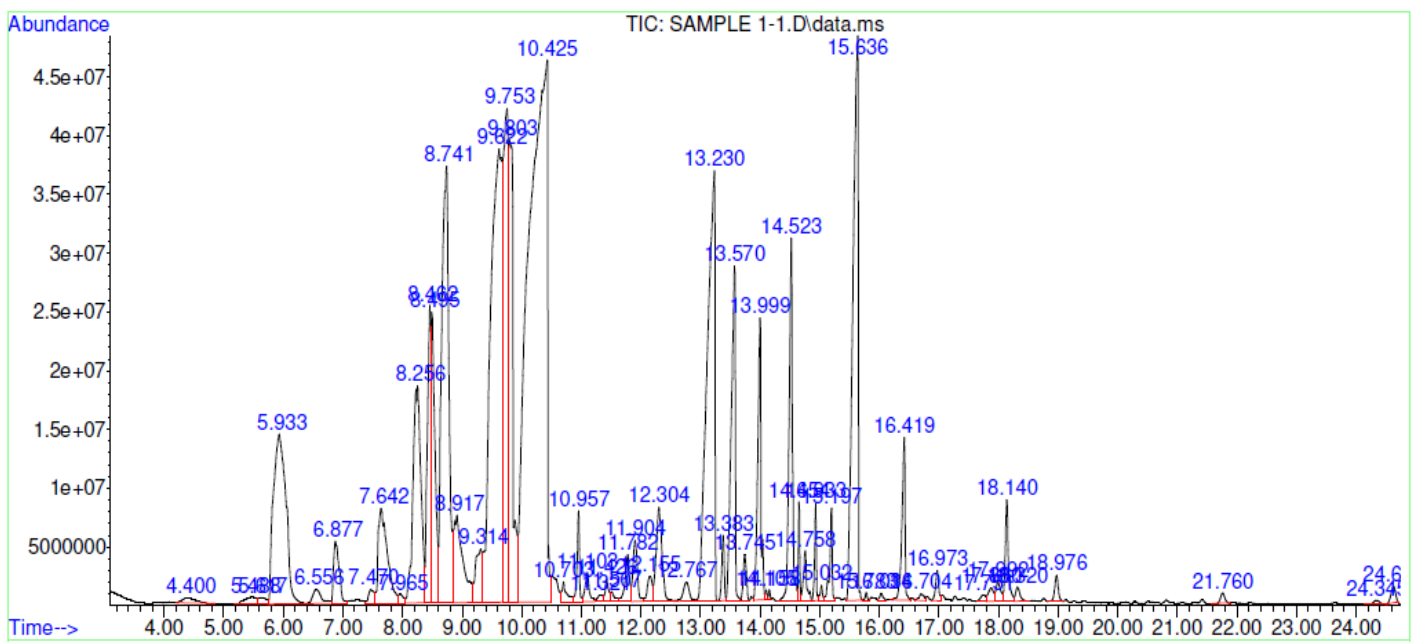


Figure 1: GCMS profile of *bawing* bio-active ingredients

Source: GC-MS report conducted at Centre for Instrumentation and Science Services, Universiti Malaysia Sabah.

Figure 1 presents the GC–MS chromatogram of *Bawing*, while Table 1 summarizes the identified major compounds. Citral, comprising both (E)- and (Z)-isomers, represents the principal compound responsible for the characteristic lemon-like aroma of *Bawing*. Caryophyllene and humulene are sesquiterpenes that contribute to its woody and earthy scent, respectively, and are known for their pharmacological effects, particularly in anti-inflammatory and cytotoxic pathways (Srivastava et al. 2018). Detailed GC–MS peak data Supplementary Tables S1.

Table 1: *Bawing* Top Compounds Identified (Based on Area % Contribution)

Compound	Retention Time (min)	Area (%)	Compound Class	CAS Number	Notable Properties / Biological Significance
Citral (E/Z isomers)	9.62 / 10.43	43.93	Monoterpenoid aldehyde	106-26-3 / 5392-40-5	Lemon-like aroma; antimicrobial, antifungal, anticancer
Caryophyllene	13.23	7.20	Sesquiterpene	87-44-5	Anti-inflammatory; CB ₂ receptor agonist; analgesic
Humulene	15.63	6.48	Sesquiterpene	6753-98-6	Anti-inflammatory; antibacterial; appetite suppressant
Geranyl acetate derivative	8.74	6.92	Monoterpene ester	695-12-5 / 50727-95-2	Floral fragrance; anti-inflammatory; antimicrobial
5-Hepten-2-one, 6-methyl-	5.93	4.69	Ketone	110-93-0	Fruity odor; possible oxidation marker
Caryophyllene oxide	16.42	1.11	Oxygenated sesquiterpene	1139-30-6	Antifungal; cytotoxic potential
Estragole	8.92	1.80	Phenylpropanoid	140-67-0	Aromatic flavor; digestive aid; potential toxicity at high dose

The uses and biological relevance of these compounds are summarized in Table 2. Citral, the dominant compound, is well-documented for its antimicrobial, antifungal, and anticancer properties, and widely applied in the fragrance and flavor industries (Telci et al. 2011). Caryophyllene acts as a CB₂ receptor agonist, potentially modulating inflammation without psychoactive effects, while humulene has been linked to anti-inflammatory and appetite-suppressing activities.

Table 2: *Bawing* major compounds and uses

Major Compound	Key Pharmacological Activities	Common Applications	References
Citral (E/Z)	Antimicrobial, antifungal, anti-inflammatory, anticancer	Perfume and flavoring; natural preservative	Boulaares et al. 2024
Caryophyllene	CB ₂ receptor agonist; analgesic; anti-inflammatory	Therapeutic oils; pain and inflammation management	Ahmad et al. 2024
Humulene	Anti-inflammatory; antibacterial; appetite suppressant	Cosmetic and nutraceutical formulations	Hussain et al. 2025
Geranyl acetate	Anti-inflammatory; antimicrobial	Fragrance and skincare products	Saraswathi et al. 2024

In addition to these major constituents, *Bawing* oil also contains several minor compounds (Supplementary Tables S2), such as limonene, α/β -pinene, linalool, and estragole, which contribute synergistically to its aromatic and pharmacological profile. Limonene and pinene enhance its citrus-pine aroma and exhibit bronchodilator and antibacterial actions. Linalool, known for its calming and antimicrobial properties, may enhance its use in aromatherapy and skin formulations. Detailed minor compound information are provided in Supplementary Tables S2.

DISCUSSION

Qualitative data analysis indicates that *bawing* is widely regarded as a symbol of purity, protection, therapeutic healing, and balance. These findings correspond with the phytochemical analysis of *bawing*, which demonstrates the presence of bioactive compounds such as citral, humulene, and linalool constituents recognized for their medicinal properties. Recent studies also validate many of its traditional uses, supporting claims of its antimicrobial, anti-inflammatory, antibacterial, antifungal and antioxidant activity (Y Yuliani et.al, 2022; Adithya Guntur et.al, 2021; Fri Rahmawati & Hertina Silaban, 2021; Fanny Maulida Junita et.al, 2020; Sholichah Rohmani dan Muhammad, 2019; Ema Lindawati et.al, 2014. For example, research done by Adithya Guntur et.al (2021) claimed that basil species is one of the plants that has antibacterial potential. In general, basil exhibits antibacterial, antifungal, antioxidant, anti-aging, anti-inflammatory, anti-carcinogenic, and cardiovascular agent properties. Sari et al. (2022) also demonstrated that combined extracts of lemon basil and key lime (*Citrus aurantifolia*) exert significant antibacterial effects against *Streptococcus mutans*, a primary oral pathogen. Among various ratios tested, the 30 % basil : 70 % lime combination produced the widest inhibition zone (16.75 mm), a result attributed to synergistic phytochemicals such as rosmarinic acid, eugenol, and β -sitosterol from basil, and d-limonene, flavonoids, and β -pinene from lime. These findings validate traditional Southeast Asian uses of both plants in oral, gastrointestinal, and respiratory remedies, while supporting their role as natural alternatives to synthetic antimicrobials.

Complementing these results, Tahira et al. (2013) quantified phytochemical variation in lemon basil parts, reporting the highest total phenols (215.43 mg GAE/100 g DW) and flavonoids (221 mg CE/100 g DW) in leaves, and the highest essential oil yield in flowers (0.28 %). Essential oils consistently outperformed methanolic extracts in antioxidant activity, with leaf oil exhibiting up to 74.11 % radical-scavenging potential at 200 ppm, corroborating its ethnomedicinal use as an antimicrobial, anti-inflammatory, and antioxidant agent. In a taxonomic and distributional context, Kalita and Devi (2023) recorded *O. africanum* for the first time in Northeast India, clarifying morphological distinctions from *O. americanum* and *O. basilicum*. They emphasized its characteristic citral-rich aroma and bioactive constituents, including caffeic acid, flavonoids, rosmarinic acid, and linalool, which underpin its therapeutic and aromatic value. Collectively, these studies strengthen the evidence base for lemon basil as a multifunctional plant with substantial applications in traditional medicine, functional foods, and industrial formulations, while also highlighting the importance of accurate species identification for conservation and commercial development.

This scientific recognition supports efforts to integrate traditional knowledge into health research. *Bawing* is a citrus-scented hybrid basil, widely cultivated in rural Sabah. Known for its small, bright green leaves and antimicrobial properties, it is commonly used in culinary dishes and traditional medicines. However, its cultural use far exceeds physical remedies, it is embedded in the cosmological and spiritual life of the communities that grow it. The continued use of *bawing* in rural communities demonstrates cultural resilience, but this knowledge is increasingly at risk due to urban migration and generational gaps. Many rituals associated with *bawing* are not formally documented or recorded, making them vulnerable to loss. Initiatives for community-based education and agro-cultural tourism may help reinvigorate interest in *bawing*'s cultural and medicinal relevance. The synthesis of local wisdom as well as cultural heritage and scientific discovery formulate new opportunities for integrative herbal innovation. Locally led research and product development using *bawing* can empower communities economically while treasuring its cultural as well as spiritual values.

CONCLUSION

This study demonstrates that *bawing* represents the integration of cultural heritage and medicinal science. It is not only a plant of pharmacological and therapeutic value but also a sacred herb imbued with cultural symbolism and spiritual significance. As both a cultural symbol and healing resource, *bawing* offers opportunities for sustainable development rooted in indigenous knowledge. Its preservation must therefore be holistic encompassing ecological sustainability, community participation, and cultural respect. This mixed-method study exclusively examines the cultural and scientific benefits of *bawing* through laboratory experiments, interviews, and content analysis. An interdisciplinary approach that integrates ethnography, survey research, pharmacology, and policy studies can address existing knowledge gaps and promote both conservation and responsible

innovation. Future ethnographic research should engage local practitioners to examine *bawing*'s relevance in contemporary spiritual and healing practices.

Ultimately, *bawing* represents more than a medicinal herb. It is a cultural symbol deeply rooted into the spiritual, medicinal, and social fabric of indigenous Sabahan life. Documenting and safeguarding such plant knowledge is vital not only for cultural continuity but also for enriching Malaysia's plural heritage. Recognizing *bawing*'s dual legacy of cultural heritage and scientific evidence invites a more inclusive model of sustainable development, one that values indigenous wisdom alongside modern science. A culturally respectful and scientifically rigorous approach to *bawing* may serve as a model for the preservation and study of other ethnobotanical resources in Borneo, particularly Sabah and beyond. By merging indigenous knowledge with scientific inquiry, this multidisciplinary study advances the sustainable use of local herbal resources and promotes product innovation in beauty, aromatherapy, and therapeutics, supporting the RDCI and HGHV strategies under RMK-13.

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Interview

1. Anita Mohamed. Director of AFCL Bioscience Sdn Bhd, KKIP. Interviewed on August, 2023.
2. Bibah Maidin. Housewife, Kg. Tukulilan, Tenom, Sabah. Interviewed on June, 2025.
3. Dr. Siti Aidah Hj Lokin. UMS Lecturer, Kg Gadong, Beaufort, Sabah. Interviewed on September, 2025
4. Hasanah Abu Bakar, Kg Pimping, Membakut, Sabah. Interviewed on June, 2025
5. Juhaini Dayun. Owner of Wanita di Hati Beauty & SPA, Tuaran, Sabah. Interviewed on July 2024.
6. Maimunah Abd Karim. Farmer, Kg Taun Gusi 2, Kota Belud, Sabah. Interviewed on April, 2025.
7. Rubayah Abdul Mumin. Housewife and former teacher, Kg. Kuala Abai, Kota Belud, Sabah. Interviewed on April, 2025.
8. Suriani Junaid. Housewife, Kg Solob, Sipitang, Sabah. Interviewed on June, 2025.

APPENDIX

Supplementary Table S1. Detailed GC–MS peak data.

Peak #	RT (min)	Compound Name	Area %	CAS Number	Quality
19	10.427	Citral / 2,6-Octadienal, 3,7-dimethyl-, (E)	21.89	106-26-3 / 141-27-5	91
16	9.620	Citral / 2,6-Octadienal, 3,7-dimethyl-, (Z)	11.12	106-26-3 / 5392-40-5	91
31	13.227	Caryophyllene	7.20	87-44-5	99
13	8.739	Cyclohexane, ethenyl- / Geranyl acetate epoxy	6.92	695-12-5 / 50727-95-2	43
17	9.753	Citral / 2,6-Octadienal, 3,7-dimethyl-, (Z)	5.65	106-26-3 / 5392-40-5	93
44	15.634	Humulene	6.48	6753-98-6	72
18	9.805	Citral / 2,6-Octadienal, 3,7-dimethyl-, (Z)	4.27	106-26-3 / 5392-40-5	95
4	5.932	5-Hepten-2-one, 6-methyl-	4.69	110-93-0	46
35	13.997	Humulene / 1,4,7-Cycloundecatriene	2.03	6753-98-6 / 1000062-61-9	97
11	8.465	(7,7-Dimethyl-2-oxobicyclo[2.2.1]hept-1-yl)-methanesulfonyl chloride	2.08	1000194-76-1	43

Supplementary Table S2. Minor compounds of Bawing essential oil and their uses

Compound	Area (%)	Biological / Industrial Significance
Limonene	0.27	Citrus aroma; anti-inflammatory; solvent
α/β -Pinene	0.15–0.18	Bronchodilator; antibacterial
β -Ocimene	0.76	Antifungal; antiviral
Linalool	1.92	Calming (aromatherapy); antimicrobial
Estragole	1.80	Flavoring; digestive aid
Geranyl acetate derivative	6.92	Fragrance; anti-inflammatory
5-Hepten-2-one, 6-methyl-	4.69	Flavoring; oxidation marker
Caryophyllene oxide	1.11	Antifungal; cytotoxic potential