

# Ethnomedicinal survey and scientific validation of inflammation-healing plants used by the Tengger community in East Java, Indonesia

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**Abstract.** *Bhagawan WS, Ekasari W, Agil M. 2025. Ethnomedicinal survey and scientific validation of inflammation-healing plants used by the Tengger community in East Java, Indonesia. Biodiversitas 26: 3160-3173.* This study investigates the profound ethnomedicinal knowledge of the Tengger community in East Java, Indonesia, with a specific focus on plant species traditionally used to manage inflammation and pain-related conditions. The primary objective was to meticulously document the medicinal plants utilized by the community and assess their pharmacological relevance through literature-based validation. Data were obtained through semi-structured interviews and in-depth observations with selected informants, using a snowball sampling technique. Quantitative indices (species use value, family use value, fidelity level, and informant consensus factor) were applied to evaluate each species' cultural and therapeutic significance. A total of 82 plant species belonging to 42 families were identified and utilized in various preparations to treat 15 inflammation and pain-related disorders. Notably, 4 of the 6 plant species with the highest species use value have been scientifically validated for their anti-inflammatory and analgesic activities, providing a solid foundation for the community's traditional knowledge. However, the pharmacological properties of *Borreria laevis* and *Elaeocarpus longifolius* remain unexplored. The enduring use of these medicinal plants is a testament to the community's rich ethnomedicinal tradition, and further pharmacological investigations may lead to the discovery of new therapeutic agents for treating inflammation and pain.

**Keywords:** Ethnomedicine, inflammation, medicinal plants, Tengger community

## INTRODUCTION

Inflammation is a critical immune response that protects the body from tissue damage and pathogen invasion (Ribaldone et al. 2018; Gusev and Zhuravleva 2022). In its acute phase, inflammation triggers the release of various chemical mediators, facilitates leukocyte recruitment, and removes damaged cells, thereby promoting tissue homeostasis (Fullerton and Gilroy 2016; Parisien et al. 2022). However, dysregulation or persistence of the inflammatory process can lead to chronic inflammation, which is closely linked to the development of numerous degenerative and metabolic disorders, including Alzheimer's disease, cancer, rheumatoid arthritis, type 2 diabetes, obesity, and cardiovascular diseases (Nishimura et al. 2009; Saltiel and Olefsky 2017; Herrero-Cervera et al. 2022). It is estimated that over 350 million individuals globally suffer from inflammation-related diseases and inflammatory pain (Ma et al. 2021; Zhou et al. 2021). While Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) remain the primary treatment for inflammation, their long-term use is frequently associated with adverse effects such as gastrointestinal bleeding, renal toxicity, and cardiovascular risks (Schjerning et al. 2020; Ribeiro et al. 2022; Wirth et al. 2024). This concern has prompted significant interest in exploring natural products, particularly medicinal plants, as safer and more sustainable

alternatives for inflammation management (Deng et al. 2022; Khumalo et al. 2022).

Historically, medicinal plants have served as a primary source of therapeutic agents for various health conditions, particularly as anti-inflammatory and analgesic remedies (Garg and Adams 2012; Forouzanfar and Hosseinzadeh 2018; Tasneem et al. 2019). The use of plants in traditional medicine is deeply rooted in human history and supported by centuries of ethnomedicinal practices (Claro et al. 2024; Wanzala and Minyoso 2024). Indonesia, recognized as one of the world's biodiversity hotspots, boasts an exceptional array of medicinal plant resources. With approximately 40,000 plant species and an estimated 7,500 species utilized in traditional medicine (Ministry of National Development Planning 2016; Cahyaningsih et al. 2021a, b, c), Indonesia represents a treasure trove of untapped pharmacological potential (Pusparini et al. 2023; Sanka et al. 2023; Sun et al. 2024).

Indonesia's extraordinary biodiversity is closely intertwined with its rich cultural diversity, resulting in a long-standing tradition of herbal medicine practices (von Rintelen et al. 2017). One of the most prominent legacies of Indonesian ethnomedicine is *jamu*, a traditional herbal remedy whose origin dates to the ancient Javanese kingdoms (Beers 2001; Laplante 2016). Historical records of *jamu* practices are evident in the Borobudur Temple reliefs (8th-9th century AD), which portray the use of

*kalpataru* leaves, symbolized as the "immortal tree" for medicinal purposes (Heinrich et al. 2017). Initially, *jamu* was exclusively consumed by members of the royal family. However, its use spread over time among the general population, incorporating diverse plant-based formulations. Among the most popular preparations are *beras kencur* (a blend of rice and aromatic ginger) and *kunir asem* (turmeric combined with tamarind), both widely recognized for their inflammation-healing properties (Tilaar and Widjaja 2016).

In Indonesia, the Tengger community represents the last remaining Hindu ethnic group on the island of Java that continues to uphold ancient traditions, including traditional medicine (Hefner 1985; Nugraha et al. 2024). Their proximity to montane forest ecosystems provides them access to abundant medicinal plant resources (Bhagawan et al. 2024). This unique interaction between cultural preservation and ecological richness has shaped their distinctive ethnomedicinal knowledge (Jadid et al. 2020). Despite ongoing ethnomedicinal documentation within the Tengger community over the past decade (Rohman et al. 2019; Kuspraningrum et al. 2020; Jadid et al. 2020; Bhagawan and Kusumawati 2021; Bhagawan et al. 2023a), existing studies have primarily focused on general medicinal plant use without specific attention to anti-inflammatory and analgesic applications. This gap in recorded knowledge hinders scientific validation and limits the potential integration of these traditional practices into modern healthcare systems. Therefore, this study aimed to document the use of medicinal plants by the Tengger community for treating inflammation and pain and to correlate these traditional uses with scientific evidence through a comprehensive literature review.

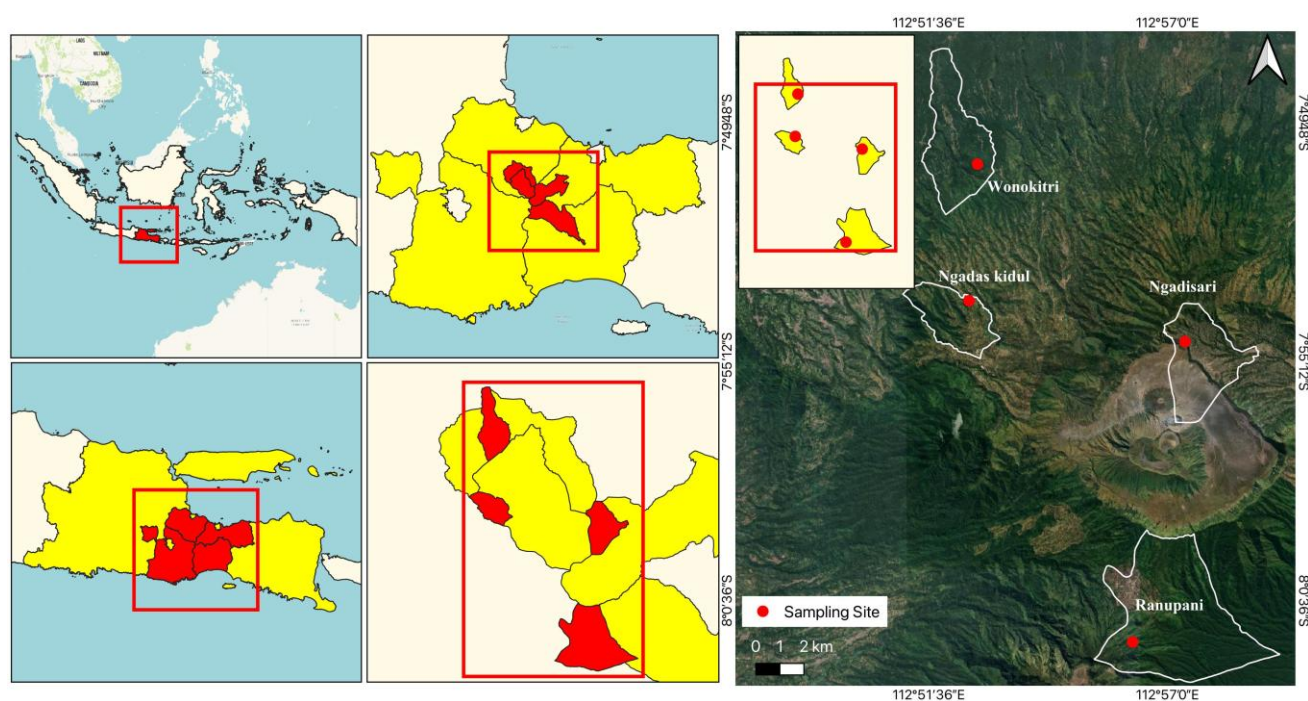
## MATERIALS AND METHODS

### Ethics and legal considerations

Ethical approval for this study was obtained from the Health Research Ethics Commission, Faculty of Pharmacy, Universitas Airlangga, Indonesia, under permit no. 29/LE/2024. The research adhered to the seven ethical principles established by the World Health Organization, including social and scientific value, fair distribution of burdens and benefits, risk minimization, prevention of exploitation, confidentiality and privacy protection, and informed consent. In compliance with international legal frameworks, the study followed the Convention on Biological Diversity regulations and the Nagoya Protocol on Access and Benefit Sharing. Additionally, ethical guidelines from the International Society of Ethnobiology (2006) were observed to ensure the responsible and respectful engagement with indigenous knowledge holders. Prior informed consent was obtained in writing from village authorities and verbally from all individual informants participating in the study.

### Background of the study area

To ensure the data's representativeness, fieldwork was conducted in four core Tenggerese Villages located within the Bromo Tengger Semeru National Park, each situated in a different administrative District: Ranupani (Lumajang District), Ngadas Kidul (Malang District), Ngadisari (Probolinggo District), and Wonokitri (Pasuruan District), as seen in Figure 1. These villages were selected due to their strong adherence to Tengger traditions and active use and preservation of ethnomedicinal knowledge.



**Figure 1.** The study area map shows the location of four core Tenggerese Villages within the Bromo Tengger Semeru National Park, East Java, Indonesia

Ranupani Village, situated in Lumajang District, is located at coordinates 8.0255°S, 112.9369°E and spans approximately 3.93 km<sup>2</sup>. Positioned at an altitude of over 2,100 meters above sea level (m asl), it is one of the highest inhabited settlements in Java (BPS-Statistics of Lumajang District 2024).

Ngadas Kidul Village, in Malang District, lies at 7.8971°S, 112.8752°E and covers an area of around 12.11 km<sup>2</sup>. Renowned for preserving ancient healing practices, it is the only recognized Tenggerese Village in Malang District (BPS-Statistics of Malang District 2024).

Ngadisari Village, located in Probolinggo District, is positioned at 7.9125°S, 112.9566°E, encompassing an area of approximately 29.89 km<sup>2</sup>. Owing to its proximity to Mount Bromo, it is one of the most frequently visited Tenggerese settlements and remains a vital center for ritual activities (BPS-Statistics of Probolinggo District 2024).

Wonokitri Village, in Pasuruan District, is situated at 7.8457°S, 112.8784°E, with a total area of about 13.72 km<sup>2</sup>. The village plays a central role in spiritual ceremonies, particularly as a key site for the annual *yadnya kasada* ritual in Pasuruan District (BPS-Statistics of Pasuruan District 2024).

The Bromo Tengger Semeru National Park's unique montane ecosystem shapes these villages' physical environment. The region is characterized by a highland tropical climate with temperatures between 7°C and 22°C, high humidity, and distinct wet and dry seasons. These conditions create a favorable microclimate for the growth of diverse medicinal flora, including montane herbs, shrubs, and trees commonly used in Tenggerese traditional medicine. The vegetation is predominantly sub-montane to montane forest, interspersed with alpine meadows and cultivated terraces, where local communities grow medicinal plants alongside food crops such as potatoes and cabbage. The volcanic soil in this area is highly fertile, further enhancing the growth of pharmacologically valuable plant species. Topographically, the region consists of rugged highlands, steep valleys, and volcanic ridges. This diversity in altitude and landscape contributes to high plant endemism and ecological variation, which are often reflected in local ethnobotanical classifications (<https://bromotenggersemeru.org/>). The daily lives of the Tengger people are deeply connected to this environment, and many traditional healing practices are rooted in ecological observations and sustainable plant harvesting methods that have been passed down through generations (Putri et al. 2022; Bhagawan et al. 2023a).

### Ethnomedicinal data collection

This ethnomedicinal study was conducted over 42 months, from September 2021 to February 2025, encompassing 27 field visits. Each visit lasted approximately four days. Data collection followed well-established ethnographic protocols, including participant observation, semi-structured interviews, and systematic documentation of traditional medicinal practices. Informants were selected through a snowball sampling technique, initiated with referrals from respected community members recognized for their knowledge of

traditional medicine. These included *dukun pandhita* (customary leaders), *dukun bayi* (traditional child healers), and *pak tinggi* (village leaders), who were consulted in each village due to their cultural authority and extensive experience with ethnomedicinal practices. The adoption of this sampling strategy was consistent with previous studies conducted in the Tengger region, ensuring cultural appropriateness and the reliability of the data collected (Jadid et al. 2020; Bhagawan et al. 2023a, b; Nugraha et al. 2024). Plant specimens were collected and subsequently identified based on field observations and interviews with informants. The initial identification process was informed by relevant ethnomedicinal research literature about the study area. To ensure taxonomic accuracy, the scientific names of plant species and their corresponding families were verified using the World Flora Online database (<https://wfoplantlist.org/>).

### Quantitative ethnomedicinal data analysis

To quantitatively assess ethnomedicinal knowledge, we employed a set of ethnomedicinal indices, including Species Use Value (SUV), Family Use Value (FUV), Informant Consensus Factor (ICF), and Fidelity Level (FL) (Andrade-Cetto and Heinrich 2011). These metrics allowed us to measure the medicinal plant use's relative cultural significance and consistency within the studied community.

#### Species Use Value (SUV)

The Species Use Value (SUV) index was applied to evaluate the relative importance of each medicinal plant species cited by the informants for treating inflammation and pain. This index helps to highlight species with high therapeutic relevance and widespread use (Phillips and Gentry 1993a; Hu et al. 2020).

$$SUV = \frac{\sum U}{N}$$

Where, SUV refers to the use value of a species, U is the total number of citations or mentions of the species. N is the total number of informants. A higher SUV indicates that a plant is frequently cited and thus culturally significant, while a lower SUV (approaching zero) suggests limited use and lower relevance in the local pharmacopoeia.

#### Family Use Value (FUV)

To understand the distribution of ethnomedicinal knowledge across different botanical families, we calculated the Family Use Value (FUV). This index provides insight into the average use value of all species within a given plant family, reflecting its overall contribution to traditional healing practices (Phillips and Gentry 1993b; Saensouk et al. 2024).

$$FUV = \frac{\sum UV}{N}$$

Where,  $\sum UV$  is the sum of use values of all species within a family. N is the total number of species within that family.

### *Informant Consensus Factor (ICF)*

The Informant Consensus Factor (ICF) was utilized to assess the degree of agreement among informants regarding using plants to treat specific disease categories. This measure reflects the level of shared traditional knowledge and can indicate whether plant selection is based on empirical experience or random choice (Trotter and Logan 1986; Ralte et al. 2024).

$$ICF = \frac{Nur - Nt}{Nur - 1}$$

Where, Nur is the number of use reports for a particular ailment category. Nt is the number of plant species used for that category. ICF values range from 0 to 1. A value near 1 indicates strong consensus and deliberate species selection, while values near 0 suggest a lack of agreement or random plant use among the population.

### *Fidelity Level (FL)*

The Fidelity Level (FL) index is used to determine the specificity of a plant species in treating particular ailments, such as inflammation and pain. Based on informant consensus, it reflects the degree of preference for using a specific species for a particular therapeutic purpose (Friedman et al. 1986; Leonti 2022).

$$FL = \frac{Np}{Nu} \times 100$$

Where, Nu denotes the number of informants who cited all known uses of a given species for various therapeutic purposes, including different inflammation- and pain-related conditions. Np represents the number of informants who specifically reported using the species to treat a particular inflammatory or pain-related disease. A higher FL value indicates greater agreement among informants on the specific use of the species for a targeted ailment, suggesting a strong ethnomedicinal relevance for that condition.

### **Pharmacological validation**

To scientifically validate the traditional use of the most cited plant species, a comprehensive literature review was performed to assess their pharmacological potential for inflammation and pain management. The search used multiple scientific databases, including PubMed, ScienceDirect, Google Scholar, Scopus, and Web of Science. Keywords such as "pain", "inflammation", "anti-inflammatory", and "cyclooxygenases" were combined with the scientific names of each plant species documented in the ethnomedicinal survey. This approach aimed to correlate traditional knowledge with available biomedical evidence to support the therapeutic relevance of the recorded species.

## **RESULTS AND DISCUSSION**

### **Demographic characteristics of informants**

Based on Table 1, 256 informants participated in the ethnomedicinal survey conducted across four core

Tenggerese Villages. The gender distribution was relatively balanced, with male informants slightly dominating (50.70%) compared to female informants (49.30%). This near-equal representation contrasts with many ethnomedicinal studies in other regions of Indonesia, where male knowledge holders often dominate due to sociocultural norms (Azis et al. 2020; Febriyanti et al. 2024). The balanced gender representation in this study may suggest a shared responsibility in practicing and transmitting ethnomedicinal knowledge among Tengger men and women.

The informants' ages ranged widely, with the majority between the ages of 21 and 60. Specifically, 35.94% of respondents were aged 21-40, and 39.85% were aged 41-60. Notably, individuals 61-80 (16.79%) still contributed significantly to the knowledge pool, indicating the persistence of traditional knowledge among elder community members. However, the smaller proportion of informants under 20 (4.69%) and more than 80 (2.73%) raises concerns about the continuity of ethnomedicinal traditions across generations. The aging of traditional knowledge holders, if not accompanied by active knowledge transmission, could gradually erode valuable ethnomedicinal wisdom (Sujarwo et al. 2014; Ouma 2022).

In terms of educational background, a significant portion of the informants had received only elementary education (53.92%), while others had attained junior high school (23.83%), senior high school (11.72%), or university-level education (3.90%). Only 6.63% of participants were illiterate. These figures highlight that ethnomedicinal knowledge is not exclusively retained by the illiterate or elderly but is also preserved among individuals with varying educational levels, supporting the role of formal and informal transmission within the community (Oktavia et al. 2022; Bhagawan et al. 2023b).

**Table 1.** Demographic characteristics of the informants participating in the ethnomedicinal survey

Distribution	Categories	Informants number	Percentage (%)
By gender	Male	130	50.70
	Female	126	49.30
By age range	Less than 20 years	12	4.69
	21-40 years	92	35.94
	41-60 years	102	39.85
	61-80 years	43	16.79
	More than 80 years	7	2.73
By education level	Illiterate	17	6.63
	Elementary school	138	53.92
	Junior high school	61	23.83
	Senior high school	30	11.72
	University education	10	3.90
By main profession	Farmer	240	93.76
	Customary leader	4	1.56
	Traditional child healer	5	1.95
	Government employee	7	2.73

Occupationally, most informants were farmers (93.76%), which reflects the agrarian lifestyle of the Tenggerese people and their close interaction with the natural environment, particularly medicinal plants. A small number of participants were customary leaders (1.56%), traditional child healers (1.95%), and government employees (2.73%), indicating that traditional medicinal knowledge spans various societal roles (Putri et al. 2022). Importantly, customary leaders and healers still serve as key figures in safeguarding and transmitting traditional practices, often acting as community educators and guardians of ritual knowledge.

### Diversity of medicinal plants utilized for inflammation and pain treatment

A total of 82 medicinal plant species belonging to 43 botanical families were documented in this study as being traditionally used by the Tenggerese community for managing inflammation and pain. Detailed ethnomedicinal knowledge associated with these species has been systematically compiled and presented in Table 2. This includes key ethnomedicinal indices such as the Species Use Value (SUV), Family Use Value (FUV), and Fidelity Level (FL), alongside scientific names, botanical family affiliations, local (vernacular) names, traditional indications, plant parts used, methods of preparation, and routes of administration. The recorded diversity underscores the richness of Tenggerese ethnomedicinal knowledge and highlights the community's reliance on a broad spectrum of plant resources for treating inflammatory conditions and pain-related ailments.

#### Distribution of plant families and their FUV

Based on the data presented in Table 2, 42 botanical families were identified as being utilized by the Tenggerese community to treat inflammation and pain. Among these, Zingiberaceae emerged as the most dominant, with 11 documented species, followed by Solanaceae and Asteraceae (6 species), Poaceae, and Rubiaceae, each represented by four species. The remaining families contributed between one and three species to the overall medicinal plant inventory. The prominent use of the Zingiberaceae family in treating inflammation and pain is consistent with findings from previous ethnomedicinal studies in other countries, such as Gampaha, Sri Lanka (Napagoda et al. 2018) and Arunachal Pradesh, India (Namsa et al. 2009), where members of this botanical family are also widely utilized for similar therapeutic purposes.

Concerning Family Use Value (FUV), the highest values were recorded for Acoraceae (0.85), followed by Elaeocarpaceae (0.46), Apiaceae (0.32), Piperaceae (0.23), Lycoperdaceae and Solanaceae (0.20). Interestingly, these families were often represented by only one or two species, suggesting that high FUV does not necessarily correlate with species richness within a family. Instead, the FUV appears to be more influenced by the cultural importance and frequency of use of specific species within each family (Najem et al. 2019). Moreover, the elevated FUV values may also reflect the pharmacological potential of these families, many of which are known to contain rich

concentrations of bioactive compounds with recognized antibacterial, antioxidant, and anti-inflammatory properties (Sharma et al. 2024).

#### Key plant species with the highest SUV

This study documented 82 medicinal plant species for their traditional use in treating inflammation and pain among the Tengger Tribe. The most frequently used species was *Acorus calamus* (SUV: 0.84), followed by *Foeniculum vulgare* (0.73), *Borreria laevis* (0.57), *Elaeocarpus longifolius* (0.46), *Allium sativum* (0.35), *Mikania cordata* (0.31), and *Artemisia vulgaris* (0.26). All seven species showed SUV above 0.25 (Table 2).

*Acorus calamus*, locally known in Indonesia as *dringu* or *jeringau*, emerged as the species with the highest SUV, frequently cited for its traditional use in managing inflammatory and pain conditions. Its prominence in local knowledge is further supported by high citation frequency in other ethnomedicinal studies across Indonesia (Navia et al. 2022; Rambey et al. 2024; Singarimbun et al. 2024). These findings highlight *A. calamus* as a culturally significant species with strong potential for further pharmacological investigation in the context of inflammation-related disorders.

### Plant parts, methods of preparation, and modes of administration

In this study, various parts of medicinal plants were reported to be used by the Tenggerese community to treat inflammation and pain-related ailments (Figure 2.A). Based on the frequency of use, leaves were the most utilized plant part, accounting for 29 instances (35.40%). This was followed by the fruit and rhizome parts, each used in 11 cases (13.40%), and fruits used in 8 cases (9.80%). The dominant use of leaves is consistent with other ethnomedicinal studies, which suggest that leaves are preferred due to their ease of harvest, sustainability, and high concentrations of bioactive compounds such as flavonoids, alkaloids, and tannins (Bhagawan et al. 2022). The frequent utilization of rhizomes and fruits may also be attributed to their storage of secondary metabolites known for their anti-inflammatory and analgesic properties. Significantly, the preference for using leaves and above-ground plant parts contributes positively to conservation efforts, as it avoids the need to uproot entire plants. This sustainable harvesting practice helps preserve local biodiversity, particularly in sensitive ecosystems such as the Bromo Tengger Semeru highlands, where many of these species grow.

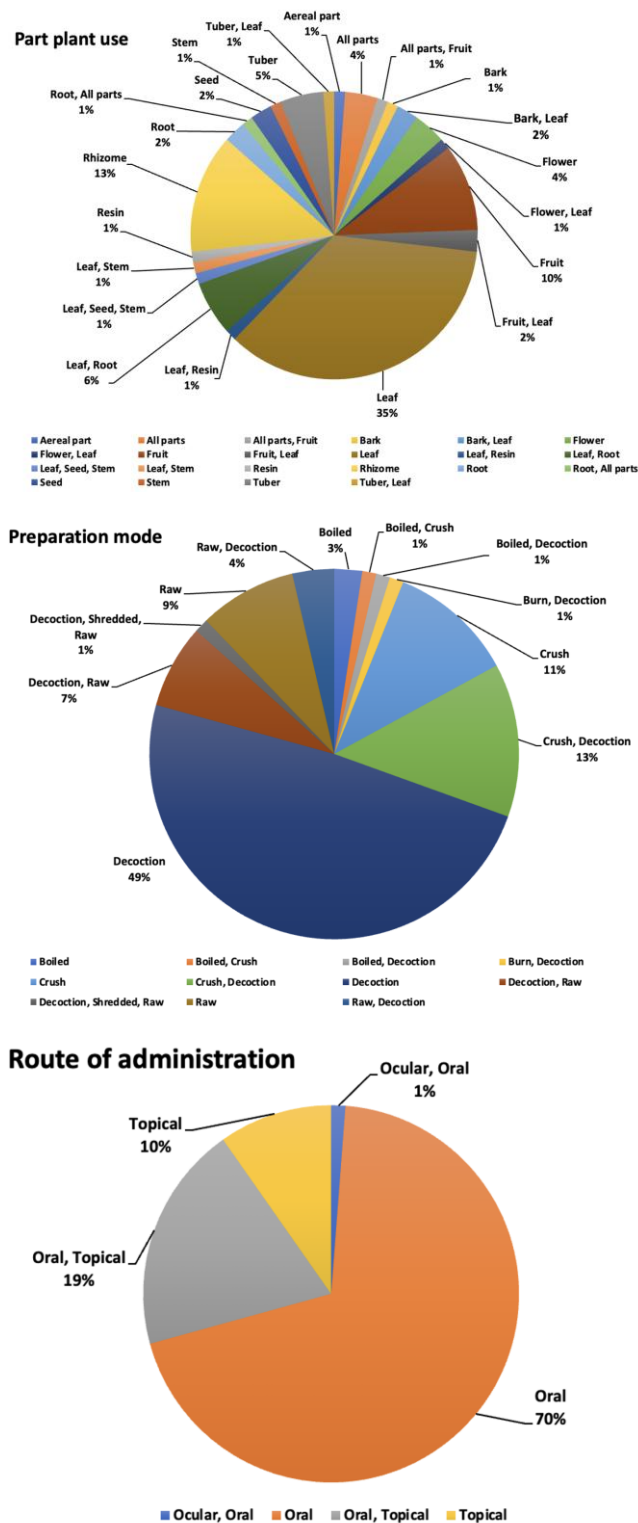
The diversity in preparation methods illustrates the rich ethnopharmacological knowledge embedded within the community and tailored to the specific therapeutic indications of each plant species (Figure 2.B). In terms of modes of administration (Figure 2.C), most remedies were administered orally (57 uses, 70%), underscoring the systemic nature of many traditional treatments for internal inflammatory conditions. Topical applications were reported in 8 cases, typically used to address localized symptoms such as muscle pain. Ocular administration, the least frequent route, was recorded only once and likely corresponds to specific traditional treatments for eye pain.

**Table 2.** Medicinal taxa utilized by the Tengger community for the treatment of inflammation and pain

Family (FUV) and Species name	Local name	Part used	Diseases treated (FL)	Preparation	Administration	SUV
<b>Acanthaceae</b> (0.05)						
<i>Andrographis paniculata</i>	Sambiloto	Leaf	Abdominal pain (21.42%), fever (85.71%), General pain (64.28%), Muscle pain (7.14%), swelling (7.14%), Wound infection (21.42%)	Boiled, Decoction	Oral	0.05
<b>Acoraceae</b> (0.85)						
<i>Acorus calamus</i>	Dringu	Leaf	Fever (100%)	Crush	Topical	0.84
<b>Asphodelaceae</b> (0.05)						
<i>Aloe vera</i>	Lidah buaya	Leaf	Wound infection (100%)	Crush	Topical	0.05
<b>Amaranthaceae</b> (0.03)						
<i>Beta vulgaris</i>	Buah bit	Tuber	Fever (100%), Wound infection (100%)	Raw	Oral	0.03
<b>Amarillydaceae</b> (0.16)						
<i>Allium cepa</i>	Bawang merah	Tuber	Fever (46.87%), Abdominal pain (21.87%)	Crush	Oral	0.12
<i>Allium fistulosum</i>	Bawang pre	Leaf	Rheumatic (100%)	Decoction	Oral	0.01
<i>Allium sativum</i>	Bawang putih	Tuber	Abdominal pain (4.44%), fever (94.44%), General pain (1.11%)	Crush	Topical	0.35
<b>Annonaceae</b> (0.10)						
<i>Annona muricata</i>	Sirsak	Leaf	Fever (7.78%), swelling (6.67%)	Decoction	Oral	0.02
<i>Cananga odorata</i>	Kenanga	Flower	Rheumatic (100%)	Decoction	Oral	0.19
<b>Apiaceae</b> (0.32)						
<i>Coriandrum sativum</i>	Ketumbar	Fruit	Abdominal pain (100%)	Decoction, Raw	Oral	0.07
<i>Foeniculum vulgare</i>	Adas	Leaf	Fever (93.58%), General pain (36.36%)	Crush	Topical, Oral	0.73
<i>Pimpinella pruatjan</i>	Purwoceng	Root	General pain (18.91%), Muscle pain (84.09%)	Decoction	Oral	0.18
<b>Apocynaceae</b> (0.04)						
<i>Alstonia scholaris</i>	Pule	Bark, Leaf	Fever (92.30%), Muscle pain (38.46%), backache (7.69%)	Decoction	Oral	0.05
<i>Alyxia reinwardtii</i>	Pulosari	Leaf	Fever (100%), Toothache (12.50%)	Decoction	Oral	0.03
<i>Plumeria rubra</i>	Kamboja	Flower, Leaf	Headache (100%), Rheumatic (9.09%), Swelling (18.18%), Toothache (18.18%)	Decoction	Oral	0.04
<b>Araliaceae</b> (0.03)						
<i>Polyscias scutellaria</i>	Mangkokan	Leaf	Wound infection (100%), swelling (77.78%)	Decoction	Oral	0.03
<b>Arecaceae</b> (0.01)						
<i>Areca catechu</i>	Jambe	Fruit	Fever (100%), toothache (100%), Abdominal pain (100%)	Raw	Oral	0.01
<b>Asteraceae</b> (0.12)						
<i>Artemisia vulgaris</i>	Ganjan	Leaf, Resin	Swelling (40.29%), Wound infection (95.52%)	Decoction, Raw	Oral, Topical	0.26
<i>Elephantopus scaber</i>	Tapak liman	Leaf	General pain (100%), Rheumatic (40%)	Decoction	Oral	0.01
<i>Gynura procumbens</i>	Sambung nyawa	Leaf	Wound infection (100%)	Decoction	Oral	0.01
<i>Helianthus annuus</i>	Bunga matahari	Leaf	Wound infection (100%)	Decoction	Oral	0.01
<i>Mikania cordata</i>	Sempretan	Leaf, Root	Fever (38.75%), Muscle pain (1.25%), General pain (15%), swelling (97.50%), Wound infection (46.25%)	Crush, Decoction	Topical, Oral	0.31
<i>Pluchea indica</i>	Beluntas	Leaf	Rheumatic (100%), Toothache (100%)	Decoction	Oral	0.01
<b>Athyriaceae</b> (0.18)						
<i>Diplazium esculentum</i>	Pakis	Leaf	General pain (47.91%), Wound infection (93.75%)	Decoction, Crush	Oral, Topical	0.18
<b>Basellaceae</b> (0.19)						
<i>Anredera cordifolia</i>	Binahong	Leaf	General pain (66%), Rheumatic (60%), swelling (64%), Wound infection (68%)	Decoction, Crush	Oral, Topical	0.19
<b>Brassicaceae</b> (0.12)						
<i>Brassica chinensis</i>	Sawi hijau	Leaf	Fever (100%)	Raw, Decoction	Oral	0.04
<i>Raphanus raphanistrum</i>	Lobak	Tuber, Leaf	General pain (49.12%), Rheumatic (50.87%), Abdominal pain (94.73%), Muscle pain (94.73%)	Decoction, Shredded, Raw	Oral	0.22

<b>Canaceae</b> (0.01)							
<i>Canna indica</i>	Ganyong	Rhizome	Abdominal pain (100%)	Boiled	Oral		0.01
<b>Convolvulaceae</b> (0.05)							
<i>Jacquemontia paniculata</i>	Tirem	Leaf	Muscle pain (100%)	Boiled	Oral		0.05
<b>Cluseaceae</b> (0.01)							
<i>Garcinia × mangostana</i>	Manggis	Fruit	Mouth ulcer (100%)	Raw	Oral		0.01
<b>Elaeocarpaceae</b> (0.46)							
<i>Elaeocarpus longifolius</i>	Jambu wer	Fruit	Abdominal pain (100%), Fever (55.93%)	Decoction, Raw	Oral		0.46
<b>Euphorbiaceae</b> (0.05)							
<i>Jatropha curcas</i>	Jarak pagar	Leaf, Seed, Stem	Fever (15.38%), Mouth ulcer (15.38%), Muscle pain (84.61%), Abdominal pain (15.38%), toothache (7.69%)	Crush, Decoction	Oral, Topical		0.05
<b>Fabaceae</b> (0.03)							
<i>Abrus laevigatus</i>	Krangean	Leaf	Backache (100%)	Decoction	Oral		0.02
<i>Euchresta horsfieldii</i>	Pronojiwo	Leaf	Fever (20%), headache (20%), Wound infection (53.34%)	Burn, Decoction	Topical, Oral		0.06
<i>Sesbania grandiflora</i>	Turi	Flower	Internal body pain (100%)	Decoction	Oral		0.01
<b>Lamiaceae</b> (0.02)							
<i>Mentha × piperita</i>	Min	Leaf	Mouth ulcer (83.34%), headache (33.34%)	Decoction	Oral		0.02
<b>Lauraceae</b> (0.09)							
<i>Cinnamomum sintoc</i>	Sintok	Bark, Leaf	General pain (100%), Rheumatic (100%)	Decoction	Oral		0.12
<i>Cinnamomum verum</i>	Keningar	All parts	Abdominal pain (100%)	Decoction	Oral		0.07
<b>Leguminosae</b> (0.08)							
<i>Erythrina variegata</i>	Dadap srep	Leaf	Fever (61.29%), Sore throat (32,25%), Rheumatic (64.51%)	Raw, Decoction	Topical, Oral		0.12
<i>Tamarindus indica</i>	Asem	Fruit, Leaf	Fever (6.66%), Mouth ulcer (93,33%)	Decoction	Oral		0.05
<b>Lycoperdoceae</b> (0.20)							
<i>Calvatia bovista</i>	Jamur impes	All parts	Swelling (67.30%), Muscle pain (65.38%)	Cush, Decoction	Topical, Oral		0.20
<b>Loranthaceae</b> (0.01)							
<i>Dendrophthoe pentandra</i>	Kemlanden	Leaf	Fever (100%)	Decoction	Oral		0.01
<b>Melastomataceae</b> (0.01)							
<i>Melastoma malabathricum</i>	Senggani	Leaf	Wound infection (100%)	Crush	Topical		0.01
<b>Musaceae</b> (0.01)							
<i>Musa × paradisiaca</i>	Pisang	Resin	Wound infection (100%)	Raw	Topical		0.01
<b>Myrtaceae</b> (0.01)							
<i>Melaleuca leucadendron</i>	Kayu putih	Leaf	Fever (100%)	Decoction	Oral		0.01
<i>Psidium guajava</i>	Jambu biji	Leaf	Abdominal pain (100%)	Decoction	Oral		0.01
<b>Oxalidaceae</b> (0.01)							
<i>Averrhoa bilimbi</i>	Blimbing wuluh	Fruit	Mouth ulcer (100%)	Raw	Oral		0.01
<b>Parmeliaceae</b> (0.16)							
<i>Usnea barbata</i>	Jenggot wesi	All parts	Abdominal pain (9.75%), General pain (90.24%), Rheumatic (14.63%), Swelling (100%), Wound infection (92.68%)	Decoction, Crush	Oral, Topical		0.16
<b>Phyllanthaceae</b> (0.01)							
<i>Phyllanthus niruri</i>	Meniran	Leaf	Abdominal pain (100%)	Decoction	Oral		0.01
<b>Piperaceae</b> (0.23)							
<i>Piper betle</i>	Sirih	Leaf	Wound infection (40.67%), General pain (49.15%), Abdominal pain (40.67%), swelling (45.76%), Mouth ulcer (22.03%)	Decoction	Oral		0.23
<b>Poaceae</b> (0.07)							
<i>Cymbopogon citratus</i>	Sereh	Leaf, Stem	Abdominal pain (41.67%), Headache (75%), Fever (66.67%)	Decoction	Oral		0.09
<i>Cynodon dactylon</i>	Grinting	Stem	Wound infection (100%)	Crush	Topical		0.01
<i>Imperata cylindrica</i>	Alang-alang	Root, All parts	Abdominal pain (70.58%), fever (67.64%), Mouth ulcer (67.64%), Muscle pain (79.41%), toothache (79.41%)	Decoction, Raw	Oral		0.13

<i>Phragmites karka</i>	<i>Gembokan</i>	Leaf, Root	Rheumatic (100%)	Decoction	Oral	0.07
<b>Polypodiaceae (0.11)</b>						
<i>Microsorium buergerianum</i>	<i>Pangotan</i>	Leaf, Root	Abdominal pain (79.31%), fever (79.31%), General pain (100%)	Crush, Decoction	Oral, Topical	0.11
<b>Plantaginaceae (0.09)</b>						
<i>Digitalis purpurea</i>	<i>Digitalis</i>	Leaf, Root	Wound infection (100%)	Decoction	Oral	0.01
<i>Plantago major</i>	<i>Suri pandak</i>	Leaf, Root	Abdominal pain (23.91%), fever (91.30%), General pain (86.95%)	Decoction	Oral	0.17
<b>Pteridaceae (0.01)</b>						
<i>Adiantum peruvianum</i>	<i>Paku suplir</i>	Root	General pain (100%)	Decoction	Oral	0.01
<b>Rubiaceae (0.16)</b>						
<i>Borreria laevis</i>	<i>Tepung otot</i>	Aerial part	Swelling (83.78%), Rheumatic (52.70%), Internal body pain (58.78%), General pain (59.45%)	Crush	Topical	0.57
<i>Coffea arabica</i>	<i>Kopi</i>	Seed	Headache (100%)	Decoction	Oral	0.04
<i>Morinda citrifolia</i>	<i>Bentis</i>	Fruit, Leaf	General pain (100%), Rheumatic (100%)	Decoction, Raw	Oral	0.02
<i>Paederia foetida</i>	<i>Sembukan</i>	Leaf	Mouth ulcer (100%)	Raw	Oral	0.01
<b>Rutaceae (0.01)</b>						
<i>Citrus aurantiifolia</i>	<i>Jeruk nipis</i>	Fruit	Abdominal pain (100%)	Decoction, Raw	Oral	0.01
<b>Selaginellaceae (0.01)</b>						
<i>Selaginella doederleinii</i>	<i>Cakar ayam</i>	Leaf	Fever (100%), Oedema (100%)	Decoction	Oral	0.01
<b>Solanaceae (0.20)</b>						
<i>Brugmansia suaveolens</i>	<i>Kecubung gunung</i>	Flower	Eye pain (94.54%), Fever (5.45%)	Raw, Decoction	Ocular, Oral	0.21
<i>Capsicum chinense</i>	<i>Lombok terong</i>	Fruit	Muscle pain (100%)	Crush	Topical	0.02
<i>Physalis angulata</i>	<i>Ciplukan</i>	All parts, Fruit	Backache (55.04%), Muscle pain (93.57%), Rheumatic (58.71%)	Decoction	Oral	0.12
<i>Solanum betaceum</i>	<i>Terong belanda</i>	Fruit	Abdominal pain (51.21%), Mouth ulcer (36.58%)	Raw	Oral	0.16
<i>Solanum nigrum</i>	<i>Ranti</i>	Leaf	Fever (100%)	Decoction	Oral	0.21
<i>Solanum tuberosum</i>	<i>Kentang</i>	Tuber	Swelling (100%)	Boiled, Crush	Oral, Topical	0.05
<b>Typhaceae (0.08)</b>						
<i>Typha angustifolia</i>	<i>Ampet</i>	Bark	Abdominal pain (100%)	Decoction	Oral	0.08
<b>Zingiberaceae (0.12)</b>						
<i>Alpinia galanga</i>	<i>Laos</i>	Rhizome	Abdominal pain (100%), headache (30.00%)	Decoction	Oral	0.03
<i>Curcuma aeruginosa</i>	<i>Temu ireng</i>	Rhizome	Abdominal pain (50.00%), General pain (50.00%)	Decoction	Oral	0.01
<i>Curcuma heyneana</i>	<i>Temu giring</i>	Rhizome	Rheumatic (100%)	Decoction	Oral	0.03
<i>Curcuma longa</i>	<i>Kunir</i>	Rhizome	Abdominal pain (87.23%), Fever (63.82%), General pain (53.19%), Headache (63.82%), Swelling (17.02%)	Decoction, Crush	Oral, Topical	0.18
<i>Curcuma xanthorrhiza</i>	<i>Temulawak</i>	Rhizome	Abdominal pain (75.00%), General pain (50.00%)	Decoction	Oral	0.01
<i>Elettaria cardamomum</i>	<i>Kapulaga</i>	Seed	Abdominal pain (100%)	Decoction	Oral	0.01
<i>Kaempferia galanga</i>	<i>Kencur</i>	Rhizome	Abdominal pain (100%)	Decoction	Oral	0.08
<i>Kaempferia rotunda</i>	<i>Kunci pepet</i>	Rhizome	Abdominal pain (80.00%), fever (5.00%), General pain (100%), swelling (85.00%)	Decoction, Crush	Oral, Topical	0.07
<i>Zingiber cassumunar</i>	<i>Bangle</i>	Rhizome	Abdominal pain (14.28%), Fever (42.85%), Headache (42.85%), Muscle pain (57.14%), Rheumatic (28.57%)	Decoction, Crush	Oral, Topical	0.02
<i>Zingiber officinale</i>	<i>Jahe</i>	Rhizome	Abdominal pain (43.75%), General pain (43.75%), headache (75.00%)	Decoction	Oral	0.11
<i>Zingiber zerumbet</i>	<i>Lempuyang</i>	Rhizome	Fever (45.00%), General pain (40.00%), Muscle pain (45.00%), Rheumatic (85.00%), swelling (90.00%)	Crush, Decoction	Topical, Oral	0.08



**Figure 2.** A. Plant part uses, B. Preparation methods, C. Administration routes employed by the Tengger community for treating inflammation and pain-related ailments

**Categories of inflammatory conditions and ICF values**

In this ethnomedicinal investigation, the Tenggerese community was found to utilize medicinal plants to treat a broad spectrum of inflammation-related ailments, totaling

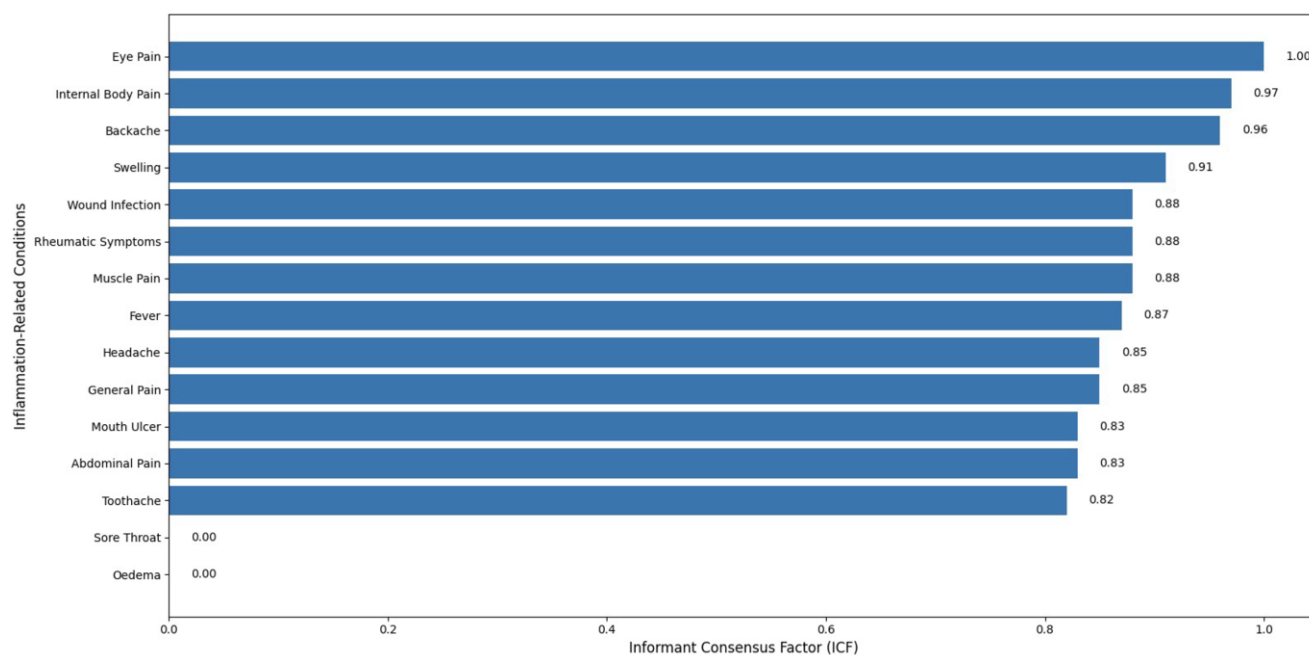
15 distinct categories. The Informant Consensus Factor (ICF) values for these categories ranged from 0.00 to 1.00, reflecting varying degrees of agreement among informants regarding the selection of plant species for each condition (Figure 3).

The highest ICF value was observed for eye pain (ICF: 1.00), followed closely by internal body pain (ICF: 0.97) and backache (ICF: 0.96). These high values suggest that a relatively small number of plant species were repeatedly cited by multiple informants for the same condition, indicating high ethnomedicinal agreement and possibly reflecting the perceived efficacy of these traditional remedies. Other conditions with high consensus included swelling (ICF: 0.91), muscle pain (ICF: 0.88), rheumatic symptoms (ICF: 0.88), fever (ICF: 0.87), and headache (ICF: 0.85). This indicates that the use of medicinal plants for these common inflammatory symptoms is well-established and widely shared across the community. Conversely, oedema and sore throat exhibited the lowest ICF values (0.00), suggesting a lack of consensus among informants. This may be due to the sporadic occurrence of these conditions or limited knowledge transmission related to their treatment within the community (Abebe and Chane Teferi 2021). Similarly, low ICF values may highlight areas where ethnomedicinal knowledge is more fragmented or where biomedical health services have partially supplanted traditional practices (Xiong and Long 2020; Kharchoufa et al. 2021).

**Fidelity level of medicinal plant species**

Based on fidelity level analysis, the medicinal plants used for treating inflammation and pain among the Tengger community are presented in Table 2. The recorded plant species' Fidelity Levels (FL) ranged from 1.11% to 100%, indicating varying degrees of informant agreement on their specific use. *Brugmansia suaveolens* exhibited the highest FL value for eye pain (FL: 94.54%), while *Sesbania grandiflora* showed a perfect fidelity level (FL: 100%) for internal body pain. For backache, *Abrus laevigatus* was the most cited species (FL: 100%), whereas for swelling, *Usnea barbata* and *Solanum tuberosum* were the most relevant. In treating muscle pain, *Jacquemontia paniculata* and *Capsicum chinense* also showed maximum fidelity (FL: 100%).

Similarly, *Plumeria rubra* and *Coffea arabica* were the most specific for headache, while *Areca catechu* and *Pluchea indica* were highly cited for toothache (FL: 100%). Mouth ulcers were treated with *Averrhoa bilimbi*, *Garcinia mangostana*, and *Paederia foetida*, all having FL values of 100%. Seven species were used exclusively for rheumatic conditions with complete informant agreement, including *Allium fistulosum*, *Cananga odorata*, *Cinnamomum sintoc*, *Curcuma heyneana*, *Morinda citrifolia*, *P. indica*, and *Phragmites karka*. For wound infections, 9 species reached 100% FL, including *Aloe vera*, *Beta vulgaris*, *Cynodon dactylon*, *Digitalis purpurea*, *Gynura procumbens*, *Helianthus annuus*, *Melastoma malabathricum*, *Musa paradisiaca*, and *Polyscias scutellaria*.



**Figure 3.** Categories of inflammation-related conditions and their corresponding Informant Consensus Factor (ICF) values among the Tenggerese community

The fever category also included nine (9) species with maximum FL values, such as *A. calamus*, *Alyxia reinwardtii*, *A. catechu*, *B. vulgaris*, *Brassica chinensis*, *Dendrophthoe pentandra*, *Melaleuca leucadendron*, *Selaginella doederleinii*, and *Solanum nigrum*. Six species were reported for general pain, including *Adiantum peruvianum*, *Elephantopus scaber*, *C. sintoc*, *Microsorium buergerianum*, *M. citrifolia*, and *Kaempferia rotunda*. Finally, abdominal pain was associated with 12 species, all showing FL values of 100%, including *Alpinia galanga*, *A. catechu*, *Canna indica*, *Cinnamomum verum*, *Citrus aurantiifolia*, *Coriandrum sativum*, *E. longifolius*, *Elettaria cardamomum*, *Kaempferia galanga*, *Phyllanthus niruri*, *Psidium guajava*, and *Typha angustifolia*. The significance of these plants in managing inflammation and pain in the study area may stem from their extensive use in traditional Indonesian medicine for treating a wide range of ailments (Wuart 2007; Arozal et al. 2020; Iswantini et al. 2025).

### Pharmacological validation of frequently reported medicinal plants

Our recent ethnomedicinal investigation revealed that the Tenggerese community possesses rich traditional knowledge regarding herbal remedies for managing inflammation and pain. This empirical knowledge, supported by various quantitative indices, is a testament to the community's expertise and holds significant potential for bioprospecting efforts to discover novel anti-inflammatory and analgesic agents. To support this potential, we conducted a bibliographic review to examine the pharmacological evidence available for these plants. Of the six most commonly reported species in the study area (SUV > 0.25, see Table 2), four species — *A. calamus* (SUV: 0.84), *F. vulgare* (SUV: 0.73), *M. cordata* (SUV:

0.31), and *A. vulgaris* (SUV: 0.26)— have been pharmacologically confirmed to possess anti-inflammatory and analgesic effects.

The aqueous extract of *A. calamus* leaves has been shown to suppress the production of pro-inflammatory cytokines IL-8 and IL-6, likely through modulation of key signaling pathways, including NF- $\kappa$ B and IRF3 (Kim et al. 2009). In an in vitro investigation of anti-inflammatory potential, the aqueous extract of *A. calamus* rhizome at a concentration of 10 mg/mL exhibited minimal inhibitory effects on hemolysis and red blood cell membrane stabilization, indicating limited activity in this model system (Karthiga et al. 2016). Furthermore, the butanol fraction of *A. calamus* demonstrated significant anti-inflammatory activity, particularly through inhibition of arachidonic acid metabolism, suggesting its involvement in the downregulation of COX and LOX pathways, which are pivotal in inflammatory processes (Ahmed et al. 2014). The essential oil derived from the rhizome of *A. calamus* demonstrated anti-inflammatory activity, exhibiting an IC<sub>50</sub> value of 172.41  $\mu$ g/mL. However, its potency was lower than that of sodium diclofenac, which showed a significantly more substantial effect with an IC<sub>50</sub> of 21.0  $\mu$ g/mL (Loying et al. 2019). Daily intraperitoneal administration of  $\alpha$ -Asarone, a bioactive compound isolated from *A. calamus*, at doses of 30 mg/kg and 60 mg/kg over three months in APP/PS1 transgenic mice led to significant improvements in cognitive performance and a marked reduction in neuroinflammatory responses (Zenga et al. 2021).  $\beta$ -Asarone, another primary compound of *A. calamus*, administered at a dose of 25 mg/kg/day for 14 days, ameliorated dizocilpine-induced cognitive impairments in rats. The treatment also significantly suppressed the expression of pro-inflammatory mediators,

including IL-6, IL-1 $\beta$ , iNOS, and COX-2, and inhibited microglial activation, suggesting a potential neuroprotective and anti-inflammatory role in the central nervous system (Xiao et al. 2019).

The anti-inflammatory potential of *F. vulgare* seed hydro methanolic extract was demonstrated in vitro through its significant inhibition of protein denaturation (35.68 $\pm$ 0.4% at 200  $\mu$ g/mL), protease activity (58.09 $\pm$ 0.1% at 250  $\mu$ g/mL), and heat-induced red blood cell hemolysis (9.67 $\pm$ 0.3% at 200  $\mu$ g/mL), with results comparable to the reference drug indomethacin. The methanolic extract of *F. vulgare* fruit, administered at a dose of 200 mg/kg in rodent models, exhibited notable anti-inflammatory effects, type IV antiallergic activity, and central analgesic properties, highlighting its multi-target potential in inflammation-related conditions (Choi and Hwang 2004). Two bioactive compounds isolated from *F. vulgare* fruit demonstrated anti-inflammatory effects by suppressing lipopolysaccharide (LPS)-induced nitric oxide production in RAW 264.7 macrophage cells, indicating their potential role in modulating inflammatory responses at the cellular level (Dong et al. 2024).

The extract of *A. sativum* has been shown to suppress LPS-induced expression of the COX-2 gene and reduce levels of TNF- $\alpha$ , NF- $\kappa$ B, and IL-6 in the colon of mice (Recinella et al. 2022). Additionally, administration of *A. sativum* extract leads to a reduction in leukocyte count and inflammatory cell infiltration, covering only 10-20% of the alveolar surface, while the proportion of dilated alveoli decreases from more than 50% to less than 30% (Savira et al. 2023). Alliin, the main active compound in *A. sativum*, exhibits a stronger binding affinity for the COX-2 enzyme compared to other constituents (Sadeghi et al. 2022).

*M. cordata* methanol extract demonstrated significant anti-inflammatory effects by suppressing the production of pro-inflammatory mediators and cytokines and inhibiting the activation of NF- $\kappa$ B and MAPKs pathways in LPS-stimulated RAW 264.7 macrophages (Kang et al. 2023). *M. cordata* essential oil and extracts exhibited significant anti-inflammatory effects, with the essential oil showing the highest edema inhibition (72.80%) in carrageenan-induced rat paw edema, suggesting its potential for treating inflammation-related conditions (Siddiqui et al. 2018). The 26 constituents of *M. cordata*, particularly methyl-3,5-di-O-caffeoyl quinate, exhibited potential as inhibitors of COX 2, HNE, LOX, MMP 2, MMP 9, and mPGES 2, suggesting their therapeutic potential for treating acute and chronic inflammatory diseases (Radhakrishnan et al. 2023).

Ethanollic and ethyl acetate extracts of *A. vulgaris* leaves exhibited significant anti-inflammatory effects in mice, with the ethanollic extract at 400 mg/kg from higher altitudes showing the highest efficacy (54.05% edema inhibition), comparable to indomethacin (Pandey et al. 2021). Methanolic extract of *A. vulgaris* and its compound  $\beta$ -caryophyllene oxide significantly reduced carrageenan-induced inflammation in rats by restoring antioxidant enzyme activity and lowering C-reactive protein and lipid peroxidation levels, indicating anti-inflammatory potential supported by in silico analysis (Kumar et al. 2025). Flavonoids from *A. vulgaris*, particularly apigenin, showed

vigorous anti-inflammatory activity by inhibiting nitric oxide and TNF- $\alpha$  production in LPS-induced macrophages, supported by molecular docking results (Trinh et al. 2023). Artemvulactone E, isolated from the ethanol extract of *A. vulgaris*, demonstrated significant anti-inflammatory activity in LPS-induced RAW264.7 cells by inhibiting NO production (IC<sub>50</sub>: 0.9 $\pm$ 0.2  $\mu$ M) and downregulating COX-2 protein expression in a dose-dependent manner (Liu et al. 2022).

*Borreria laevis* and *E. longifolius*, with high SUV values of 0.57 and 0.46, respectively, have not been pharmacologically proven to possess anti-inflammatory and analgesic effects. Based on literature review, *B. laevis* has been reported to exhibit immunomodulatory and antidiabetic properties (Wahyuni et al. 2023; Prasetyo et al. 2024), while studies on *E. longifolius* have primarily reported its phytochemical constituents and antibacterial activity (Bhagawan et al. 2023a; et al. 2025). However, to date, no scientific evidence has confirmed their anti-inflammatory or analgesic properties. Despite this, these species show significant potential for future pharmacological testing to evaluate their anti-inflammatory and analgesic properties. Further research and development of these plants could uncover novel therapeutic agents for inflammation-related conditions.

In conclusion, this study systematically documents and analyzes the ethnomedicinal knowledge of the Tengger people in East Java, identifying various medicinal plants used to treat inflammatory and pain-related conditions. Integrating quantitative ethnomedicinal indices, such as ICF, FL, SUV, and FUV, enhances the validity of the findings and highlights key species with significant cultural and therapeutic value. Moreover, the correlation between traditional use and pharmacological evidence strengthens the scientific foundation of these treatments, supporting their potential for further investigation and drug development. This study relied primarily on verbal interviews, which may be subject to recall bias and subjective interpretation. In addition, the ethnomedicinal data were collected only from four core Tengger villages, potentially overlooking variations in plant use across other settlements. Furthermore, the pharmacological validation was based solely on secondary data sources, without experimental testing of the reported medicinal species. Future research should aim to conduct pharmacological testing, particularly on culturally significant but scientifically underexplored species such as *B. laevis* and *E. longifolius* and expand ethnobotanical surveys to other Tengger settlements or related ethnolinguistic groups to uncover broader patterns and potential bioactive compounds.

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