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Medicinal plants for gastrointestinal ailments among the Toraja people, South Sulawesi, Indonesia

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Abstract. *Mangalik ES, Susandarini R. 2025. Medicinal plants for gastrointestinal ailments among the Toraja people, South Sulawesi, Indonesia. Asian J Ethnobiol 8: 301-311.* South Sulawesi, a province in Indonesia, is facing a significant health challenge with high rates of gastrointestinal disorders, potentially leading to fatal outbreaks. The Toraja people, a community in South Sulawesi, have a long-standing tradition of using medicinal plants to address various health issues, including gastrointestinal disorders. This study aims to document their local resources and preserve their traditional knowledge. Data were collected from October 2024 to January 2025 through semi-structured interviews with 42 informants, comprising 23 males (54.76%) and 19 females (45.24%), using snowball and purposive sampling methods. Plant specimens were collected during field exploration for the subsequent process of herbarium preparation and identification. Qualitative and quantitative data analysis methods were performed, including Use Value (UV), Fidelity Level (FL), and Informant Consensus Factor (ICF). The study identified 53 medicinal plant species from 43 genera and 29 families, with Zingiberaceae, Asteraceae, Amaranthaceae and Euphorbiaceae being the most common families. These plants are traditionally used to treat gastrointestinal issues, including diarrhea, abdominal pain, appendicitis, acid reflux, and gastritis. Herbs comprised 55% of the species, with leaves (46%) being the most used plant part, and boiling was the primary processing method. *Ageratum conyzoides* had the highest UV (0.83). The highest FL (100%) was found in *Acorus calamus, Corchorus capsularis,* and *Psidium guajava* for treatment of abdominal pain, while *Amaranthus spinosus* and *Boehmeria nivea* were reported for curing appendicitis. The highest ICF values were observed for abdominal pain with *P. guajava*, having an ICF of 0.75, and gastritis was treated with *A. conyzoides*, with an ICF value of 0.66. This study represents the first systematic ethnobotanical investigation of medicinal plants used by the Toraja community to treat gastrointestinal ailments, highlighting their diversity and contributing to the preservation of traditional knowledge, supporting species conservation, and offering potential pathways for pharmaceutical development.

Keywords: Ethnobotany, gastrointestinal ailments, indigenous knowledge, medicinal plants, Toraja

INTRODUCTION

Medicinal plants play a crucial role in global healthcare. In 2023, the World Health Organization (WHO) and the Global Traditional Medicine Centre (GTMC) reported that about 80% of people, especially in rural areas of developing countries, rely on medicinal plants due to limited healthcare access. Despite advances in modern medicine, traditional remedies remain widely used because of accessibility, ease of use, and economic benefits (Zhou et al. 2023). Many plant species with medicinal potential remain scientifically unexplored and under-documented (Horackova et al. 2023), highlighting the need for ongoing ethnobotanical studies. Indonesia, one of the world's biodiversity hotspots, has a long history of using medicinal plants. The Toraja people of South Sulawesi, Indonesia, known for their cultural identity and close connection to nature, use local flora in healing practices. However, despite their rich heritage, the Toraja remain underrepresented in ethnobotanical research, particularly regarding gastrointestinal (GI) ailments. GI conditions are the most prevalent health issues addressed with traditional remedies in this community. According to the Basic Health Survey (Ministry of Health, Basic Health Research 2013), South Sulawesi is among the five provinces with the highest incidence of GI disorders, especially diarrhea. In 2016, the Ministry of Health notes diarrhea remains endemic in Indonesia, with 18 outbreaks reported across 11 provinces in 2015, causing 1,213 cases and 30 deaths with a Case Fatality Rate (CFR) of 2.47% (Isnawati et al. 2019).

Globally, various ethnobotanical studies have shown that gastrointestinal ailments are among the most frequently treated conditions using medicinal plants in traditional societies. For instance, Ralte et al. (2024) in Mizoram, India, found that gastrointestinal ailments accounted for the highest number of medicinal plant species used, totaling 67 species (54%), with diarrhea being the most frequently treated condition. Similarly, Hani et al. (2022) reported that 142 plant species were used to treat gastrointestinal ailments in Lebanon, while Lu et al. (2022) identified 101 species used for the same purpose in Guangxi, China. In Indonesia, several ethnobotanical studies have also reported extensive use of medicinal plants to address gastrointestinal problems among local communities. Yusro et al. (2021) documented the use of various plant species for treating gastrointestinal disorders among the Dayak Muara Tribe in West Kalimantan. Khastini et al. (2021) reported similar findings among the Baduy ethnic group in West Java, while Pitopang et al. (2024) highlighted the use of medicinal plants for gastrointestinal complaints among the Kaili Ledo Ethnic in

Central Sulawesi. To date, no published study has systematically documented the use of medicinal plants for gastrointestinal disorders among the Toraja people, indicating a significant research gap in the ethnomedicinal context of Sulawesi.

Gastrointestinal (GI) ailments affect the digestive tract, including diarrhea, ulcers, gastritis, gastroenteritis, dyspepsia, acid reflux (GERD), abdominal pain, flatulence, hemorrhoids, and constipation (Lee and Kim 2022; Jabłońska and Mrowiec 2023). In South Sulawesi, these conditions are common due to unsafe water and food contamination. The Toraja have developed unique ethnomedicinal practices closely connected to beliefs, rituals, and ecological knowledge. Some remedies involve ritual offerings or preparations by traditional healers, reflecting the cultural aspect of healing. Since this knowledge is passed down orally, it is increasingly at risk of being lost because of modernization and declining intergenerational transfer (WHO 2019). Ethnobotanical research is essential to preserving this knowledge and identifying potential compounds for modern medicine. Despite the persistence and cultural importance of traditional healing practices among the Toraja people, scientific documentation of medicinal plants used specifically for GI ailments remains limited. This gap in documentation might cause a risk of neglect on plant species used in traditional healing, particularly as modernization reshapes indigenous practices (Demie et al. 2018; Mahali et al. 2023). Documenting ethnobotanical knowledge supports biodiversity preservation, sustainable resource use, drug discovery, and integration of traditional medicine into healthcare systems (Tugume et al. 2016; Tahir et al. 2023; Muhakr et al. 2024). This study addresses this gap by quantitatively analyzing GI medicinal plants in the Toraja cultural context using Use Value (UV), Fidelity Level (FL), and Informant Consensus Factor (ICF).

This study aims to (i) document medicinal plant species used to treat gastrointestinal ailments, (ii) assess their cultural importance using quantitative indices (UV, FL, ICF), (iii) analyze the plant parts used and traditional preparation methods, and (iv) investigate how this knowledge is transmitted within the community. The findings are expected to support both the preservation of ethnomedicinal knowledge and future pharmacological research.

MATERIALS AND METHODS

Study area

This study was conducted in the highlands of Toraja, South Sulawesi, Indonesia, encompassing Tana Toraja and North Toraja Districts (Figure 1). The study area is located approximately 280-355 km northeast of Makassar, the capital city of South Sulawesi Province, at coordinates 2°40'S to 3°25'S and 119°30'E to 120°25'E and featuring a mountainous landscape with elevations ranging from 600 to 2,800 masl. Geomorphologically, Toraja is dominated by rocky-mountains, hills, valleys, forests, rivers, rice fields, and plantations, with traditional settlements that follow the contours of the mountainous terrain. The area has a humid tropical climate with high annual rainfall (1,500-3,500 mm), and fertile volcanic soils support a rich diversity of vegetation, including herbs, shrubs, epiphytes, lianas, succulents, and trees—many of which are used in traditional medicine.

The population in Tana Toraja District is approximately 257,901 (132,284 males and 125,617 females). In comparison, North Toraja District has around 261,007 inhabitants (133,005 males and 128,001 females), with the majority being of the indigenous Toraja ethnic group. The study focused on four traditional villages: Sillanan (sub-district of Gandangbatu Sillanan) and Tongkonan Karuaya (sub-district of North Sangalla) in Tana Toraja, as well as Ke'te' Kesu' (sub-district of Kesu') and Pallawa (sub-district of Sesean) in North Toraja (Figure 1). Diverse ecosystems, including agroforestry landscapes, agricultural fields, plantations, rivers, and various forest types, surround these villages. This ecological and cultural diversity supports a rich plant life that is deeply embedded in the ethnobotanical knowledge of the Toraja people, playing a vital role in local healthcare, food security, and agrarian livelihoods.

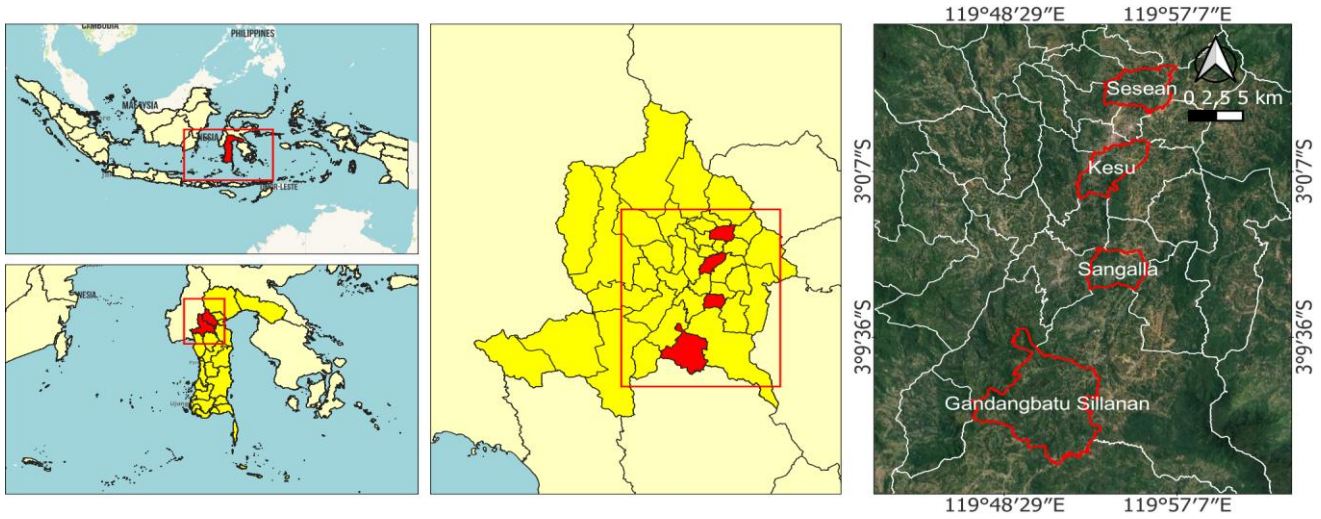

Figure 1. Map of the study area in Tana Toraja and North Toraja Districts, South Sulawesi, Indonesia

Ethnomedicinal data collection

Ethnobotanical data collection was conducted from October 2024 to January 2025 through community surveys using semi-structured interviews. A total of 42 informants were selected through purposive and snowball sampling methods across four traditional villages. These informants were chosen for their knowledge of medicinal plants and split into two groups: key informants, who were traditional healers with extensive knowledge of ethnomedicinal practices, and general informants, such as community leaders (sub-district heads, hamlet heads, customary leaders, village officials), as well as local residents with practical experience using medicinal plants. The sample size was deemed sufficient based on data saturation, where no new information emerged after several interviews (Alexiades 1996). Inclusion criteria included adults (≥18 years) with experience in using medicinal plants, while those lacking such knowledge were excluded.

The demographic profiles of the informants were diverse, covering males and females of different ages and occupations. The interviews were conducted to gather detailed ethnomedicinal data, including the types of plants used, the health conditions and ailments they addressed, plant parts used, methods of preparation and application, and strategies for preserving both traditional knowledge and plant habitats. As no new plant species or ethnomedicinal information emerged in the last three consecutive interviews, this confirms sample adequacy. GI ailments mentioned by participants were classified into biomedical categories following Lee and Kim (2022) and Jabłońska and Mrowiec (2023). The study followed ethical principles of voluntary participation and community respect. Prior informed consent was obtained verbally from all participants before interviews and plant collection, and the research followed the ethical guidelines of the International Society of Ethnobiology (ISE 2006), including principles of respect, confidentiality, and fair benefit-sharing.

Plant collection and identification

Medicinal plant specimens were collected during informant-guided field work. The plants were collected from gardens, home yards, or forests. Whole individual specimens were collected for small plants, while branches (30-40 cm) with leaves, flowers, and fruits were taken from larger trees. Reproductive organs (flowers, fruits, or seeds) of tall trees were obtained using tools. Samples were labeled, photographed, and pressed between newspaper sheets, then preserved in 70% alcohol. Detail photographs were taken for large specimens unsuitable for herbarium preparation. Collected samples were dried in an oven at 60-70°C for 2-6 days at the Plant Systematics Laboratory, Universitas Gadjah Mada (UGM), Yogyakarta, Indonesia, before being mounted on herbarium sheets for identification and storage. The identification of medicinal plant specimens was conducted using reference books such as *Tumbuhan Berguna Indonesia* (Heyne 1987), *Illustrated Guide to Tropical Plants* (Corner and Watanabe 1969), *Flora of Malesiana* (Van Steenis 1955), and the plant specimen database World of Flora Online (https://www.worldfloraonline.org/). The validity of species names and author citations was confirmed using online databases such as Plants of the World Online (https://powo.science.kew.org/). Taxonomists from the Department of Plant Systematics at UGM validated all identifications. Herbarium specimens were prepared for most species and deposited at the Faculty of Biology, UGM. Some species, particularly large trees or easily recognized taxa, were documented through photographs and field notes.

Data analysis

The data were analyzed using both qualitative-descriptive and quantitative methods. Descriptive-qualitative analysis was employed to examine the data and information related to the use of plants as traditional medicine within the community in a comprehensive and detailed manner. Meanwhile, quantitative analysis was conducted to obtain measurable and objective data regarding the complexity of medicinal plant species utilized by the community. The quantitative analysis includes the Use Value Index (UV), Fidelity Level (FL), and Informant Consensus Factor (ICF).

Use Value (UV)

UV is used to assess the relative importance of a plant species based on its frequency of use by the community. The UV is calculated using the formula:

$$UVi = \frac{\Sigma Ui}{n}$$

Where, UV represents the total use value of a medicinal plant species, U is the number of usage reports for a species, and n is the total number of informants interviewed (Phillips et al. 1994).

Fidelity Level (FL)

FL is used to determine the percentage of specific use of a plant species in treating a particular disease. The formula for FL is:

$$FL\% = \frac{Ip}{IU} \times 100$$

Where FL% is the percentage of the Fidelity Level Index of a plant species, Ip is the number of informants who report the use of the species for a particular disease, and IU is the total number of informants who report the use of the species for various diseases (Friedman 1986).

Informant Consensus Factor (ICF)

ICF is used to determine the level of agreement among informants regarding the use of plants for a specific disease category. The following formula is applied for ICF:

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

Where ICF is the Informant Consensus Factor value for a specific disease category, Nur is the number of reports on the use of a plant species to treat that particular disease

category, and Nt is the total number of plant species used to treat that disease category (Heinrich 1998).

RESULTS AND DISCUSSION

Demographic profiles of the informants

The informant profile was presented based on four categories: gender, level of knowledge, age, and occupation (Table 1). Among the 42 informants, 23 were male (54.76%) and 19 were female (45.24%). The majority of informants were traditional healers (40.48%). In terms of age, most informants were 61-70 years old (28.57%), with an average age of 63 years, with the youngest being 41 and the oldest 86. Regarding occupation, the majority of informants were farmers (69.05%). The information collected included the types of plants used, the plant parts utilized, the diseases treated, the methods of use, and the types of plant conservation efforts.

Diversity of medicinal plants

In the present study, a total of 53 medicinal plant species were recorded in the treatment of gastrointestinal disorders, encompassing 43 genera and 29 families (Table 2). These species are traditionally used to treat a variety of gastrointestinal ailments, including diarrhea, abdominal pain, acid reflux (GERD), appendicitis, gastritis/gastric ulcer, stomach ulcers, flatulence, hemorrhoids, gastroenteritis, and constipation. The family of Zingiberaceae was the most frequently represented, with 8 species documented, followed by Asteraceae with 4 species, and Amaranthaceae and Euphorbiaceae, each represented by 3 species (Figure 2).

Among the 53 medicinal plant species recorded, *Ageratum conyzoides* L. had the highest Use Value (UV = 0.83), reflecting its wide usage across multiple gastrointestinal conditions, particularly gastritis and gastric ulcers. Pharmacologically, this species is known to contain flavonoids such as kaempferol, quercetin, and sinensetin, which exhibit anti-inflammatory, antibacterial, and gastroprotective activities (Aladdin et al. 2017; Rajput et al. 2022). Other highly cited species include *Psidium guajava* L. and *Acorus calamus* L., both of which showed high Fidelity Levels (FL = 100%) for treating abdominal pain. These plants have documented antidiarrheal and antispasmodic effects and are commonly available in homegardens or nearby forests, making them easily accessible for local communities. The study recorded both cultivated species, such as *Zingiber officinale* Roscoe*, Anredera cordifolia* (Ten.) Steenis*,* and *Senna alata* (L.) Roxb., as well as wild-collected species like *Hyptis capitata* Jacq.*, Flemingia strobilifera* (L.) W.T.Aiton and *Euphorbia hirta* L.. This highlights the community's reliance on both managed and natural ecosystems for traditional medicine. Although none of the recorded species are currently listed as endangered in the IUCN Red List, the potential future threats from continued harvesting from the wild, particularly for endemic or slow-growing plants, are a cause for concern. These findings underline the need for sustainable harvesting practices and conservation awareness. Representative species used for gastrointestinal ailments by the Toraja community are illustrated in Figure 3.

Table 1. Demographic profiles of the informants

Category	Description	Number of informants (n=42)	Respondent frequency (%)
Gender	Male	23	54.76
	Female	19	45.24
Level of knowledge	Traditional healers	17	40.48
	Community leader	10	23.81
	Traditional medicine users	15	35.71
Age group (years old)	40-50	8	19.05
	51-60	10	23.81
	61-70	12	28.57
	71-80	9	21.43
	>80	3	7.14
Occupation	Farmer	29	69.05
	Traditional leader	7	16.67
	Government official	4	9.52
	Housewife	2	4.76

Note: n: Total of informants

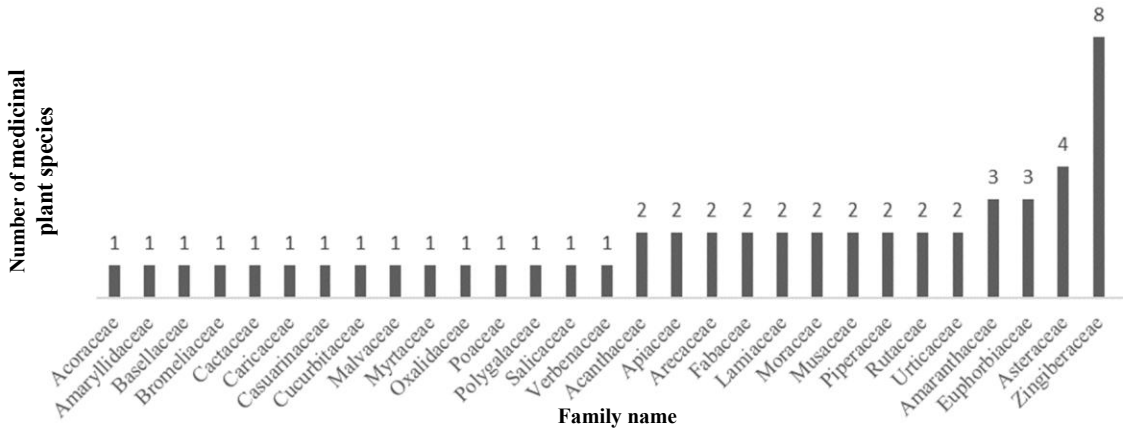

Figure 2. Family-wise medicinal plant species to treat gastrointestinal disorders by the Toraja community in South Sulawesi, Indonesia

Table 2. Medicinal plants used by the Toraja people to treat gastrointestinal ailments in South Sulawesi, Indonesia

Family	Scientific name	Vernacular name	Growth form	Parts used	Gastrointestinal ailments treated	Mode of use	UV	FL (%)
Acanthaceae	*Andrographis paniculata* (Burm.fil.) Nees	*Sambiloto*	Herb	Leaves	Abdominal pain, diarrhea	Boiling	0.26	14.29
Acanthaceae	*Graptophyllum pictum* (L.) Griff.	*Katilamun*	Shrub	Leaves	Hematemesis	Boiling	0.26	12.50
Acoraceae	*Acorus calamus* L.	*Kariango*	Herb	Rhizome	Abdominal pain	Eaten raw	0.07	100
Amaranthaceae	*Alternanthera sessilis* (L.) R.Br. ex DC.	*Parapa*	Herb	Leaves, whole plant	Acid reflux (GERD), appendicitis	Boiling	0.07	50.00
Amaranthaceae	*Alternanthera philoxeroides* (Mart.) Griseb.	*Bekke rada*	Herb	Leaves	Hernia	Boiling	0.05	100
Amaranthaceae	*Amaranthus spinosus* L.	*Bayam duri*	Herb	Leaves	Appendicitis	Boiling	0.05	100
Amaryllidaceae	*Allium cepa* var. *aggregatum* G.Don	*Lassuna rarang*	Herb	Tuber	Flatulence	Pounded	0.07	50.00
Apiaceae	*Centella asiatica* (L.) Urb.	*Leme'*	Herb	Leaves, whole plant	Abdominal pain, liver, gastritis/gastric ulcer	Boiling, crushed	0.43	8.33
Apiaceae	*Apium graveolens* L.	*Daun so'*	Herb	Leaves	Acid reflux, liver	Boiling	0.10	50.00
Arecaceae	*Cocos nucifera* L.	*Kaluku*	Tree	Fruit water	Poisoning	Drunk directly	0.10	100
Arecaceae	*Arenga pinnata* (Wurmb) Merr.	*Induk*	Tree	Fruit	Jaundice	Eaten raw	0.21	14.29
Asteraceae	*Ageratum conyzoides* L.	*Tassi'-tassi'*	Herb	Leaves, whole plant	Gastritis/gastric ulcer, abdominal pain	Crushed, boiling	0.83	54.17
Asteraceae	*Gymnanthemum amygdalinum* (Delile) Sch.Bip. ex Walp.	*Kloropil*	Shrub	Leaves	Gastritis/gastric ulcer, acid reflux	Crushed, boiling	0.64	23.53
Asteraceae	*Chromolaena odorata* (L.) R.M.King & H.Rob.	*Sarambuallo*	Shrub	Leaves	Gastritis/gastric ulcer	Crushed, boiling	0.79	38.10
Asteraceae	*Pluchea indica* (L.) Less.	*Beluntas*	Shrub	Leaves	Acid reflux (GERD)	Crushed, boiling	0.12	50.00
Basellaceae	*Anredera cordifolia* (Ten.) Steenis	*Minahong*	Climber	Leaves	Gastritis/gastric ulcer	Boiling	0.17	33.33
Bromeliaceae	*Ananas comosus* (L.) Merr.	*Pondan*	Herb	Ripe fruit	Constipation	Eaten raw	0.05	100
Cactaceae	*Leuenbergeria bleo* (Kunth) Lodé	*Daun tujuh bilah*	Shrub	Leaves	Gastritis/gastric ulcer	Boiling	0.02	100
Caricaceae	*Carica papaya* L.	*Taliki*	Tree	Leaves, fruit	Jaundice, gastritis, abdominal pain	Boiling, eaten raw	0.29	14.29
Casuarinaceae	*Casuarina junghuhniana* Miq.	*Buangin*	Tree	Root	Jaundice	Boiling	0.02	100
Cucurbitaceae	*Cucurbita moschata* (Duchesne) Duchesne ex Poir.	*Lau*	Climber	Fruit	Gastritis/gastric ulcer	Boiling	0.07	66.67
Euphorbiaceae	*Acalypha indica* L.	*Akar kucing*	Herb	Whole plant	Acid reflux (GERD)	Boiling	0.05	100
Euphorbiaceae	*Jatropha curcas* L.	*Pallan*	Shrub	Leaves	Poisoning	Boiling	0.60	6.67
Euphorbiaceae	*Euphorbia hirta* L.	*Pa'tik-pa'tik*	Herb	Whole plant	Appendicitis	Boiling	0.07	50.00
Fabaceae	*Flemingia strobilifera* (L.) W.T.Aiton	*Ora'-ora'*	Shrub	Leaves, root	Gastritis/gastric ulcer, acid reflux (GERD)	Boiling	0.05	50.00
Fabaceae	*Senna alata* (L.) Roxb.	*Galinggang*	Shrub	Leaves	Gastritis/gastric ulcer	Boiling	0.12	33.33
Lamiaceae	*Hyptis capitata* Jacq.	*Swalang*	Herb	Leaves, whole plant	Flatulence	Crushed, boiling	0.26	90.00
Lamiaceae	*Ocimum sanctum* L.	*Kamangi*	Shrub	Whole plant	Gastroenteritis	Boiling	0.07	33.33
Malvaceae	*Corchorus capsularis* L.	*Songkadulang*	Herb	Fruit, seeds	Abdominal pain, diarrhea	Pounded, eaten raw	0.12	100
Moraceae	*Artocarpus altilis* (Parkinson) Fosberg	*Baka'*	Tree	Leaves	Liver, abdominal pain	Boiling	0.19	20.00
Moraceae	*Ficus septica* Burm.fil.	*Lebannu*	Shrub	Leaves	Jaundice	Boiling	0.12	50.00

Musaceae	*Musa* spp.	*Punti*	Herb	Fruit	Gastritis/gastric ulcer	Eaten raw	0.19	28.57
Musaceae	*Musa balbisiana* Colla	*Punti sanggara*	Herb	Fruit	Gastritis/gastric ulcer	Eaten raw	0.02	100
Myrtaceae	*Psidium guajava* L.	*Dambu batu*	Tree	Leaves	Abdominal pain, diarrhea, gastroenteritis	Eaten raw, crushed	0.50	100
Oxalidaceae	*Oxalis corniculata* L.	*Pisik*	Herb	Whole plant	Gastritis/gastric ulcer	Boiling, crushed	0.21	14.29
Piperaceae	*Piper betle* L.	*Daun bolu*	Climber	Leaves	Gastritis/gastric ulcer	Crushed, boiling	0.26	16.67
Piperaceae	*Piper umbellatum* L.	*Lepo*	Shrub	Leaves	Hemorrhoids, hernia	Boiling	0.07	100
Poaceae	*Imperata cylindrica* (L.) Raeusch.	*Ria*	Herb	Root	Flatulence	Boiling	0.21	16.67
Polygalaceae	*Polygala paniculata* L.	*Akar wangi*	Herb	Root	Flatulence	Boiling, apply directly	0.05	100
Rutaceae	*Citrus ×aurantiifolia* (Christm.) Swingle	*Lemo tadi*	Shrub	Leaves	Flatulence	Crushed, Squeezed	0.14	20.00
Rutaceae	*Citrus hystrix* DC.	*Lemo dondo'*	Shrub	Fruit	Jaundice	Squeezed	0.07	50.00
Salicaceae	*Flacourtia rukam* Zoll. & Moritzi	*Karondang*	Tree	Leaves	Appendicitis	Boiling	0.05	50.00
Urticaceae	*Boehmeria nivea* (L.) Gaudich.	*Karra'-karra'*	Herb	Leaves	Appendicitis	Boiling	0.05	100
Urticaceae	*Boehmeria cylindrica* (L.) Sw.	*Sissing tuak*	Herb	Leaves	Appendicitis	Boiling	0.10	33.33
Verbenaceae	*Lantana camara* L.	*Kassi'-kassi'*	Shrub	Leaves	Gastritis/gastric ulcer	Crushed, boiling	0.40	27.27
Zingiberaceae	*Zingiber cassumunar* Roxb.	*Bangle*	Herb	Rhizome	Abdominal pain, diarrhea	Pounded, eaten raw	0.31	66.67
Zingiberaceae	*Zingiber montanum* (J.Koenig) Link ex A.Dietr.	*Bangle lotong*	Herb	Rhizome	Abdominal pain, diarrhea	Eaten raw	0.02	100
Zingiberaceae	*Zingiber officinale* Roscoe	*Laiya*	Herb	Rhizome	Flatulence, jaundice	Boiling, eaten raw	0.14	20.00
Zingiberaceae	*Zingiber officinale* var. *rubrum.*	*Laiya rarang*	Herb	Rhizome	Abdominal pain	Boiling	0.02	100
Zingiberaceae	*Curcuma longa* L.	*Kunyi'*	Herb	Rhizome	Gastritis/gastric ulcer, GERD, jaundice	Grated, eaten raw	0.17	66.67
Zingiberaceae	*Curcuma caesia* Roxb.	*Kunyi' lotong*	Herb	Rhizome	Abdominal pain	Eaten raw	0.07	100
Zingiberaceae	*Curcuma zanthorrhiza* Roxb.	*Tammula'*	Herb	Rhizome	Gastritis/gastric ulcer	Grated, pounded	0.10	25.00
Zingiberaceae	*Alpinia purpurata* (Vieill.) K.Schum.	*Likkua' rarang*	Herb	Rhizome	Gastritis/gastric ulcer	Grated	0.02	100

Note: UV: Use Value, FL: Fidelity Level

Figure 3. Medicinal plants used for gastrointestinal ailments by the Toraja community in South Sulawesi, Indonesia. A. *Ageratum conyzoides*, B. *Gymnanthemum amygdalinum*, C. *Chromolaena odorata,* D. *Hyptis capitata,* E. *Euphorbia hirta,* F. *Jatropha curcas*

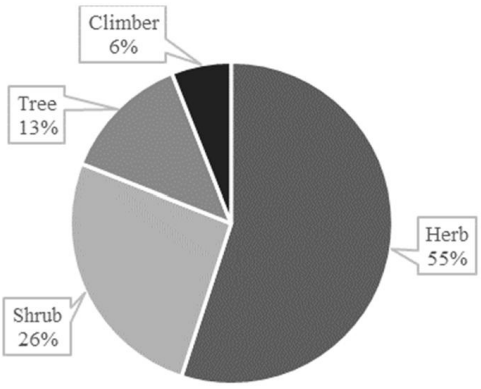

Figure 4. Growth forms of medicinal plants used by the Toraja people to treat gastrointestinal ailments in South Sulawesi, Indonesia

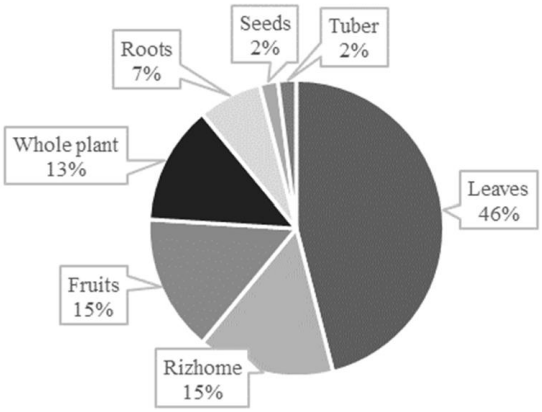

Figure 5. Plant parts used in traditional remedies to treat gastrointestinal ailments by the Toraja people in South Sulawesi, Indonesia

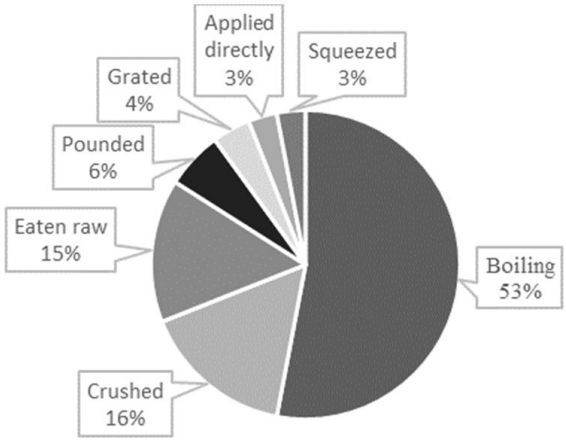

Figure 6. Modes the preparation or processing methods of traditional herbal recipes to treat gastrointestinal ailments by the Toraja people in South Sulawesi, Indonesia

Medicinal plants' growth form

The medicinal plant species documented in this study exhibited a variety of growth forms, reflecting their ecological adaptation and accessibility for traditional use. These growth forms included herbs, shrubs, trees, and climbers. Herbs constituted the highest proportion, accounting for 29 species (55%) of the total 53 species recorded, followed by shrubs with 14 species (26%), trees with 7 species (13%), and climbers with 3 species (6%). The distribution of these growth forms is illustrated in Figure 4, providing a visual representation of their relative importance of usage in the study area.

Plant parts used and mode of preparation

There was diversity in plant parts utilized for traditional remedies to treat gastrointestinal ailments by the Toraja community. Some species have multiple plant parts used, and the calculation is based on the total number of use reports rather than the total number of species. The most frequently used part was leaves, with 28 species (46%) of the total, reflecting their accessibility and ease of preparation. Other plant parts used in herbal preparations were rhizome (15%), fruits (15%), and whole plant (13%). Meanwhile, roots (7%), seeds (2%), and tubers (2%) were used less frequently. The widespread use of leaves and fruits indicates a preference for renewable and easily harvestable plant parts. The proportion of plant parts used is illustrated in Figure 5, highlighting their relative significance in traditional medicinal practices.

The modes of preparation for medicinal plant recipes varied depending on the ailment being treated and the specific part of the plant used. Some species have multiple plant parts used, and the calculation is based on the total number of use reports rather than the total number of species. Boiling was the most common method (53%), followed by crushed (16%), eaten raw (15%), pounded (6%), grated (4%), squeezed (3%), and direct application without any specific preparation (3%). These methods reflect the community's practical knowledge in extracting bioactive compounds and ensuring their efficacy. Figure 6 presents the proportional use of different preparation methods.

Gastrointestinal ailments categories and medicinal plant utilization

Local communities of Toraja employed a wide range of plant species to manage digestive problems, highlighting the depth of ethnomedicinal knowledge and the significance of traditional healthcare practices. Among the various conditions of gastrointestinal ailments, gastritis/gastric ulcer or ulcer-related symptoms were the most frequently reported, which were treated with 18 plant species. Other gastrointestinal health problems found in local communities and the number of plant species used to treat them were abdominal pain (12 species), acid reflux (7 species), jaundice (7 species), appendicitis (6 species), flatulence (6 species), and diarrhea (5 species). Other less commonly cited ailments were gastroenteritis, liver poisoning, constipation, hemorrhoids, hematemesis, and hernia, each treated with 1 to 3 species. In total, 53 unique plant species were documented for gastrointestinal treatments. Several of these species were used to treat more than one ailment, resulting in 67 cumulative use reports across different gastrointestinal conditions. The detailed list of gastrointestinal ailments and the number of medicinal plant species used for their treatment is presented in Table 3.

Table 3. Ailment categories, number of species used, and Informant Consensus Factor (ICF) of medicinal plants to treat gastrointestinal problems by Toraja people in South Sulawesi, Indonesia

Gastrointestinal ailment categories	Number of citations (Nur)	Number of species used (NT)	ICF	Most frequently used species
Gastritis/gastric ulcer	51	18	0.66	*Ageratum conyzoides* L.
Abdominal pain	45	12	0.75	*Psidium guajava* L.
Acid reflux (GERD)	9	7	0.25	*Pluchea indica* (L.) Less.
Jaundice	10	7	0.33	*Ficus septica* Burm.fil.
Appendicitis	7	6	0.17	*Boehmeria cylindrica* (L.) Sw.
Flatulence	14	6	0.62	*Hyptis capitata* Jacq.
Diarrhea	7	5	0.33	*Zingiber cassumunar* Roxb.
Liver	4	3	0.33	*Apium graveolens* L.
Gastroenteritis	2	2	0.00	*Ocimum sanctum* L.
Poisoning	3	2	0.50	*Cocos nucifera* L.
Constipation	2	1	1.00	*Ananas comosus* (L.) Merr.
Hemorrhoids	2	1	1.00	*Piper umbellatum* L.
Hematemesis	1	1	0.00	*Graptophyllum pictum* (L.) Griff.
Hernia	1	1	0.00	*Alternanthera philoxeroides* (Mart.) Griseb.

Use Value (UV), Fidelity Level (FL), and Informant Consensus Factor (ICF)

Use Value (UV)

Based on the analysis of Use Value (UV), a variation in the importance of medicinal plant species was observed among informants. The highest UV was recorded for *A. conyzoides* (0.83), indicating it was the most frequently cited and widely used species. This was followed by *Chromolaena odorata* (L.) R.M.King & H.Rob. (0.79) and *Gymnanthemum amygdalinum* (Delile) Sch.Bip. ex Walp. (0.64), both of which were also commonly mentioned. Moderate UV values were found in *Jatropha curcas* L. (0.60) and *P. guajava* (0.50), while the lowest UV value (0.02) was recorded for six species, including *Casuarina junghuhniana* Miq., indicating limited citation across informants.

Fidelity Level (FL)

The result of the FL analysis showed that several species achieved the highest FL value (100%), indicating complete agreement among informants regarding their specific medicinal uses. *Acorus calamus, Corchorus capsularis* L., and *P. guajava* were consistently cited for the treatment of abdominal pain; *Amaranthus spinosus* L. and *Boehmeria nivea* (L.) Gaudich. for appendicitis; and *Leuenbergeria bleo* (Kunth) Lodé and *Acalypha indica* L. for gastritis and acid reflux (GERD). For flatulence, *H. capitata* showed a slightly lower FL (90%), yet still reflected strong informant agreement. In contrast, *J. curcas* had the lowest FL (6.67%), indicating its use for poisoning, but with greater variability in reported applications. However, the greater variability in reported applications for *J. curcas* highlights the complexity of the data.

Informant Consensus Factor (ICF)

The ICF calculation showed a high level of agreement among informants in certain ailment categories. Abdominal pain had the highest ICF value (0.75), indicating strong consensus in plant use, with *P. guajava* being the most frequently cited species. Gastritis/gastric ulcer (0.66) and flatulence (0.62) were recorded at a considerable degree, both reflecting substantial agreement; the most commonly used species were *A. conyzoides* and *H. capitata*. In contrast, lower ICF values were observed for acid reflux (GERD) (0.25) and appendicitis (0.17), with *Pluchea indica* (L.) Less. and *Boehmeria cylindrica* (L.) Sw. being the most frequently cited species for each condition, respectively, indicating greater variability in plant use.

Discussion

The level of knowledge and understanding of informants regarding the use of medicinal plants is linked to their profiles. In this study, 23 males (54.76%) and 19 females (45.24%) were interviewed, with males being more dominant in traditional healing practices. This phenomenon is obviously influenced by a patriarchal culture that favors the passing down of healing knowledge to sons, as well as men's greater mobility, which allows them to access medicinal plants in nature. This finding is in agreement with Supit et al. (2023), who found male dominance in traditional medicine in Wawona Village, South Minahasa. Informants aged 61-70 had a deeper understanding of medicinal plants, which is consistent with the report from Soraya (2022), who noted that people in this age group tend to inherit knowledge across generations. However, Ikaditya (2016) suggested that the knowledge of medicinal plants is not always directly related to age or education, since factors like life experience and memory also play a role. Most informants (69%) were farmers, contributing the most information about medicinal plants due to their direct interaction with nature. Supit et al. (2023) also found that farmers had the highest knowledge of plant use. On average, informants could name 14 species of medicinal plants, with 83% mentioning more than 10 species and 38% over 15 species. This result is in line with previous ethnobotanical studies indicating that naming more than 10-15 species reflects strong local knowledge (Martin 1995; Alexiades 1996; da Silva et al. 2019). Based on the results, this study revealed that the knowledge of medicinal plant use in the community remains high and well-preserved, with a strong indication of being influenced by

age, gender, profession, and the intergenerational tradition of using plants as medicine. However, this knowledge is increasingly at risk of erosion due to modernization and reduced transmission to younger generations. Preserving such traditional knowledge is vital not only for cultural identity but also for safeguarding biocultural heritage. This biocultural heritage is deeply connected to local ecosystems, highlighting the intricate and profound relationship between culture and nature.

This study highlights the significant role of medicinal plants in treating gastrointestinal (GI) ailments within the local community of Toraja. A total of 53 species were recorded, covering 43 genera and 29 families, with the most frequently represented families being Zingiberaceae, Asteraceae, Amaranthaceae, and Euphorbiaceae. The relatively high utilization of these families reflects patterns observed in other ethnobotanical studies, indicating a broader trend in traditional plant use driven by local availability, perceived effectiveness, and cultural knowledge. For instance, Ralte et al. (2024) documented Asteraceae (11 species), Zingiberaceae (9 species), and Euphorbiaceae (8 species) as the most commonly used families in Mizoram, India, including for GI ailments. Similarly, Shah et al. (2013) identified Amaranthaceae (9 species) as the dominant family in Makerwal and Gulla Khel, Pakistan, also contributing to treatments for gastrointestinal issues. These similarities underscore the consistent and important role of these plant families in traditional healthcare systems. The use of medicinal plants to treat gastrointestinal ailments among the Toraja people also reflects patterns observed among other Indonesian ethnic groups. Yusro et al. (2021) reported that the Dayak Muara in West Kalimantan extensively used various species, particularly from Zingiberaceae, to treat diarrhea and stomach disorders.

Similarly, Khastini et al. (2021) documented the reliance of the Baduy community in West Java on medicinal plants from families such as Zingiberaceae and Euphobiaceae for gastrointestinal health. Pitopang et al. (2024) also observed overlapping ethnobotanical knowledge among the Kaili Ledo in Central Sulawesi, who commonly utilized species from Asteraceae and Euphorbiaceae for similar purposes. These parallels suggest a recurring ethnomedicinal pattern in Indonesia's diverse cultural landscapes, potentially shaped by similar ecological resources and long-standing oral traditions. In the case of Toraja, intergenerational knowledge transmission still occurs through oral traditions, daily observation, and mentorship from elders to younger family members. However, this process has weakened due to increasing reliance on modern healthcare systems, formal education, and reduced interest among youth in traditional practices.

Herbaceous species accounted for 55% of the total medicinal plants used. These plants are preferred because they are easy to find, grow quickly, and are believed to have medicinal value throughout all parts of the plant. Additionally, the communities often believe that herbaceous plants provide quick relief for common ailments, are safe due to their long history of use, and can be easily prepared with minimal processing. This pattern is consistent with findings from other regions, such as in Okhaldhunga, eastern Nepal, where 46% of medicinal plants reported were herbaceous (Karki et al. 2023), and in Haripur, northern Pakistan, where the proportion reached 41.25% (Siddique et al. 2021). The high Use Value (UV) of *A. conyzoides* (0.83) reflects its widespread use in traditional medicine, as seen in its mention across various ailment categories (Phillips et al. 1994). *Ageratum conyzoides* contains flavonoids such as kaempferol, quercetin, ageconyflavone, sinensetin, and amenoflavone, which have demonstrated antibacterial, anti-inflammatory, gastroprotective, and antiulcerogenic properties, thereby supporting its traditional use for treating gastritis or gastric ulcer (Aladdin et al. 2017; Thorat et al. 2018; Kotta et al. 2020; Rajput et al. 2022; Li et al. 2025). The Fidelity Level (FL) analysis shows strong consensus on specific uses, such as *A. calamus, C. capsularis,* and *P. guajava* for abdominal pain, all with 100% FL. *Acorus calamus* contains terpenoids such as α-asarone and β-asarone, which have been reported to exhibit antibacterial, antidiarrheal, carminative, and antispasmodic properties, potentially supporting its traditional use for treating abdominal pain (Rajput et al. 2014; Umamaheshwari and Rekha 2018). *P. guajava* is rich in flavonoids such as quercetin, which demonstrate antidiarrheal (Ugbogu et al. 2022). In contrast, *J. curcas* showed the lowest FL (6.67%) for poisoning, indicating more diverse or inconsistent applications (Friedman 1986). The highest Informant Consensus Factor (ICF) was found for abdominal pain (0.75), reflecting a strong agreement among informants on the use of *P. guajava*. Lower ICF values for acid reflux (0.25) and appendicitis (0.17) suggest greater variability and less shared knowledge in these categories (Heinrich 1998). Several medicinal plant species identified in this study deserve special attention, especially those that are endemic or have not been thoroughly studied for their phytochemical properties. For example, *Pigafetta elata* (Mart.) H.Wendl. is a unique species native to this region and could have medicinal potential, but its bioactive compounds are still largely unknown. Likewise, *C. capsularis* and *L. bleo* are traditionally used for medicinal purposes, but there is limited scientific information about their specific chemical components and biological effects. These gaps emphasize the need for further research to support conservation and sustainable use of these species. Additionally, these results highlight the importance of incorporating local ecological knowledge into future pharmacological studies. By focusing on underexplored species with high cultural significance, such as *P. elata* and *L. bleo*, this study provides a foundation for future drug discovery based on ethnobotanical data.

The most commonly used plant part was the leaves (46%). This preference is deeply rooted in local traditions and beliefs that leaves are considered the most potent and safest plant part for medicinal use. This is due to their ease of processing, versatility in application, and long-standing presence in traditional healing practices. Several studies support this trend, including Simbo (2010) in Babungo, Northwest Region, Cameroon, where 65% of plant uses involved leaves, and Koch et al. (2015) in the East Sepik province of Papua New Guinea, with more than 30%. These studies highlight that leaves are favored for their

high content of bioactive compounds, year-round availability, ease of access, and simple preparation. Additionally, leaf harvesting does not require uprooting or cutting the plant, unlike roots or rhizomes, making it a more sustainable option. The predominant preparation methods, boiling (53%) and crushing (16%), further reinforce the continuity of ethnomedicinal practices across regions. Boiling is widely practiced for its effectiveness in extracting active compounds into liquid form, making them easier to consume or apply. It is considered a safe, economical, and flexible method, as mentioned by Lestari and Susanti (2019), who found that the Suku Anak Dalam in Bengkulu, Indonesia, favor boiling for its ability to release more compounds and eliminate harmful pathogens. Meanwhile, the crushing method, often applied to leaves, is known to be a practical and quick alternative method requiring no special tools. It is commonly used for topical or oral applications, as reported by Demie et al. (2018) in Southeast Ethiopia, where 20% of preparations of herbal medicine involved crushing. This method is particularly effective due to the water-soluble nature of bioactive compounds in leaves.

The study underscores the potential for bioprospecting, particularly among understudied species that exhibited high Use Value (UV), Fidelity Level (FL), Informant Consensus Factor (ICF), and endemic species, such as *A. conyzoides, A. calamus, C. capsularis, B. nivea, L. bleo, C. junghuhniana, Flacourtia rukam* Zoll. & Moritzi, and *A. indica.* Their ethnomedicinal relevance suggests promising pharmacological properties yet to be fully explored. As demonstrated by the development of modern drugs like quinine from *Chincona* sp. and artemisinin from *Artemisia annua* L., traditional knowledge can serve as a foundation for new therapeutic discoveries (Hsu 2006; Gachelin et al. 2017; Cao and Xia 2023). The findings of this study carry important conservation implications. The growing reliance on wild-harvested species raises ecological concerns. To mitigate this, sustainable harvesting, cultivation initiatives, and wider clinical validation are crucial to ensure both the preservation of biodiversity and the continuity of ethnobotanical knowledge. Therefore, integrating ethnobotanical documentation with biodiversity conservation strategies is essential to safeguard both cultural heritage and ecosystem health. This is particularly urgent in Toraja, where cultural shifts, land-use changes, and younger generations' decreasing familiarity with medicinal plants pose a threat to the continuity of traditional practices. However, community-based efforts can play a significant role in preserving traditional knowledge and biodiversity, making the local community an integral part of the conservation process. By highlighting the medicinal uses of locally known plants, this study contributes to efforts aimed at sustaining both ecological integrity and cultural resilience through community-based conservation and knowledge revitalization.

In conclusion, this study highlights the rich ethnobotanical knowledge of the Toraja community in treating gastrointestinal disorders, documenting 53 medicinal plant species, with *A. conyzoides, P. guajava,* and *A. calamus* being the most frequently cited. Key species contain bioactive compounds, such as flavonoids and terpenoids, which support their traditional use and potential for pharmacological validation. We recommend: (i) conservation and community cultivation of species like *C. capsularis* to reduce pressure on wild populations; (ii) clinical and phytochemical validation of the most cited plants; (iii) documentation and educational programs to maintain intergenerational knowledge transfer; (iv) integration of validated remedies into local healthcare and biodiversity management. These actions can protect cultural heritage and biodiversity, promote sustainable use of medicinal plants, and guide future ethnopharmacological research in Toraja.

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