Asian Journal of Ethnobiology

| Asian J Ethnobiol | vol. 8 | no. 1 | May 2025 |
| E-ISSN 2580-4510|

Pteropus giganteus (Brünnich, 1782) photo by Chris Kirby-Lambert

Published semiannually **PRINTED IN INDONESIA**

E-ISSN: 2580-4510

Asian Journal of Ethnobiology

| Asian J Ethnobiol | vol. 8 | no. 1 | May 2025 | E-ISSN 2580-4510 |

Asian Journal of Ethnobiology

| Asian J Ethnobiol | vol. 8 | no. 1 | May 2025 |

ONLINE
http://smujo.id/aje

e-ISSN
2580-4510

PUBLISHER
Smujo International

ASSOCIATION
Society for Indonesian Biodiversity

INSTITUTION
Universitas Padjadjaran, Sumedang, Indonesia

OFFICE ADDRESS
Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran. Jl. Raya Bandung-Sumedang Km 21, Jatinangor, Sumedang 45363, West Java, Indonesia. Tel. +62-22-7796412 line 104, Fax. +62-22-7794545, email: editors@smujo.id

PERIOD OF ISSUANCE
May, November

EDITOR-IN-CHIEF
Johan Iskandar – Universitas Padjadjaran, Sumedang, Indonesia

MANAGING EDITOR
Dede Mulyanto – Universitas Padjadjaran, Sumedang, Indonesia

EDITORIAL BOARD
Ankur Patwardhan – Abasaheb Garware College, Pune, India
Bhubaneswar Sabar – Centre for Multi-Disciplinary Development Research, Dharwad, India
Budiawati S. Iskandar – Universitas Padjadjaran, Sumedang, Indonesia
Cedric B. Baker – Mercer University, Atlanta, USA
Herwarsono Soedjito – Research Centre for Biology, National Research and Innovation Agency, Indonesia
Nicholas Malone – University of Auckland, Auckland, New Zealand
Percy E. Sajise – University of the Philippines at Los Banos, Laguna, Philippines
Ramadhanil Pitopang – Universitas Tadulako, Palu, Indonesia
Roy F. Ellen – University of Kent, Canterbury, UK
Yohanes Purwanto – Research Centre for Biology, National Research and Innovation Agency, Indonesia

List of reviewers: https://smujo.id/aje/reviewers

Society for Indonesian Biodiversity

Universitas Padjadjaran Sumedang, Indonesia

Published by Smujo International for The Society for Indonesian Biodiversity and Universitas Padjadjaran Sumedang, Indonesia

GUIDANCE FOR AUTHORS

Aims and Scope ***Asian Journal of Ethnobiology*** **(Asian J Ethnobiol)** encourages submission of manuscripts dealing with relationships between humans and their biological nature, including ethnobotany, ethnomycology, ethnozymology, ethnozoology, ethnoecology, traditional environmental/ ecological knowledge, ethnometereology, ethnoastronomy, ethnomedicine, ethnopharmacognosy, ethnoveterinary, ethnogastronomy, urban ethnobiology, linguistic ethnobiology, ethical and legal aspects of the biodiversity conservation and other related fields of study within anthropology and biology; as well as impact of economic activity on individuals in community and its social consequences.

Article types The journal seeks for: (i) **Research papers**, (ii) **Reviews**, and (iii) **Short communications**. Original full-length research manuscripts are limited to 8,000 words (including tables and figures) or proportional to articles in this publication number (beyond that, it should be with notice). Review articles are also limited to 8,000 words, while Short communications should be less than 2,500 words, except for pre-study (can be more).

Submission: The journal only accepts online submissions through the open journal system **(https://smujo.id/aje/about/submissions)** or, for login problems, email the editors at unsjournals@gmail.com (or editors@smujo.id). Submitted manuscripts should be the original works of the author(s). Please ensure that the manuscript is submitted using the template, which can be found at (https://biodiversitas.mipa.uns.ac.id/D/template.doc). The manuscript must be accompanied by a cover letter containing the article title, the first name and last name of all the authors, and a paragraph describing the claimed novelty of the findings versus current knowledge. Please also provide a list of five potential reviewers in your cover letter. They should come from outside your institution and better from three different countries. Submission of a manuscript implies the submitted work has not been published (except as part of a thesis or report, or abstract) and is not being considered for publication elsewhere. When a group writes a manuscript, all authors should read and approve the final version of the submitted manuscript and its revision; and agree on the submission of manuscripts for this journal. All authors should have made substantial contributions to the concept and design of the research, acquisition of the data and its analysis, drafting the manuscript, and correcting the revision. All authors must be responsible for the work's quality, accuracy, and ethics.

Ethics Author(s) must be obedient to the law and/or ethics in treating the object of research and pay attention to the legality of material sources and intellectual property rights.

Copyright If the manuscript is accepted for publication, the author(s) still hold the copyright and retain publishing rights without restrictions. For the new invention, authors must manage its patent before publication.

Open Access The journal is committed to free-open access that does not charge readers or their institutions for access. Readers are entitled to read, download, copy, distribute, print, search, or link to the full texts of articles, as long as not for commercial purposes. The license type is CC-BY-NC-SA.

Acceptance Only articles written in US English are accepted for publication. Manuscripts will be reviewed by editors and invited reviewers (double-blind review) according to their disciplines. Authors will generally be notified of acceptance, rejection, or need for revision within 1 to 2 months of receipt. Manuscripts will be rejected if the content does not align with the journal scope, does not meet the standard quality, is in an inappropriate format, or contains complicated grammar, dishonesty (i.e., plagiarism, duplicate publications, fabrication of data, citations manipulation, etc.), or ignoring correspondence in three months. The primary criteria for publication are scientific quality and significance. **Uncorrected proofs** will be sent to the corresponding author by system or email as .doc or .docx files for checking and correcting typographical errors. The corrected proofs should be returned in 7 days to avoid publication delays. The accepted papers will be published online in chronological order at any time but printed at the end of each month.

Free of charge This publication is dedicated entirely to the advancement of science and technology, therefore author(s) or author institution(s) are not subject to publication fees. **Reprint** Authors or other parties may freely download and distribute. However, a printed request will be charged. It may be purchased when ordering by sending back the uncorrected proofs by email.

Manuscript preparation Manuscript is typed on A4 (210x297 mm^2) paper size, in a single column, single space, 10-point (10 pt) Times New Roman font. The margin text is 3 cm from the top, 2 cm from the bottom, and 1.8 cm from the left and right. Smaller lettering sizes can be applied in presenting tables and figures (9 pt). Word processing program or additional software can be used; however, it must be PC compatible, use the template, and be Microsoft Word based (.doc or .rtf; not .docx). **Scientific names** of species (incl. subspecies, variety, etc.) should be written in italics, except in italicized sentences. Scientific names (genus, species, author) and cultivar or strain should be mentioned completely for the first time mentioning it in the body text, especially for taxonomic manuscripts. The genus name can be shortened after the first mention, except in early sentences, or where this may generate confusion; name of the author can be eliminated after the first mention. For example, *Rhizopus oryzae* L. UICC 524 can be written hereinafter as *R. oryzae* UICC 524. Using trivial names should be avoided. **Biochemical and chemical nomenclature** should follow the order of the IUPAC-IUB. For DNA sequences, it is better to use Courier New font. Standard chemical abbreviations can be applied for common and clear used, for example, completely written butilic hydroxyl toluene (BHT) to be BHT hereinafter. **Metric measurements** should use IS denominations, and other systems should use equivalent values with the denomination of IS mentioned first. A dot should not follow abbreviations like g, mg, mL, etc. Minus index (m^{-2}, L^{-1}, h^{-1}) suggested being used, except in things like "per-plant" or "per-plot." **Mathematical equations** can be written down in one column with text; in that case, they can be written separately. **Numbers** one to ten are written in words, except if it relates to measurement, while values above them are written in number, except in early sentences. The fraction should be expressed in decimal. In the text, it should be used "%" rather than "percent." Avoid expressing ideas with complicated sentences and verbiage/phrasing, and use efficient and effective sentences.

The title of the article should be written in compact, clear, and informative sentence, preferably not more than 20 words. Name of author(s) should be completely written, especially for the first and the last name. **Name and institution** address should also be completely written with street name and number (location), postal code, telephone number, facsimile number, and email address. We choose local names in Bahasa Indonesia for universities in Indonesia. The mention of "strata" program, should be avoided. Manuscript written by a group, author for correspondence along with address is required (marked with "♥"). **The title page** (first page) should include title of the article, full name(s), institution(s) and address(es) of the author(s); the corresponding authors detailed postage and e-mail addresses (P), and phone (O) and fax numbers (O).

Abstract A concise abstract is required (about 200 words). The abstract should be informative and state briefly the aim of the research, the principal results and major conclusions. An abstract is often presented separately from the article, thus it must be able to stand alone (completely self-explanatory). References should not be cited, but if essential, then cite the author(s) and year(s). Abbreviations should be avoided, but if essential, they must be defined at their first mention. **Keywords** are about five words, covering scientific and local name (if any), research themes, and special methods used; and sorted from A to Z. **Abbreviations** (if any): All important abbreviations must be defined at their first mention there. **Running title** is about five words.

Introduction is about 600 words, covering the aims of the research and provide an adequate background, avoiding a detailed literature survey or a summary of the results. **Materials and Methods** should emphasize on the procedures and data analysis. **Results and Discussion** should be written as a series of connecting sentences, however, for a manuscript with long discussion should be divided into subtitles. Thorough discussion represents the causal effect mainly explains why and how the results of the research were taken place, and do not only re-express the mentioned results in the form of sentences. **Concluding** sentence should be given at the end of the discussion. **Acknowledgements** are expressed in a brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged, and any potential conflicts of interest are noted.

Figures and Tables of a maximum of three pages should be clearly presented. The title of a picture is written down below the picture, while the title of a table is written above the table. Colored figures can only be accepted if the information in the manuscript can lose without those images; the chart is preferred to use black and white images. The author could consign any picture or photo for the front cover, although it does not print in the manuscript. All images property of others should be mentioned the source. Author is suggested referring to Wikipedia for international boundaries and Google Earth for satellite imagery. If not specifically mentioned, it is assumed to refer to these sources. **There is no appendix**, all data or data analysis is incorporated into Results and Discussions. For broad data, it can be displayed on the website as a supplement.

References Preferably 80% of it comes from scientific journals published in the last 10 years. In the text, give the author names followed by the year of publication and arrange from oldest to newest and from A to Z; in citing an article written by two authors, both of them should be mentioned; however, for three and more authors only the first author is mentioned followed by et al. For example, Saharjo and Nurhayati (2006) or (Boonkerd 2003a, b, c; Sugiyarto 2004; El-Bana and Nijs 2005; Balagadde et al. 2008; Webb et al. 2008). Extent citation should be avoided, as shown with the word "cit." Reference to unpublished data and personal communication should not appear in the list but should be cited in the text only (e.g., Rifai MA 2007, pers. com. (personal communication); Setyawan AD 2007, unpublished data). In the reference list, the references should be listed in alphabetical order. Names of journals should be abbreviated. Always use the standard abbreviation of a journal's name according to the **ISSN List of Title Word Abbreviations** (www.issn.org/2-22661-LTWA-online.php). Please include DOI links for journal papers. The following examples are for guidance.

Journal:

Saharjo BH, Nurhayati AD. 2006. Domination and composition structure change at hemic peat natural regeneration following burning; a case study in Pelalawan, Riau Province. Biodiversitas 7: 154-158. DOI: 10.13057/biodiv/d070213.

The usage of "et al." in long author lists will also be accepted:

Smith J, Jones M Jr, Houghton L et al. 1999. Future of health insurance. N Engl J Med 965: 325-329. DOI: 10.10007/s002149800025.

Book:

Rai MK, Carpinella C. 2006. Naturally Occurring Bioactive Compounds. Elsevier, Amsterdam.

Chapter in the book:

Webb CO, Cannon CH, Davies SJ. 2008. Ecological organization, biogeography, and the phylogenetic structure of rainforest tree communities. In: Carson W, Schnitzer S (eds.). Tropical Forest Community Ecology. Wiley-Blackwell, New York.

Abstract:

Assaeed AM. 2007. Seed production and dispersal of *Rhazya stricta*. 50th annual symposium of the International Association for Vegetation Science, Swansea, UK, 23-27 July 2007.

Proceeding:

Alikodra HS. 2000. Biodiversity for development of local autonomous government. In: Setyawan AD, Sutarno (eds.). Toward Mount Lawu National Park; Proceeding of National Seminary and Workshop on Biodiversity Conservation to Protect and Save Germplasm in Java Island. Universitas Sebelas Maret, Surakarta, 17-20 July 2000. [Indonesian]

Thesis, Dissertation:

Sugiyarto. 2004. Soil Macro-invertebrates Diversity and Inter-Cropping Plants Productivity in Agroforestry System based on Sengon. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

Information from the internet:

Balagadde FK, Song H, Ozaki J, Collins CH, Barnet M, Arnold FH, Quake SR, You L. 2008. A synthetic *Escherichia coli* predator-prey ecosystem. Mol Syst Biol 4: 187. DOI: 10.1038/msb.2008.24. www.molecularsystembiology.com.

THIS PAGE INTENTIONALLY LEFT BLANK

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025 E-ISSN: 2580-4510
Pages: 1-11 DOI: 10.13057/asianjethnobiol/y080101

Ethnozoological study of animal-based medicine used by traditional healers in Northern Western Ghats of Maharashtra, India

AISHWARYA ZOPE[1], AVINASH SONAWANE[1], SUNIL PATIL[1], BHORABAI NIRGUDE[2], PRANIL JAGDALE[2,♥]
[1]Research Centre in Zoology, Maharaja Sayajirao Gaikwad Arts, Science and Commerce (M.S.G.) College. Malegaon Camp, Malegaon, Nashik- 423105, Maharashtra, India
[2]Department of Zoology, MVP Samaj's Arts, Commerce and Science College. Tryambakeshwar-422212, Nashik, Maharashtra, India.
Tel.: +91-2594233508, ♥email: pranil.jagdale@gmail.com

Manuscript received: 16 July 2024. Revision accepted: 10 January 2025.

Abstract. *Zope A, Sonawane A, Patil S, Nirgude B, Jagdale P. 2025. Ethnozoological study of animal-based medicine used by traditional healers in Northern Western Ghats of Maharashtra, India. Asian J Ethnobiol 8: 1-11.* Since the beginning of human history, animals have been used for various purposes. Animals provided food, medicine, and clothes for people. In this regard studies on ethnozoology have gained interest in India over the last decade. Ethnozoological research is required to identify novel treatments for human health and it is crucial to document this information. Thus, the authors endeavor to conduct a pilot ethnozoological study from the Northern Western Ghats of Maharashtra. Ethnomedicinal data were gathered from traditional healers through interviews, casual encounters, and overt observations using semi-structured questionnaires. The information collected was analyzed using the Informant Consensus Factor (ICF) and Fidelity Level (FL). The ethnozoological data include names of the animals and their body parts (organs) used in the local language, preparation, and administration method of medicine, and other informative pieces deemed helpful for research. A total of 37 animal species were identified for treating around 59 diseases. Mammals were the most frequently used therapeutic species (33%) by traditional healers. We are the first to report oral use of Maharashtra zipper Loach (*Paracanthocobitis mooreh*) as a therapy for drooling in the study area. It is considered that documenting ethnozoological knowledge could lead to the development of novel medications. Therefore, it is believed that the data in this work will be helpful in future research on ethnozoology, ethnopharmacology, and conservation.

Keywords: Anthropological field studies, ethnomedicine, ethnozoology, indigenous knowledge, zootherapy

INTRODUCTION

Traditional medicinal knowledge is an important alternative for the healthcare system in modern society (Hyma and Ramesh 2002; Febriyanti et al. 2024). The knowledge, abilities, and practices derived from Indigenous theories, beliefs, and experiences across various cultures constitute traditional medicine utilized to prevent, diagnose, treat, or improve physical and mental ailments (Kandari et al. 2015). Traditional medicine provides primary health care to approximately 70-80% of the world's rural population (WHO 2014). These traditional medicines are primarily administered following an agreement formed privately between consenting parties, and oral folklore has typically been the source of knowledge about traditional techniques (Eshete et al. 2016). Therefore, indigenous knowledge is based on tried-and-true methods that evolve due to people interacting with their surroundings. It is the product of many years and generations of experience, close observation, and trial-and-error research (Phichonsatcha et al. 2022; Bihari 2023). However, since different ethnic groups pass down their traditional medical knowledge verbally from elderly people to future generations, this knowledge may be lost with the passing of competent elderly people (Borah and Prasad 2016).

Research in ethnobiology is crucial to understanding the future viability of biocultural systems (Fopa et al. 2020). According to Faiz et al. (2022), cultural uses of animals (such as in food, medicine, hunting, business, entertainment, and religion) can influence people to think and act in ways that benefit animal conservation operations. Nevertheless, these techniques can harm or even threaten these species if they are not carried out sustainably or are impacted by economic, marketing, and political reasons (Dickman 2010; Mozer and Prost 2023). It is crucial to consider additional factors, such as environmental and climate alterations, when examining how people utilize particular animal species for therapeutic and cultural purposes (Alves et al. 2018).

Resources that indigenous people use worldwide around 60% of commercially available medications based on bioactive substances collected from natural resources (Ansari et al. 2023; Chaachouay et al. 2023). Although plants and plant derivatives have been prominent components of traditional medicine, identifying animal resources for medical healing is also essential in human health care (Borah and Prasad 2017; Castillo and Ladio 2018; Souto et al. 2018). Paws, skins, skeletons, bird feathers, and horns are among the byproducts of domestic and wild animals that are valuable elements in the formulation of medicinal, protective, and preventive remedies (Borah and Prasad 2016; Jugli et al. 2019). Thus, ethnozoology is the study of the historical and contemporary interactions between humans and animals, documenting their distinct knowledge of animals to find new sources of food, medicine, and social aspects of animals in the world of humans (Borah and Prasad 2016; Bagde and Jain 2017).

Since ancient times, several cultures have used biodiversity as a source of therapeutics (Alves and Albuquerque 2012; Sen and Samanta 2015). As their livelihood is based on their local environment (Bhattacharjee et al. 2016; Sharma and Mohan 2024) most of the people living in the Western Ghats rely on traditional medicinal systems. People learned how to use natural systems in the form of food, medicine, and other applications for their survival (Chellappandian et al. 2014). India has an extensive biodiversity of fauna, which comprises about 10% of all reported biological species on the planet, and ranks first in terms of insects (54,600), followed by fishes (2546), birds (1232), reptiles (456), mammals (390), and amphibians (209) (Rangarajan 2006). In India, the known historical book such as Charak Samhita has reported and documented various zootherapeutic traditional medicines. Approximately 15-20% of Ayurvedic remedies are based on substances derived from animals (Unnikrishnan 1998). Different tribes and ethnic groupings in India have an immense quantity of information about animals and their medicinal usefulness for their basic healthcare needs (Mahawar and Jaroli 2008). Thus, further research is required to learn more about how India uses fauna that has therapeutic qualities. As a result, it is crucial to document the traditional indigenous knowledge of many ethnic communities, as numerous rural areas are losing their social and cultural traits (Alonso-Castro et al. 2011).

In various regions of Maharashtra, traditional medical practices are still widely used; however, research on medicinal animals or animal products has not been conducted in Maharashtra. Therefore, the current study seeks to investigate and document the traditional uses of animals and animal-derived products in their entirety in Maharashtra. It is believed that the current documentation would serve to preserve this diminishing information before it completely vanishes from tribes of the Nashik District. It is also expected that the current documentation will be crucial in protecting traditional knowledge and conserving and sustaining the biodiversity of the Northern Western Ghats for future generations.

MATERIALS AND METHODS

Study area description

The study was conducted in different regions of the Northern Western Ghats of Nashik (19.9975° N, 73.7898° E), Maharashtra. Nestled amidst verdant mountainous surroundings (Gangurde and Kumbhar 2018), Nashik is situated in the northern region of the state of Maharashtra. Also, the world-renowned Western Ghats is the northernmost portion of Nashik District. The Sahyadri Hills, another name for the Western Ghats, are renowned for their diverse and abundant flora and fauna. This region of Western Ghats extends from the north to the south of the district, which is characterized by its hilly terrain. Nashik has been endowed with enormous biodiversity with variations at the genetic, species-level, and ecological levels. Considering the facts above, the Peth, Surgana, and Trimbakeshwar tehsils of the Nashik district were chosen as the study locations (Figure 1). The Western Ghats Mountains reach into the district, because tribal communities use a broad variety of flora and fauna for the treatment of various ailments, the traditional medicine system is well established in the tribal part of Nashik District. The area is home to several tribes, including the Kokana, Bhill, Koli Mahadev, Warali, Thakur, and Katkari (Palwey 2019; Sonawane et al. 2019).

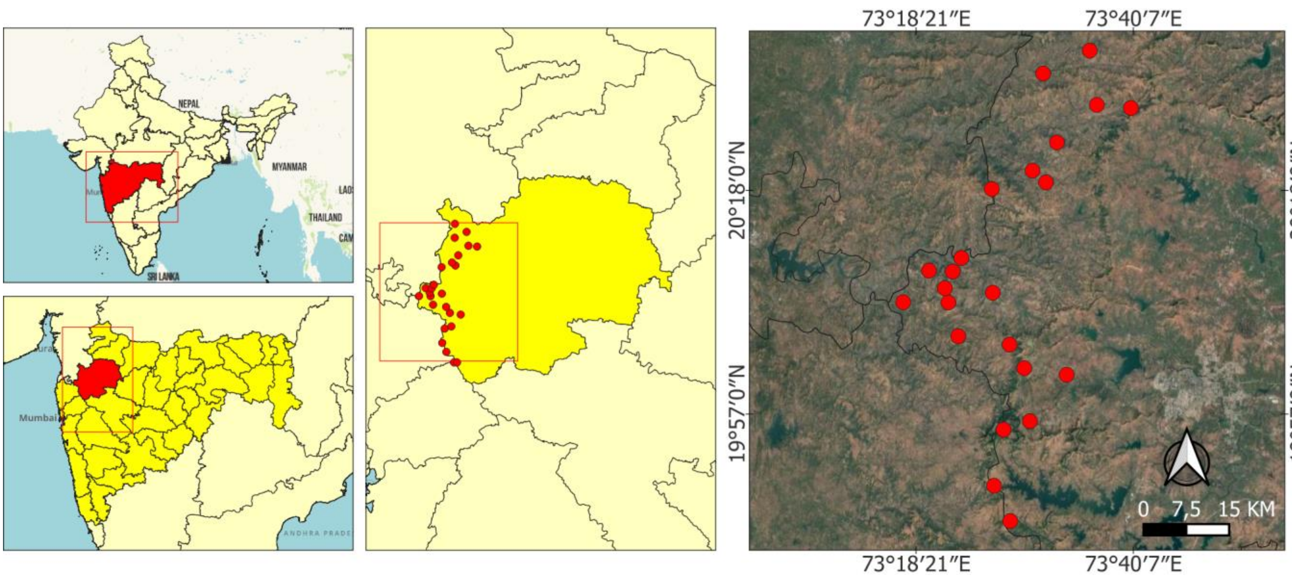


Figure 1. Map showing the field survey localities from Nashik District, Maharashtra, India

Selection of study sites

Nashik is primarily located in the vicinity of the Western Ghats, where rainfall is typically higher. The Moist Deciduous Forest is the most prominent forest type in the area, and it is abundant in biodiversity. This forest is particularly prevalent in the areas surrounding Vaitarna Lake, Trimbakeshwar, Anjaneri, Igatpuri, Peint, Harsul, and Surgana. The study was conducted in three tehsils of the Northern Western Ghats of Nashik because the area is inhabited by several tribes. These tehsils were purposefully selected because traditional medicinal practitioners and knowledgeable indigenous people are more in number as compared to other tehsils of Nashik District. During the period of December 2022 to November 2023, this investigation examined potential animals and their components that were employed to treat a variety of ailments (Figure 2).

Sampling and data collection

The study population included all traditional medicinal practitioners and selected indigenous people over the age of 18 who practiced traditional medicine, lived in the study area of the selected tehsil, and were available throughout the data collection period. Community leaders, health extension workers, and local authorities of the respective tehsils assisted in the purposeful selection of indigenous people who were recognized by the local community as knowledgeable ("experts") due to their understanding of traditional medicinal services. Moreover, a snowball sampling technique was used to locate further prospective informants from the people living in the targeted locality. A semi-structured questionnaire was utilized to collect ethnozoological data from each informant (local name, indication, components of the animal used, technique of preparation, route of administration).

Quality assurance of the study

A semi-structured questionnaire was prepared in English form after reviewing different literature. The original form of the questionnaire was translated into the local language of Marathi, and then it was translated back into english. This was done to ensure that the questionnaire remained authentic. To test the data collection checklist, a pretest was done in November 2022 among four informants in Kachurli Village of Trimbakeshwar Tehsil, Nashik District. During the entire time that the data were being collected, they were checked to ensure that they were comprehensive and consistent.

Data analysis

SPSS and Microsoft Excel spreadsheets were used to clean, enter, and analyze data. Descriptive statistics were used to analyze quantitative data. The following formula was used to calculate the fidelity level (Tugume et al. 2016), informants consensus factor (Uddin and Hassan 2014), and use-values (Vitalini et al. 2013) from the collected data. For following formula IMA denotes the number of informants who stated a specific animal species used to treat certain ailments and FC denotes the overall number of informants who used animals as medicine to treat any given ailment.

$$\text{Fidelity Level (FL\%)} = (IMA/FC) \times 100$$

Where: Nur is the number of use reports from informants for a specific animal-use category and Nt is the total number of taxa or species used by all informants for that animal-use category. ICF values vary from 0 to 1, with '1' indicating the maximum level of informant consent.

$$ICF = (Nur-Nt)/(Nur-1)$$

Ethical considerations

The purpose of the study was explained to all study participants, and their right to decline was maintained. Throughout the data-gathering phase, ethical behavior, confidentiality, and anonymity were maintained.

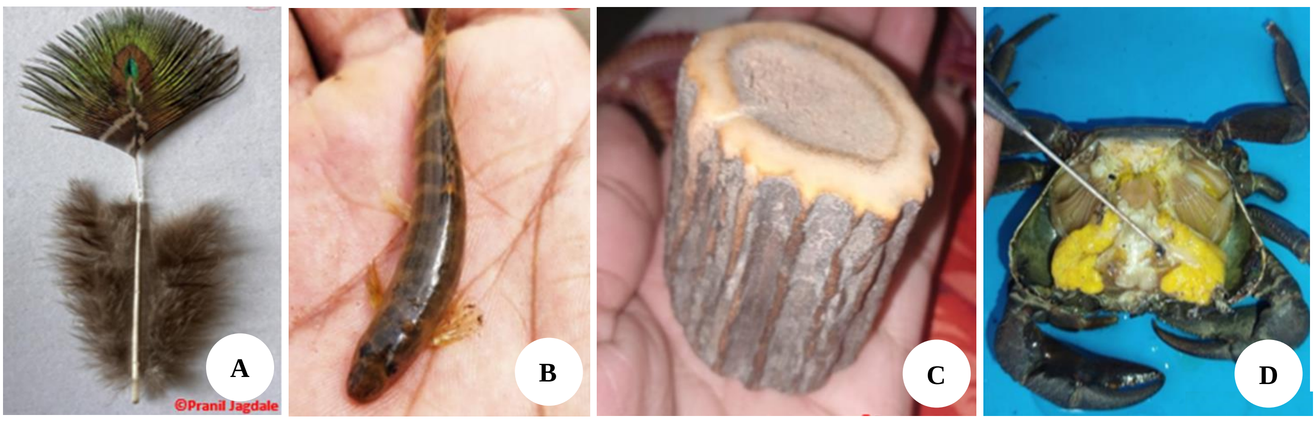


Figure 2. A. Feather/mayur of Indian peacock (*Pavo cristatus* Linnaeus, 1758.); B. Maharashtra zipper loach (*Paracanthocobitis mooreh*); C. Old horn piece with bone marrow of Samber deer (*Rusa unicolor* (Kerr, 1792)); D. Hepatopancreas of crab (*Barytelphusa cunicularis* (Westwood, 1836))

RESULTS AND DISCUSSION

Socio-demographic characteristics of informants

This study had a total of 58 participants, 56 of them were male (96.5% of the total), and only two of them were female (3.5%). A total of 34 individuals (58.5%) of the individuals who provided information were between the ages of 55 and 64, with 06 individuals (10.2%) being 65 years of age or older. A total of 51 individuals (88%) of the people who provided information were married. Figure 3 shows that more than half of the people who responded to the survey were illiterate. A total of forty people were interviewed, and sixty-six percent of them were farmers who offered private traditional medical therapy.

Ethno-zoological data

The majority of the informants, which accounted for 44.8% of the total, were taught by their father about the medical use of animals and associated products. In Figure 4, it can be seen that a sufficient number of respondents, specifically 72.4%, expressed a desire to transmit their therapeutic expertise to subsequent generations. Although forty people, or 68.9%, gave traditional medicine for the purpose of self-satisfaction or in the belief that God's gifts were bestowed upon them. Regarding the dosage, around 26 practitioners, which accounts for 44.8% of the total, utilized various measurements such as spoons, cups, mud pots, and locally available materials.

Category of animals medicinally used in the study area

During the course of this investigation, 37 different species from nine different categories including mammals, avians, reptiles, amphibians, molluscs, pisces, arthropods, and insects were utilized to treat 59 different health-related issues. Mammals were the most frequently used therapeutic species (33%) by traditional healers and Indigenous people in the study area (Figure 5). In contrast to those obtained domestically, 25 species (68%) of the total therapeutic animals or their products utilized historically came from wild sources (Table 1).

Animal parts/products used as traditional medicine

In the present study, meat or fatty meat (28.8%) was the most commonly used animal product. Followed by that whole organism (10.1%), horn powder (8.4%), and egg (6.7%) are used as major parts or products used in traditional medicine for various ailments. The remaining details of other products are given in Table 2. Furthermore, therapeutic values have been recorded for various parts including liver, ghee, eye, hoof (leg toe/nail), blood, feather, legs, bones, shell, brain and gastric content.

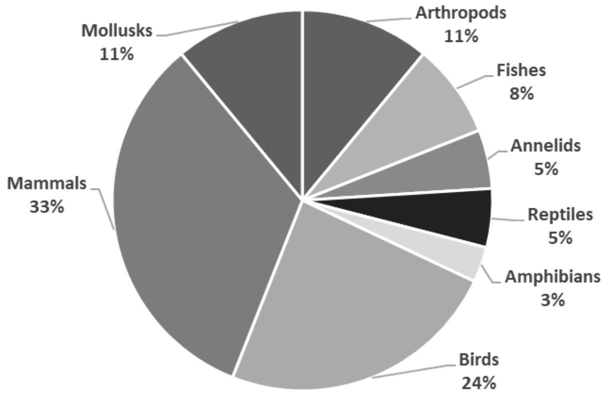


Figure 5. Category of animals used traditionally in Tribes

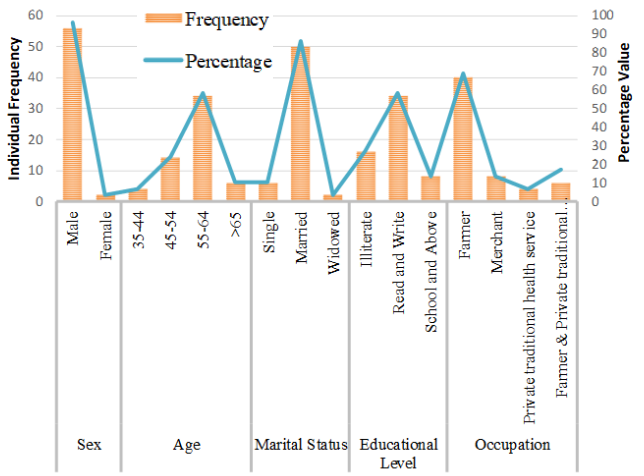


Figure 3. Socio-demographic characteristics of informants

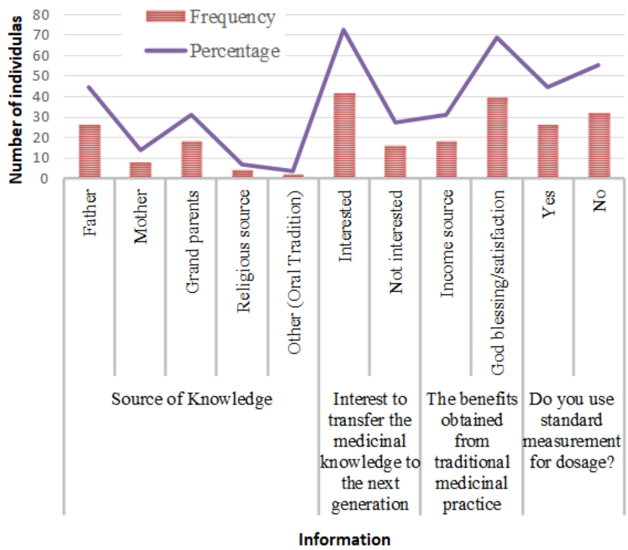


Figure 4. Chart source of knowledge, the attitude of community and practice-related information

Table 1. Medicinal animals, parts/products used, diseases treated, mode of preparation, and routes of administration in the study area

Category & Scientific name	English name	Local name	IUCN status	Ailments/ indications	Part of use	Preparation and dosage	Application	Fidelity level
Mammal								
Prionailurus rubiginosus (I.Geoffroy Saint-Hilaire, 1831)	Rusty-spotted cat	Ranmanjar	VU	Burn	Hairs	Powder mixed in oil and used till it heals	Topical	50
				Cut/injury	Hairs	Powder mixed in ghee/oil and used till it heals	Topical	60
Bos frontalis Lambert, 1804	Gaur	Bail	NE	Swelling	Horn powder	Burning the horn and apply powder on the swelling area till it heals	Topical	66.7
				Sprain/cramp	Bone with bone marrow	Massage the area with forging marrow till it heals	Topical	50
				Anemia	Liver	Eating the fresh liver	Oral	60
Pteropus giganteus (Brünnich, 1782)	Indian flying fox	Watvaghul	LC	Eye irritation	Meat	Cooked. Three pieces of fresh meat for a day	Oral	67.6
				Asthma	Meat	Cooked. Three pieces of fresh meat for a day	Oral	71.4
Lepus nigricollis F. Cuvier, 1823	Indian hare	Sasa	LC	Children cough	Milk	Boil once and give 2 spoons of milk for 3 days	Oral	75
Sus scrofa Linnaeus, 1758	Wild boar	Randukkar	LC	Wellness	Meat	Cooked. Three pieces of fresh meat for a day and consumed	Oral	75
				Joint pain	Brain oil	Cook and massage with extracted oil	Topical	81.8
Bos taurus Linnaeus, 1758	Cow	Gay	NE	Blood sugar/ cancer	Urine	Consumed cup of Urine early in the morning	Oral	71.4
				Cataracts	Ghee/ clarified butter	Put a drop of ghee in the eyes for 5-7 days	Oral/topical	100
Capra hircus Linnaeus, 1758	Goat	Bakri	NE	Blood in increase & wellness/ weakness	Liver/meat/ brain	Cooked meat pieces of fresh meat for a day and consumed	Oral	100
				Cough	Urine	Consumed cup of urine early in the morning	Oral	50
				Fracture	Leg toe	Prepare soup and drink till it heals	Oral	100
Bubalus bubalis (Linnaeus, 1758)	Water buffalo	Mhas	NE	Skin dryness/ itching	Ghee	Apply ghee on the affected surface and massage till oil is absorbed completely	Topical	50
Herpestes edwardsi (É.Geoffroy Saint-Hilaire, 1818)	Indian grey mongoose	Mongoose	LC	Snake bit (non-poisons)	Skin	Apply the paste form of powder on the snake bite	Topical	30
Equus hemionus subsp. *khur* Lesson, 1827	Indian wild ass	Gadhav	EN	Cough to baby	Fresh milk	Give 2 spoons of milk for 3 days	Oral	81.8
				Cold&Fever	Horn powder	Take Steam of horn powder for 3 days	Topical	66.7
Rusa unicolor (Kerr, 1792)	Sambar deer	Sambar	NT	Blood clotting	Horn powder	Apply the paste form of powder on the affected surface	Topical	100
				Injury/cut	Horn powder	Spread the powder on the affected surface	Topical	46.1
Bandicota indica (Bechstein, 1800)	Greater bandicoot rat	Ghus	LC	Weakness	Meat	Cooked three pieces of fresh meat for a day and consumed	Oral	66.6
Aves								
Ardeola grayii (Sykes 1832)	Indian pond heron	Khabra-bagala	LC	Asthma	Meat	Cooked two-three pieces of fresh meat for a day and consumed	Oral	100
				Injury/cut	Foot toe	Spread the powder on the affected surface	Topical	50

Columba livia J.F.Gmelin, 1789	Pigeon	Parva	LC	Paralysis	Blood	Massage the area with blood till it heals	Topical	100
				Asthma	Meat	Cooked at least three pieces of fresh meat for a day and consumed	Oral	83.3
Gallus gallus f. *domesticus*	Domestic chicken	Kombad/ Kombdi	NE	Bone injury	Egg	Consumed. Cooked or row 2 eggs per day till it heals	Oral	100
				Cough	Egg	Consumed. Cooked egg every night day till it heals	Oral	77.4
				Fracture	Meat	Cooked two or three pieces of fresh meat for a day and consumed	Oral	90.9
Coturnix coturnix (Linnaeus, 1758)	Common quail	Titar	LC	Skin problem/ rash	Meat	Cooked two or three pieces of fresh meat for a day and consumed	Oral	60.7
Anas platyrhynchos Linnaeus, 1758	Mallard Duck	Badak	LC	Thyroid	Meat/egg	Cooked two or three pieces of fresh meat for a day and consumed	Oral	50
Phalacrocorax fuscicollis Stephens, 1826	Indian Cormorant	Pankawla	LC	Menstrual cycle	Meat	Cooked at least three pieces of fresh meat for a day and consumed	Oral	70
Pavo cristatus Linnaeus, 1758	Indian Peacock	Mor	LC	Vomiting/ asthma	Feather /mayur	Consumed powder with a spoon of honey once a day	Oral	62.9
				Kidney stone	Undigested food from the stomach	Cook it and consume filtrate only	Oral	33.3
Dromaius novaehollandiae (Latham, 1790)	Ostrich	Emu	LC	Joint pain/skin problem/eye problem	Egg	Cook it and consume the whole egg	Oral	66.6
Galloperdix spadicea (J.F. Gmelin, 1789)	Red spurfowl	Kokatri	NT	Pain in ear	Legs	Cooked in water and pour 2-3 drops of water in the ear	Topical	50
Reptile								
Varanus bengalensis (Daudin, 1802)	Indian Monitor	Ghorpad	LC	Burn	Oil	Apply oil on the surface till it heals	Topical	96
				Cataracts/ blurred vision	Oil	Put a drop in the eyes for 5-7 days	Topical	66.6
				Asthama	Brain	Cooked and eaten for 2-3 days	Oral	40
				Burn	Skin	Mix the powder in oil and apply	Topical	90.9
Pangshura tecta (Gray, 1831)	Indian roofed turtle	Kasav	EN	Hemorrhoids	Meat	Cooked and eaten for 2-3 days	Topical	66.6
Amphibians								
Rana tigrina	Frog	Beduk	LC	Gain strength wellness	Meat	Cooked whole organism and eat it once a week	Oral	60
Pisces								
Labeo rohita (Hamilton, 1822)	Rohu	Rou	VU	Better vision	Meat/eyeball	Cooked whole organism and eat it once a week	Oral	90.9
Catla catla (Hamilton, 1822)	Catla	Katla	VU	Better vision	Meat/eyeball	Cooked whole organism and eat it once a week	Oral	87.5
Paracanthocobitis mooreh	Maharashtra zipper loach	Murhi	NE	Drooling	Whole organism	Keep alive fish on the tongue of baby for few seconds	Oral	80

Insect								
Apis indica Fabricius, 1798	Honey bee	Madhmashi	LC	Mouth ulcer	Honey	Apply on ulcer using finger twice a day for three days	Oral	76.7
Apis dorsata Fabricius, 1793	Rock bee	Madhmashi	LC	Cough	Honey	Take a spoonful of honey once a day for three days	Oral	89.6
Arthropoda								
Hottentotta tamulus (Fabricius, 1798)	Indian red scorpion	Vinchu	LC	Purulent	Whole organism	cooked in oil and apply extracted oil with mayur /bird feather	Topical	56.2
Barytelphusa cunicularis (Westwood, 1836)	Crab	Khekud	NE	Joint pain	Meat	Cooked and eaten for 2-3 days	Oral	100
				Tinea versicolor	Yellow matter/ hepatopancreas	Apply on the affected surface till it heals	Topical	89.6
				Strengthen bones	Bones/skeleton	Make fine powder, mix in goat milk, and have it once a week	Oral	75
Annelida								
Hirudinaria Whitman, 1886	Leech	Jalu	LC	Skin problem/ purulent	Live leech	Keep leech to affected area and allow to suck blood till it heal	Topical	40
Lumbricus terrestris Linnaeus, 1758	Earthworm	Shidad	NE	Lactation	Whole organism	Cook in water, grind it and eat a cupful of organism	Oral	80
Mollusca								
Mariaella dussumieri L.Pfeiffer, 1855	Brown slug	Gogalgai	NE	Children cough	Whole organism	Cooked the whole organism and eat it for 2 days	Oral	68.4
Turbinella pyrum (Linnaeus, 1758)	Chank shell	Shankh	NE	Digestion/upset stomach/eye disease	Novel	Pinch of powder with a spoon of honey once a day	Oral	50
Monetaria moneta (Linnaeus, 1758)	Money cowrie	Kawadi	NE	Asthma allergy/ ear infection	Cowrie white shells	Pinch of powder with a spoon of honey once a day	Oral	45.4
				Kidney stone	Cowrie white shells	5-6 shells keep overnight in lemon juice and have empty stomach next morning	Oral	66.6
Ampullariidae	Apple snails	Khube	NE	Piles	Whole organism	Prepare soup and drink empty stomach for 2 -3 days	Oral	40
				Asthma	Meat	Cook meat with chicken egg and eat once a week	Oral	50

Note: The use of above medications/treatments/therapies is not recommended for readers. The medicines/therapies/treatments discussed in this article are based on traditional practices and local beliefs. They have not been clinically studied, and their efficacy and safety have not been determined. LC: Least Concern; NT: Near Threatened; VU: Vulnerable; EN: Endangered

Table 2. Proportions of parts/products of medicinal animals used in the study area

Parts/product of animals	Frequency	Percentage
Meat/fatty meat	17	28.8
Whole organism	6	10.1
Hair Powder	2	3.3
Horn powder	5	8.4
Oil	3	5
Milk	2	3.3
Egg	4	6.7
Honey	2	3.3
Urine	2	3.3
Skin	2	3.3
Other	14	23.7

Note: Others include: Liver, ghee, eye, hoof (leg toe/ nail), blood, feather, legs, bones, shell, and gastric content which occurs in a unit frequency

Table 3. Informant consensus factor for the common indications that the medicinal animals and animal products used by traditional medicinal practitioners and Indigenous people

Indication	Number of use reports (Nur)	Number of species for the indication (Nt)	ICF
Asthma	86	7	0.92
Cough	142	6	0.96
Joint pain	90	3	0.97
Burn	44	2	0.97
Cut/lacerations	18	3	0.88
Cataracts	13	2	0.91
Bone injury	32	2	0.96
Kidney stone	10	2	0.88
Cancer	11	1	1
Paralysis	21	1	1

Routes of application of medicinal animal remedies in the study area

Therapeutic animal products or treatment remedies were reported to be used in a variety of ways. Majority of treatment is either given orally or given as topical application on the affected surface. During entire treatment the parts (organ) of animals or their products are consumed either in cooked or in a raw form. The oral method is used for more than half of the manufactured animal medical treatments, followed by the topical route (30.8%).

Fidelity level of medicinal animal or animal products

According to the present investigation, fidelity levels range is recorded from 40 to 100% in the medicinal practice of animal and their products. According to the assessment, the use of apple snails to cure piles had the lowest fidelity level at 40.0%, while the use of ghee to treat cataracts, crab meat to treat joint pain, and chicken eggs to treat bone fracture had the highest fidelity level at 100%. Pigeon blood to treat paralysis, Indian pond heron meat to treat asthma, sambar deer horn powder to treat blood clotting. Rest all the other animal species used to treat various ailments with their fidelity level are mentioned in Table 1.

Informant consensus factor

The Informant Consensus Factor (ICF) was used in this study to determine the amount of agreement among respondents about which animal to use for each illness category. According to this study, informants had a high level of agreement (ICF = 1) in the treatment of paralysis and cancer. However, the informants' level of variability in kidney stone therapy was substantial (ICF = 0.85) as given in Table 3.

Discussion

The human-animal relationship has existed for more like millions of years, and it is influenced by cultural and environmental factors (Faiz et al. 2022). Since ancient times, goods generated from fauna have been used for a variety of reasons, including food, tools, ethnomedicine, and magico-religious practices (Chaudhury et al. 2016). Using parchment documents, archives, and medical artifacts, the utilization of animals or products derived from them has been documented throughout human history, including at the urban centers of ancient Mesopotamia, Assyria, and Babylon (Vijayakumar et al. 2015). The development of emotional bonds with specific and numerous species of animals that were kept as pets, particularly birds, mammals, and, more recently, reptiles and amphibians, is associated with this kind of dependency (Alves and Souto 2015; Adil et al. 2022).

In the most recent scenario, there has been an increasing worry regarding the effects of human activity on the preservation of biodiversity and ecosystem services (Dirzo et al. 2014; Haddad et al. 2015; Liu et al. 2018). Enhancing our awareness of the social cultural, economic, and traditional functions that animals perform is the most significant asset that can be gained from conducting ethnozoological research. Accordingly, they play a key role in the management and conservation of the local biodiversity within the framework of the local human populations (de Lima et al. 2014; Alves and Souto 2015).

According to Faiz et al. (2022), Holennavar (2015), and Ahmad et al. (2023), zootherapy is the practice of using animals or products made from animals to treat human health ailments. Zootherapy is the practice of using both domestic and wild animal parts and their byproducts, such as hooves, skins, bones, feathers, and tusks, as important components in the formulation of medicinal remedies intended to be therapeutic, defensive, and preventive (Chaudhury et al. 2016).

According to the current investigation, older populations in the Nashik District of Northern Western Ghats, have more expertise and knowledge than younger generations on the traditional medicinal uses of animals. Similar tendencies were confirmed from previous studies demonstrating that elderly persons are more knowledgeable in zootherapeutical procedures and they hold the knowledge learned from their parents or senior members of their community (Verma et al. 2014; Borah and Prasad 2016, 2017; Kendie et al. 2018). In the study area, the development of contemporary higher education, modernization, migration to surrounding cities, and opinions toward the practice as a detrimental tradition are some of the responsible factors for the younger generation's involvement.

The Western Ghats are known for their diverse climatic and ecological conditions and their biodiversity, home to thousands of animal species (Nameer et al. 2001). According to a World Health Organization (WHO) assessment, the role of traditional and complementary medicine in global healthcare, highlighting its use in rural and underserved population (WHO 2019). The reliance of rural populations on traditional medicine, including animal-derived therapies, and emphasizes the ongoing importance of such practices in these areas (Shi et al. 2021). In this study, 37 animal species were observed and identified that were believed to be a cure/prevention of over 59 kinds of ailments. Similar studies (Borah and Prasad 2017) from India reported, that approximately 44 different species of animals are used for the treatment of 40 different ailments by indigenous inhabitants in the adjoining areas of Gibbon Wildlife Sanctuary, Assam, India in addition, traditional healers in Kerala's Silent Valley reportedly using 69 animal species to make 162 practices for various diseases (Vijayakumar et al. 2015). According to Mishra et al. (2011), in the Similipal Biosphere Reserve of the state Orissa, 13 animal species are used as zootherapeutic resources were used to cure 12 different kinds of illnesses.

According to a report from Gibbon Wildlife Sanctuary in Assam, India, insects may have been used primarily due to their easy availability in the study region (Borah and Prasad 2017). Mammals rank second among zootherapeutic animals because some of them are domesticated. Mammals and reptiles, however, are reportedly among the primary groups of animals utilized in traditional medicine (Alves et al. 2017). Mammals were the most commonly used domestic animals in the research locations throughout the present investigation. Additionally, Bagade and Jain (2015) found that in the Madhya Pradesh District of Chhindwara, birds were the most often used species, followed by mammals for the preparation of therapeutic remedies. However, insects and mammals were considerably more important for therapy purposes than birds for the people residing in Tamil Nadu's Kolli Hills (Raja et al. 2018).

Similarly, Das et al. (2017) conducted a review of the 19 ethnic entities in North-East India and also reported most often utilized mammal and bird organs for medical purposes include fresh flesh, gall bladder, adipose tissue, and liver tissue. In contrast, amphibians are often consumed in smaller amounts than reptiles. Many nations have traditionally used frogs as a high-protein food source (Zhan et al. 2020; Mussarat et al. 2021). A variety of active compounds with potential therapeutic applications have been extracted from amphibians (Qi et al. 2011; Zhan et al. 2020), demonstrating the significance of amphibians in medicine. Zhan et al. (2020) report that 118 bufadienolide monomers and 11 indole alkaloids have been extracted from *Bufo* spp. These compounds show a range of pharmacological effects both in vitro and in vivo, including detoxification, immunomodulation, anti-tumor, and anti-inflammatory properties.

The people of the study area were discovered to use several animal parts/products for the treatment of various diseases. Animals and products derived from their organs are included in the inventory of therapeutic compounds (González and Vallejo 2021). Additionally, Meyer-Rochow (2017) claimed that many invertebrate animal tissues were utilized as traditional treatments. The use of oil extracted from Indian monitor (*Varanus bengalensis* (Daudin 1802)) in treatment of cataracts, meat of Indian pond heron (*Ardeola grayii* (Sykes, 1832)) for asthma, horn powder of Sambar deer (*Rusa unicolor* (Kerr, 1792)) achieves the highest fidelity level, whereas hair powder of rusty-spotted cat (*Prionailurus rubiginosus* (Geoffroy Saint-Hilaire, 1831)) on cut/injury, meat of Indian cormorant (*Phalacrocorax fuscicollis* (Stephens, 1826)) used for menstrual problems, soup of apple snail (Ampullariidae) used to cure piles have the lowest fidelity. Jaroli et al. (2010) found that Garasiya informants show higher fidelity when using generally known animals compared to lesser-known species. He also reported the highest fidelity level was found in cooked bat flesh (*Cynopterus sphinx* (Vahl, 1797)) for cough and fever relief, after that pigeon blood (*Columba livia* J.F.Gmelin, 1789) for paralysis treatment, and cow urine (*Bos taurus*) for healing wounds. The lowest fidelity level was found in pig flesh (*Sus scrofa* Linnaeus, 1758) for muscular pain relief and elephant flesh (*Elephas maximus* Linnaeus, 1758) for pimples.

The most common route of medicine delivery is oral consumption (69%), followed by topical applications (31%). Nowadays most drugs are administered orally, as reported in other studies (Jaroli et al. 2010; Verma et al. 2014). Topical application is still a crucial form of treatment administration for disorders of the skeleton and muscular system, such as rheumatism, paralysis, swellings, furuncles, tetanus, and arthritis (Chellappandian et al. 2014; Kim and Song 2014; Jaroli et al. 2010; Verma et al. 2014, Vijayakumar et al. 2015). In medical terms, unintentional saliva flow from the mouth is a sign of drooling. This could be due to an excess of saliva or underdeveloped muscles in your mouth (Slavotinek and Dysmorphology 2020; Weiss and Balamuth 2020). Drooling can be caused by neurological diseases or other medical conditions (Nicholson et al. 2023). We are the first to report the oral use of *Paracanthocobitis mooreh* as a therapy for drooling in the study area. The majority of the medicine concoctions contained no additives, while the remaining ones contained various additives such as water, honey, oil, ghee, and egg. According to Mussarat (2021), numerous animals were utilized to treat a variety of diseases, individually or in combination with other animal products and plants such as seeds, flowers, latex, and roots.

In summary, this study reveals that some animal species have a significant role in traditional healing methods among people of the Northern Western Ghats. Additionally, as per the list of IUCN (Table 1), conserving specific threatened animal species is crucial for preserving traditional medical knowledge. The sudden decrease in senior individuals who rely on animals is expected to result in a loss of oral traditional knowledge, which has been observed in regions of Kerala (Vijayakumar et al. 2015). We recognize very well that traditional knowledge of animal uses that has been passed down orally must be preserved in sustainable ways.

In conclusion, since this study is the initial step for recording the traditional knowledge and practice of zootherapy among the Indigenous peoples of Nashik District from Northern Western Ghats, the findings show that the region is inhabited with a variety of medicinal animals that are utilized to treat a range of ailments in human beings. In the research site, the major healthcare system is the use of animals and animal-derived products for indigenous medical treatments. It may also assist raise awareness of the need to conserve, preserve, and use biological diversity sustainably before it is completely destroyed. This investigation showed that traditional healers in the area are still using animals to cure a variety of ailments. In addition to its medicinal significance, traditional knowledge is important because it relates to the various cultural traditions and emotions had by the indigenous people. This study lays the groundwork for future scientific validation of the therapeutic efficacy of different zootherapeutic traditional applications by these people, as well as the discovery of novel biological compounds towards the discovery of new pharmaceuticals.

ACKNOWLEDGEMENTS

We are grateful to all respondents who provided their traditional zootherapeutic knowledge. Without their contributions, this study would not have been feasible. The authors are grateful to the Principals of M.S.G. College in Malegaon and MVPs ACS College in Trimbakeshwar, Nashik, for providing facilities and encouragement. The authors also thank Dr. Sharad Kambale for significant guidance during the work. We are thankful to the reviewers and the subject editor for their valuable suggestions and constructive criticism that improved the manuscript. This work was funded by Mahatma Jyotiba Phule Research and Training Institute (An Autonomous Institute of The Other Backward Class Bahujan Welfare Department, Govt. of Maharashtra) under Mahatma Jyotiba Phule Research Fellowship-2022 for first author [File No. MAHAJYOTI/2022/Ph.D.Fellow/1002 (17)]. PJ prepared the first draft; AZ and BN were involved in field surveys and data collection; AS, SP, and PJ critically revised the manuscript; and AZ, PJ, SP, and AS were involved in data analysis, interpolation, and final write-up.

REFERENCE

Adil S, Altaf M, Hussain T, Umair M, Ni J, Abbasi AM, Bussmann RW, Ashraf S. 2022. Cultural and medicinal use of amphibians and reptiles by indigenous people in Punjab, Pakistan with comments on conservation implications for herpetofauna. Animals (Basel) 12 (16): 2062. DOI: 10.3390/ani12162062.

Ahmad S, Akram M, Riaz M, Munir N, Mahmood Tahir I, Anwar H, Zahid R, Daniyal M, Jabeen F, Ashraf E, Sarwar G, Rasool G, Ali Shah SM. 2023. Zootherapy as traditional therapeutic strategy in the Cholistan desert of Bahawalpur-Pakistan. Vet Med Sci 9 (4): 1861-1868. DOI: 10.1002/vms3.491.

Ansari MKA, Iqbal M, Chaachouay N, Ansari AA, Owens G. 2023. The Concept and Status of Medicinal and Aromatic Plants: History, Pharmacognosy, Ecology, and Conservation. In Plants as Medicine and Aromatics, 129-144. CRC Press, Boca Raton, FL, USA. DOI: 10.1201/9781003226925-10.

Alonso-Castro AJ, Carranza-Álvarez C, Maldonado-Miranda JJ, Del Rosario Jacobo-Salcedo M, Quezada-Rivera DA, Lorenzo-Márquez H, Figueroa-Zúñiga LA, Fernández-Galicia C, Ríos-Reyes NA, de León-Rubio MÁ, Rodríguez-Gallegos V, Medellín-Milán P. 2011. Zootherapeutic practices in Aquismón, San Luis Potosí, México. J Ethnopharmacol 138 (1): 233-237. DOI: 10.1016/j.jep.2011.09.020.

Alves RRN, Albuquerque UP. 2012. Animals as a Source of Drugs: Bioprospecting and Biodiversity Conservation. In: Alves R, Rosa I (eds.). Animals in Traditional Folk Medicine. Springer, Berlin, Heidelberg. DOI: 10.1007/978-3-642-29026-8_5.

Alves RRN, Souto WMS. 2015. Ethnozoology: A Brief Introduction. Ethnobiol Conserv 4: 1-14. DOI: 10.15451/ec2015-1-4.1-1-13.

Alves RRN, Oliveira TPR, Medeiros MFT. 2017. Trends in medicinal uses of edible wild vertebrates in Brazil. Evidence-Based Complement Altern Med 14901329: 1-22. DOI: 10.1155/2017/4901329.

Alves RRN, Silva JS, da Silva Chaves L, Albuquerque UP. 2018. Ethnozoology and Animal Conservation. In Ethnozoology. Elsevier, Amsterdam, Netherlands. DOI: 10.1016/B978-0-12-809913-1.00025-9.

Bagde N, Jain S. 2015. Study of traditional man-animal relationship in Chhindwara district of Madhya Pradesh, India. J Glob Biosci 4: 1456-1463.

Bagde N, Jain S. 2017. Traditional and ethnozoological practices by tribes and rurals of Chhindwara District of Madhya Pradesh, India. World J Pharm Med Res 3 (8): 263-268.

Bihari S. 2023. Cultural heritage and indigenous knowledge: Reviving traditions for future generations. Sustainable Development Goals in SAARC Countries: Key Issues, Opportunities and Challenges 1: 24-32. DOI: 10.5281/zenodo.8049777.

Borah MP, Prasad SB. 2016. Ethnozoological remedial uses by the indigenous inhabitants in adjoining areas of Pobitora Wildlife Sanctuary, Assam, India. Intl J Pharm Pharm Sci 8 (4): 90-96.

Borah MP, Prasad SB. 2017. Ethnozoological study of animals-based medicine used by traditional healers and indigenous inhabitants in the adjoining areas of Gibbon Wildlife Sanctuary, Assam, India. J Ethnobiol Ethnomed 13 (1): 39. DOI: 10.1186/s13002-017-0167-6.

Bhattacharjee S, Sarkar A, Devarani L, Sheikh FM. 2016. Temporally changing livelihood pattern of rural people: A case study on tribes of Tripura. Environ Ecol Res 34 (4A): 1834-1838.

Castillo L, Ladio AH. 2018. Zootherapy and rural livestock farmers in semiarid Patagonia: The transfer of animal aptitudes for health. Ethnobiol Conserv 8: 1-23. DOI: 10.15451/ec2019--01--8.02-1--24.

Chaudhury S, Rahaman CH, Singh H. 2016. Some ethnozoological uses of Birhor tribe of West Bengal, India. J Tradit Folk Pract 4 (1): 33-42.

Chaachouay N, Azeroual A, Ansari MKA, Zidane L. 2023. Use of Plants as Medicines and Aromatics by Indigenous Communities of Morocco: Pharmacognosy, Ecology and Conservation. In Plants as Medicine and Aromatics. CRC Press Boca Raton, USA. DOI: 10.1201/9781003226925-4.

Chellappandian M, Pandikumar P, Mutheeswaran S, Gabriel Paulraj M, Prabakaran S, Duraipandiyan V, Ignacimuthu S, Al-Dhabi NA. 2014. Documentation and quantitative analysis of local ethnozoological knowledge among traditional healers of Theni district. J Ethnopharmacol 154 (1): 116-130. DOI: 10.1016/j.jep.2014.03.028.

Das KS, Choudhury S, Nonglait KC. 2017. Zootherapy among the ethnic groups of North eastern region of India—A critical review. J Crit Rev 4 (2): 1-9. DOI: 10.22159/JCR.2017V4I2.14698.

de Lima JRB, Florêncio RR, Santos CABd. 2014. Contribuições da Etnozoologia para a conservação da fauna silvestre. Rev Ouricuri 4 (3): 48-67. DOI: 10.15451/ec2015-1-4.1-1-13.

Dirzo R, Young HS, Galetti M, Ceballos G, Isaac NJ, Collen B. 2014. Defaunation in the Anthropocene. Science 345 (6195): 401-406. DOI: 10.1126/science.1251817.

Dickman AJ. 2010. Complexities of conflict: The importance of considering social factors for effectively resolving human–wildlife conflict. Anim Conserv 13 (5): 458-466. DOI: 10.1111/j.1469-1795.2010.00368.x.

Eshete MA, Kelbessa E, Dalle G. 2016. Ethnobotanical study of medicinal plants in Guji Agro-pastoralists, Blue Hora District of Borana Zone, Oromia Region, Ethiopia. J Med Plants Stud 4 (2): 170-184.

Faiz M, Altaf M, Umair M, Almarry KS, Elbadawi YB, Abbasi AM. 2022. Traditional uses of animals in the Himalayan Region of Azad Jammu and Kashmir. Front Pharmacol 13: 807831. DOI: 10.3389/fphar.2022.807831.

Febriyanti RM, Saefullah K, Susanti RD, Lestari K. 2024. Knowledge, attitude, and utilization of traditional medicine within the plural medical system in West Java, Indonesia. BMC Complement Med Ther 24 (1): 64. DOI: 10.1186/s12906-024-04368-7.

Fopa GD, Simo F, Kekeunou S, Ichu IG, Ingram DJ, Olson D. 2020. Understanding local ecological knowledge, ethnozoology, and public opinion to improve pangolin conservation in the center and east regions of Cameroon. J Ethnobiol 40 (2): 234-251. DOI: 10.2993/0278-0771-40.2.234.

Gangurde PC, Kumbhar DS. 2018. A geographical factors affecting the types of rural settlements in Nashik District (Maharashtra). Research Journey. Multidisciplinary Intl E-Res J 45: 25-31.

González JA, Vallejo JR. 2021. Relics and historical uses of human zootherapeutic products in contemporary Spanish ethnoveterinary medicine. Vet Sci 8 (12): 323. DOI: 10.3390/vetsci8120323.

Haddad NM, Brudvig LA, Clobert J, Davies KF, Gonzalez A, Holt RD, Lovejoy TE, Sexton JO, Austin MP, Collins CD, Cook WM, Damschen EI, Ewers RM, Foster BL, Jenkins CN, King AJ, Laurance WF, Levey DJ, Margules CR, Melbourne BA, Nicholls AO, Orrock JL, Song DX, Townshend JR. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Sci Adv 1 (2): e1500052. DOI: 10.1126/sciadv.1500052.

Holennavar PS. 2015. Use of animal and animal derived products as medicines by the inhabitants of villages in Athani Taluka of Belagavi District (Karnataka). Intl J Appl Res 1 (12): 437-440.

Hyma B, Ramesh A. 2002. Traditional medicine. Its extent and potential for incorporation into modern national health systems. In Health and development (pp. 65-82). Routledge.

Jaroli DP, Mahawar MM, Vyas V. 2010. An ethnozoological study in the adjoining areas of Mount Abu Wildlife Sanctuary, India. J Ethnobiol Ethnomed 6: 6. DOI: 10.1186/1746-4269-6-6.

Jugli S, Chakravorty J, Meyer-Rochow VB. 2019. Zootherapeutic uses of animals and their parts: An important element of the traditional knowledge of the Tangsa and Wancho of eastern Arunachal Pradesh, North-East India. Environ Dev Sustain 22: 4699-4734. DOI: 10.1007/s10668-019-00404-6.

Kandari LS, Negi T, Thakur AK, Yilma E. 2015. Ethnobotanical and indigenous knowledge of important plants in East Hararghe, Eastern Ethiopia. J Mt Sci 12: 1521-1533. DOI: 10.1007/s11629-014-3137-7.

Kendie SA, Mekuriaw SA, Dagnew MA. 2018. Ethnozoological study of traditional medicinal appreciation of animals and their products among the indigenous people of Metema Woreda, North-Western Ethiopia. J Ethnobiol Ethnomed 14 (1): 37. DOI: 10.1186/s13002-018-0234-7.

Kim H, Song MJ. 2014. Ethnozoological study of medicinal animals on Jeju Island, Korea. J Ethnopharmacol 146 (1): 75-82. DOI: 10.1016/j.jep.2012.11.011.

Liu J, Wilson M, Hu G, Liu J, Wu J, Yu M. 2018. How does habitat fragmentation affect the biodiversity and ecosystem functioning relationship? Landsc Ecol 33: 341-352. DOI: 10.1007/s10980-018-0620-5.

Mahawar MM, Jaroli DP. 2008. Traditional zootherapeutic studies in India: A review. J Ethnobiol Ethnomed 4: 17. DOI: 10.1186/1746-4269-4-17.

Meyer-Rochow VB. 2017. Therapeutic arthropods and other, largely terrestrial, folk-medicinally important invertebrates: A comparative survey and review. J Ethnobiol Ethnomed 13 (1): 9. DOI: 10.1186/s13002-017-0136-0.

Mishra N, Rout SD, Panda T. 2011. Ethno-zoological studies and medicinal values of Similipal Biosphere Reserve, Orissa, India. Afr J Pharm Pharmacol 5 (1): 6-11.

Mussarat S, Ali R, Ali S, Mothana RA, Ullah R, Adnan M. 2021. Medicinal animals and plants as alternative and complementary medicine in Southern Regions of Khyber Pakhtunkhwa, Pakistan. Front Pharmacol 12: 649046. DOI: 10.3389/fphar.2021.649046.

Mozer A, Prost S. 2023. An introduction to illegal wildlife trade and its effects on biodiversity and society. Forensic Sci Intl: Anim Environ 3: 100064. DOI: 10.1016/j.fsiae.2023.100064.

Nameer PO, Molur S, Walker S. 2001. Mammals of Western Ghats: A simplistic overview. Zoos'print J 16 (11): 629-639. DOI: 10.11609/JOTT.ZPJ.16.11.629-39.

Nicholson AM, Hess JM. 2023. Esophagus, stomach, and duodenum. In: Walls RM (eds.). Rosen's Emergency Medicine: Concepts and Clinical Practice. 10th ed. Elsevier, Philadelphia.

Palwey SD. 2019. Indigenous knowledge of medicinal plants among the tribal population of Dang-Surgana forest of Western Ghats, India. Intl J Curr Res 11 (3): 1875-1879. DOI: 10.24941/ijcr.34828.03.2019.

Phichonsatcha T, Pentrakoon D, Gerdsri N, Kanjana-Opas A. 2022. Extending indigenous knowledge to unveil the evolutionary journey of food preferences and socio-cultural phenomena. Appetite 170: 105884. DOI: 10.1016/j.appet.2021.105884.

Qi F, Li A, Inagaki Y, Kokudo N, Tamura S, Nakata M, Tang W. 2011. Antitumor activity of extracts and compounds from the skin of the toad *Bufo bufo gargarizans* Cantor. Intl Immunopharmacol 11 (3): 342-349. DOI: 10.1016/j.intimp.2010.12.007.

Raja L, Matheswaran P, Anbalagan M, Sureshkumar V, Ganesan D, Banu GS. 2018. Ethnozoological study of animal-based products practices among the tribal inhabitants in Kolli Hills Namakkal District, Tamil Nadu, India. World J Pharm Pharm Sci 7 (12): 785-797. DOI: 10.20959/wjpps201812-12750.

Rangarajan M. 2006. India's Wildlife History: An Introduction. Orient Blackswan, India

Sen T, Samanta SK. 2015. Medicinal plants, human health and biodiversity: A broad review. Adv Biochem Eng Biotechnol 2015: 59-110. DOI: 10.1007/10_2014_273.

Sharma P, Mohan K. 2024. Location, livelihoods and tribal people: Exploring the linkages in India. J Rural Ind Dev 12 (1): 27-33.

Shi Y, Zhang C, Li X. 2021. Traditional medicine in India. J Tradit Chin Med 8 (1): S51-S55. DOI: 10.1016/j.jtcms.2020.06.007.

Slavotinek AM, Dysmorphology. 2020. In: Kliegman RM, St. Geme JW, Blum NJ, Shah SS, Tasker RC, Wilson KM (eds.). Nelson Textbook of Pediatrics. 21st ed. Philadelphia, Elsevier.

Sonawane VB. 2019. Ethnobotanical and medicinal plant study in Trimbkeshwar Taluka, District Nashik, (MS), India. J Drug Delivery Ther 9 (4): 529-534. DOI: 10.22270/jddt.v9i4.3101.

Souto WMS, Barboza RRD, Fernandes-Ferreira H, Júnior AJCM, Monteiro JM, Abi-Chacra ÉA, Alves RRN. 2018. Zootherapeutic uses of wildmeat and associated products in the semiarid region of Brazil: General aspects and challenges for conservation. J Ethnobiol Ethnomed 14 (1): 60. DOI: 10.1186/s13002-018-0259-y.

Tugume P, Kakudidi EK, Buyinza M, Namaalwa J, Kamatenesi M, Mucunguzi P, Kalema J. 2016. Ethnobotanical survey of medicinal plant species used by communities around Mabira Central Forest Reserve, Uganda. J Ethnobiol Ethnomed 12: 5. DOI: 10.1186/s13002-015-0077-4.

Uddin MZ, Hassan MA. 2014. Determination of informant consensus factor of ethnomedicinal plants used in Kalenga forest, Bangladesh. Bangladesh J Plant Taxon 21 (1): 83-91. DOI: 10.3329/bjpt.v21i1.19272.

Unnikrishnan PM. 1998. Animals in Ayurveda. Amruth 1 (3): 1-23.

Verma AK, Prasad SB, Rongpi T, Arjun JA. 2014. Traditional healing with animals (zootherapy) by the major ethnic group of Karbi Anglong district of Assam, India. Intl J Pharm Pharm Sci 6 (8): 593-600.

Vitalini S, Iriti M, Puricelli C, Ciuchi D, Segale A, Fico G. 2013. Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy)—An alpine ethnobotanical study. J Ethnopharmacol 145 (2): 517-529. DOI: 10.1016/j.jep.2012.11.024.

Vijayakumar S, Yabesh JEM, Prabhu S, Ayyanar M, Damodaran R. 2015. Ethnozoological study of animals used by traditional healers in Silent Valley of Kerala, India. J Ethnopharmacol 162: 296-305. DOI: 10.1016/j.jep.2014.12.055.

Weiss AK, Balamuth FB. 2020. Triage of the Acutely Ill Child. In: Kliegman RM, St. Geme JW, Blum NJ, Shah SS, Tasker RC, Wilson KM, eds. Nelson Textbook of Pediatrics. 21st ed. Elsevier, Philadelphia, PA.

World Health Organization (WHO). 2014. Traditional medicine strategy. 23: 1-76.

World Health Organization (WHO). 2019. WHO Global Report on Traditional and Complementary Medicine 2019. World Health Organization.

Zhan X, Wu H, Wu H, Wang R, Luo C, Gao B, Chen Z, Li Q. 2020. Metabolites from *Bufo gargarizans* (Cantor, 1842): A review of traditional uses, pharmacological activity, toxicity and quality control. J Ethnopharmacol 246: 112178. DOI: 10.1016/j.jep.2019.112178.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025 E-ISSN: 2580-4510
Pages: 13-25 DOI: 10.13057/asianjethnobiol/y080102

Herbal medicines sold in Wonosobo Traditional Markets, Indonesia

DAVINA ALIFIA TSURAYYA[1], DINARA AFRIDA SALEH[1], DIAN RAHMAD RENALDI[1], DEVIA RAHMA RIZKA[1], RATNA WIDYANINGYAS[1], AHMAD YASA[2], JOHAN ISKANDAR[3], SURAPON SAENSOUK[4], AHMAD DWI SETYAWAN[1,5,♥]

[1]Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: volatileoils@gmail.com
[2]Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia
[3]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran. Jl. Raya Bandung-Sumedang Km 21, Jatinangor, Sumedang 45363, West Java, Indonesia
[4]Plant and Invertebrate Taxonomy and Its Applications Unit Group, Walai Rukhavej Botanical Research Institute, Mahasarakham University. Kantarawichai District, Maha Sarakham, 44150, Thailand
[5]Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

Manuscript received: 28 November 2024. Revision accepted: 14 January 2025.

Abstract. *Tsurayya DA, Saleh DA, Renaldi DR, Rizka DR, Widyaningyas R, Yasa A, Iskandar J, Saensouk S, Setyawan AD. 2025. Herbal medicines sold in Wonosobo Traditional Markets, Indonesia. Asian J Ethnobiol 8: 13-25.* Medicinal plants hold a significant role in the field of medicine, health, and cultural preservation and are generally available at traditional markets. This study aims to document the species and the utilization of medicinal plants sold at traditional markets, in Wonosobo District, Central Java, Indonesia. The study employed a descriptive qualitative method through observations and direct interviews with 100 medicinal plant vendors. The results show that the total number of medicinal plants sold in Wonosobo's traditional markets, namely, Kertek Market and Wonosobo Induk Market, reached a total of 70 species with 34 families, i.e., 59 species at Kertek Market and 66 species at Wonosobo Induk Market, with 51.4% of suppliers coming from Wonosobo and 48.6% from Yogyakarta, dominated by the Zingiberaceae family. The most commonly used parts of medicinal plants for consumption are leaves and seeds, with boiling being the most common preparation method. The most expensive plant found is the jasmine flower, with a price of IDR 400,000/kg (1 USD = 15,500 IDR). As developments progress, traditional markets offer easy consumption of medicinal plants in the form of medicinal concoctions such as *jamu*, *wedang uwuh*, and *kembang sawanan*.

Keywords: Health, *jamu*, medicinal plants, traditional market

INTRODUCTION

The relationship between humans and plants is recognized as an important factor in human civilization's development, especially in medicine (Jadid et al. 2020). According to the World Health Organization, traditional medicine derived from medicinal plants encompasses all skills, knowledge, and practices based on theories, beliefs, and experiences from various cultures, whether scientifically explainable or not. However, it's important to note that many of these traditional practices have been found to have a scientific basis, with active compounds in plants being used in modern medicine (Che et al. 2024). The use of medicine to treat and prevent various diseases has a long history. It was first discovered when archaeologists found engravings on Sumerian clay tablets, dating back about 5000 years, depicting the use of medicinal plants for treatment. This discovery was followed by various other documents that recorded the use of natural products over time. The use of herbal medicine varies depending on the historical era, as recorded in the "Ebers Papyrus" from ancient Egypt, the Materia Medica from China, Ayurveda from India, and many others (Elkordy et al. 2021). In ASEAN countries, especially in Indonesia, indigenous communities have learned how to use herbal plants to treat various diseases and wounds, knowledge that has been passed down from generation to generation (Liu 2021).

2020). Herbal medicine, also known as traditional medicine, includes various parts of plants, the top parts of the plant such as flowers, fruits, leaves, seeds, and stems, as well as underground parts like roots, tubers, bulbs, and rhizomes (Muyumba et al. 2021). Medicinal plants can be found in traditional markets. Traditional markets serve as a meeting place for traders and buyers, where supply and demand activities are carried out through buying and selling interactions (Iskandar et al. 2018). Medicinal plants are highly sought after in traditional markets due to their availability at affordable prices (Silalahi et al. 2015). In addition to the affordability of medicinal plants, the potential for fewer side effects compared to synthetic drugs has attracted the attention of health enthusiasts (Liu et al. 2020). Traditional herbal medicine is constructive, and optimal results are achieved when the concoction is consumed regularly. The side effects of traditional medicine are not the same as synthetic drugs because medicinal plants have mechanisms to counteract or neutralize those side effects. Medicinal plants encompass all species of plants known to contain beneficial and therapeutic compounds that can prevent, reduce, or cure diseases (Nursamsu et al. 2024). These plants also generate a variety of organic compounds thought to possess medicinal properties (Mais et al. 2018; Diniz et al. 2020).

One of the places where the diversity of medicinal plant species is traded is the traditional market in Wonosobo. This study uses Kertek Market (*Pasar Kertek*) and Wonosobo Induk Market (*Pasar Induk Wonosobo*) as the main locations. These markets are important points for biodiversity and knowledge research because they originate from areas that are ecologically, culturally, and geographically diverse (Santana et al. 2024). In addition, Kertek Market and Wonosobo Induk Market are considered the study areas because both are thriving economic hubs that are accessible and open on a daily basis. The trade of medicinal plants is not only essential for health purposes but also economic development of the area (Ahmad et al. 2018). Suppliers from both markets generally come from local farmers or outside the area. Local farmers, as suppliers, will provide information about quality, including prices, to other actors (producers, collectors, processors, wholesalers, and retailers) to understand their target market (Palash et al. 2021). Besides local farmers, suppliers can also come from other regions and send their products to traditional markets. It means there is a cross-regional trade distribution network, reflecting market dynamics and the increasing consumer demand for medicinal plants. The trade of herbal plants is part of the traditional healthcare system, where indigenous communities share valuable traditional and biological knowledge (Nguyen et al. 2019).

This study aims to document the diversity, uses, suppliers, prices, and health benefits of medicinal plants sold in traditional markets in Wonosobo, Central Java, Indonesia. The need for an inventory of medicinal plants is also intended to disseminate local knowledge to a broader community, thereby maximizing its benefits.

MATERIALS AND METHODS

Study area

The study area consists of the two biggest traditional markets in Wonosobo District, Central Java, Indonesia, namely Kertek Market (*Pasar Kertek*) and Wonosobo Induk Market (*Pasar Induk Wonosobo*) (Figure 1). Kertek Market is located on Parakan Street No. 105A Kertek, Wonosobo, with coordinates -7°.38'98.99" S, 109°.96'34.36" W. The Kertek traditional market serves as a trading center for agricultural commodities and occupies a strategic location along the Banyumas-Magelang distribution route. (Wungo et al. 2024). Besides that, Wonosobo Induk Market is located at Serayu Street No. 2, Wonosobo, with coordinates -7°.36'26.12" S, 109°.90'12.01" W. The market's location in an urban area makes it a node of the transportation network, the center of population activity, and the main service point in infrastructure in the Wonosobo District (Widayat and Purwanto 2020).

Data collection

The primary data collected in this research were obtained through plant surveys and interviews. Surveys were conducted primarily to determine the diversity of medicinal plants. In contrast, interviews with a semi-structured system were conducted mainly to assess their use as medicinal components, as well as local diversity and names (Igustita et al. 2023). The interview technique was carried out using purposive sampling with 100 respondents using the criteria of herbal medicine traders at Kertek Market and Wonosobo Induk Market. The data collected includes local names, parts of plants used, basic ingredients for herbal medicines, benefits, manufacturing processes, supplies, and prices of medicinal plants. The information collected from the survey is entered into a tally sheet to facilitate data recapitulation after the field survey is completed and then processed through data analysis to conclude.

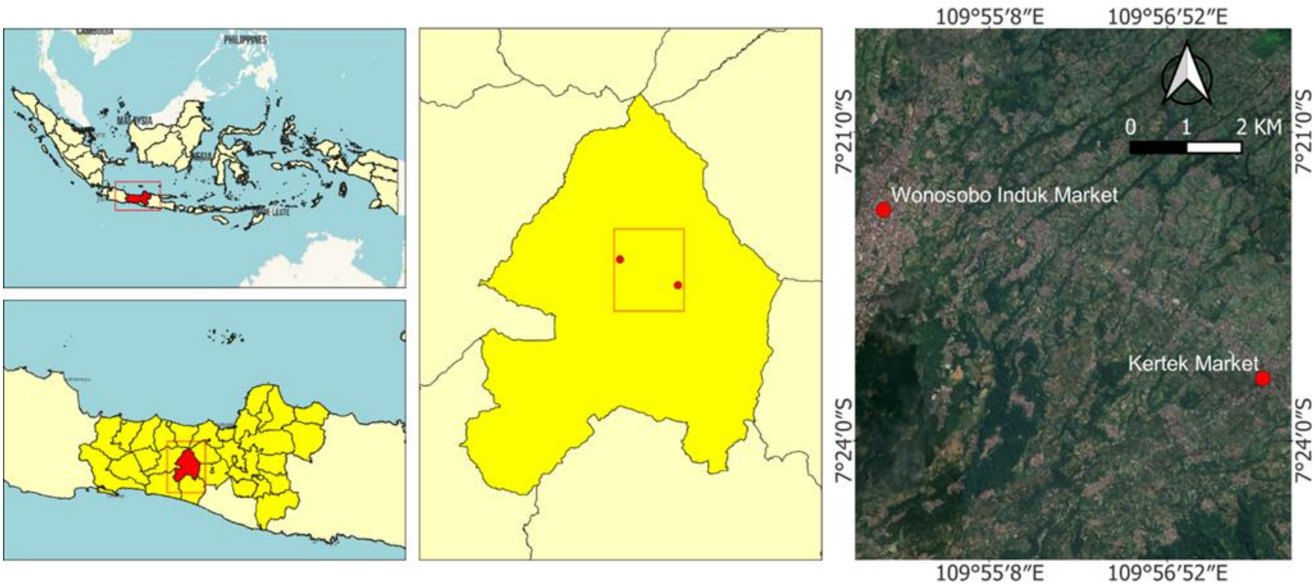


Figure 1. Map of study area in Kertek Market and Wonosobo Induk Market, Wonosobo District, Cental Java, Indonesia

Data analysis

This research used a qualitative descriptive approach to gain an in-depth understanding of the diversity of medical plants and the social, economic, and cultural impacts of trading practices at Kertek Market and Wonosobo Induk Market. Data analysis was done by identifying medicinal plants to obtain their scientific names, followed by a descriptive explanation of the data. The data analysis was then presented in tables, figures, and graphs (Fakchich and Elachouri 2021).

RESULTS AND DISCUSSION

Wonosobo's traditional market profile

Wonosobo District has several traditional markets that still exist today despite the rapid development of the times. The existence of traditional markets is a symbol of the continuation of tradition as well as a driver of the local economy that is attractive and able to adapt to changing times. These traditional markets include Kertek Market and Wonosobo Induk Market, which open daily and are the two largest traditional markets in Wonosobo District. Both markets have striking similarities, especially in the diversity of medicinal plants sold. Wonosobo Induk Market provides a complete range of medicinal plants for the community's needs, ranging from *jahe* (*Z. Officinale*) and *kunir* (*C. longa*) to herbal concoctions (Khasanah and Hermawan 2020). Similarly, Kertek Market provides other medicinal plants such as *bangle* (*Z. purpureum*), *kunir* (*C. longa*), and *sambiroto* (*A. paniculata*). The diversity of medicinal plants available in Kertek Markets and Wonosobo Induk Market is a clear indication of the stability of the market. This stability is supported by the fact that many people in Wonosobo District still believe in the efficacy of medicinal plants for consumption as an alternative natural treatment (Pratama and Lestarini 2021). The use of medicinal plants for various daily needs is still closely related to traditions in Wonosobo District. The use of medicinal plants as herbal medicine continues to develop, and they are used for healing and maintaining the health of local communities, as the research conducted by Supriyani et al. (2019), which stated that the tradition of employing traditional medicine remains robust in Wonosobo. The high demand for medicinal plants ensures their availability remains stable in Kertek Market and Wonosobo Induk Market, providing a reliable source for these traditional remedies.

Respondent characteristics

The respondents in this study were herbal medicine and spice traders from Kertek Market and Wonosobo Induk Market, totaling 100 people aged 25-80 years. The respondents obtained from each market consisted of 50 respondents (Table 1). The majority of the respondents were women because the trader of herbal medicine and spices in both markets was dominated by women because women dominated the trading of herbal medicine and spices in both markets. According to Silalahi et al. (2015), the dominance of female sellers is due to differences in knowledge between men and women in medicinal plants, which is closely related to family traditions, where this knowledge is generally inherited from women, such as mothers or grandmothers. In addition, the trade of medicinal plants benefits women because this profession allows them to earn a living while also engaging in parenting. Based on the data in the table, the distribution of respondents' education levels shows variations that reflect their different educational backgrounds. Education is commonly considered crucial for boosting the quality of business practices among traders (Babajide et al. 2023). However, according to Pant et al. (2015), education has little influence on individuals' decisions to use traditional medicine. Instead, family traditions, habitual practices, and guidance from ancestors play a more dominant role.

Diversity of medical plants in Kertek Traditional Market and Wonosobo Induk Traditional Market

The results of the identification of medicinal plant diversity found in Kertek Traditional Market and Wonosobo Induk Market include local names, Latin names, and the family of each plant. These data present information on the availability of plants, commonly used parts, processing methods, prices, and their benefits, as shown in Table 2.

Table 1. Characteristics of herbal medicine seller in Traditional Market Wonosobo, Central Java, Indonesia (n=100)

Information	Count	Percentage
Traditional Seller		
Kertek Market	50	50%
Wonosobo Induk Market	50	50%
Age		
20-30	7	7%
31-40	13	13%
41-50	26	26%
51-60	28	28%
61-70	19	19%
71-80	7	7%
Gender		
Male	19	19%
Female	81	81%
Education		
Uneducated	18	18%
Elementary	37	37%
Junior High School	25	25%
Senior High School	18	18%
University	2	2%

Table 2. Diversity of medicinal plants at the Traditional Market, Wonosobo, Central Java, Indonesia

Family	Scientific name	Indonesian name [common name]	Part used	Making process	Benefit	Availability		Supply	Price (IDR)
						KM	IM		
Acanthaceae	*Strobilanthes crispa* (L.) *Bremek.*	*Keji Beling* (Glass Splinter*)*	Leaf	Boiled	Facilitates urination	-	●	Yogyakarta	25,000/kg
Acanthaceae	*Andrographis paniculata (Burm.f.)* Wall. ex Nees	*Sambiroto* (Green Chiretta)	Leaf	Boiled	Reduces fever, treats diabetes	●	●	Yogyakarta	20,000/kg
Achariaceae	*Pangium edule* Reinw ex Blume	*Kluwek* (Pangium edule)	Seed	Soaked for 3 days then boiled	Reduces the risk of cardiovascular diseases such as stroke and heart disease	●	-	Wonosobo	2,000/seed
Acoraceae	*Acorus calamus* L.	*Dlingo* (Sweet Flag)	Root	Pounded	Reduces muscle pain and treats epilepsy, relieves headaches, gout, and migraines	●	●	Wonosobo	35,000/kg
Annonaceae	*Cananga odorata* (L.) Hook.f & Thomson	*Kenanga* (Ylang-ylang)	Flower	Boiled	Helps relieve anxiety and stress, supports skin health	-	●	Yogyakarta	50,000/kg
Apiaceae	*Anethum Graveolens* L.	*Adas Sowa* (Fennel Sowa)	Leaf	Boiled	Increases breast milk production, relieves bloating	●	●	Yogyakarta	55,000/kg
Apiaceae	*Foeniculum vulgare* Mill.	*Adas Pulowaras* (Fennel)	Root	Boiled	Boosts stamina and improves digestion	-	●	Yogyakarta	50,000/kg
Apiaceae	*Cuminum cyminum* L.	*Jinten* (Cumin)	Seed	Pounded, then boiled	Helps with bloating, reduces inflammation in the body, and relieves digestive issues and	●	●	Yogyakarta	100,000/kg
Apiaceae	*Coriandrum sativum* L.	*Ketumbar* (Coriander)	Seed and Leaf	Pounded, then boiled	Anti-inflammatory properties, improves digestion and lowers cholesterol levels	●	●	Wonosobo	30,000/kg
Apocynaceae	*Alyxia Stellata* (JRForst. & G. Forst.) Roem. & Schult.	*Adas Pulosari* (Maile)	Bark	Brewed	Treats asthma, cough, overcome irregular menstruation, and improves digestion	●	●	Yogyakarta	90,000/kg
Apocynaceae	*Parameria laevigata* (Juss.) Moldenke.	*Kayu Rapet* (Rapet Wood)	Bark	Dried, then boiled	Heals postpartum wounds, treats vaginal discharge	●	●	Yogyakarta	50,000/kg
Arecaceae	*Areca catechu* L.	*Pinang* (Areca Nut)	Seed	Boiled	Helps improve oral health	●	●	Wonosobo	10,0000/kg
Asparagaceae	*Agave amica* (Medik.) Thiede & Govaerts	*Bunga Sedap malam* (Sedap malam flower)	Flower	Pounded, then infused	Keeps blood pressure stable, and maintains blood vessel health	●	-	Yogyakarta	200,000/kg
Asteraceae	*Chrysanthemum morifolium* L.	*Kembang Seruni* (Chrysanthemum Flower	Flower	Soaked, then boiled	Improves the immune system supports eye and mouth health, treats high blood pressure.	-	●	Yogyakarta	60,000/kg
Clusiaceae	*Garcinia mangostana* L.	*Kulit Manggis* (Mangosteen peel)	Peel	Dried, then boiled	Antioxidant, good for boosting the immune system, protecting skin, and lowering cholesterol	-	●	Yogyakarta	100,000/kg
Euphorbiaceae	*Aleurites moluccanus* L.	*Kemiri* (Candlenut)	Seed	Pounded, then boiled	Help lower cholesterol levels, supports hair and skin health.	●	●	Wonosobo	60,000/kg
Fabaceae	*Tamarindus indica* L.	*Asam Jawa* (Tamarind)	Fruit	Boiled	Improves digestion and relieves constipation	●	●	Wonosobo	25,000/kg

Fabaceae	*Clitoria ternatea* L.	*Bunga telang* (Telang flower)	Flower	Boiled	Enhances memory, maintains eye health	-	●	Yogyakarta	300,000/kg
Fabaceae	*Psophocarpus tetragonolobus* (L.) DC	*Cipir* (Winged Bean)	Seed	Boiled	Help in weight loss programs and relieves inflammation and sprains, strengthens the immune system	-	●	Yogyakarta	80,000/kg
Fabaceae	*Parkia timoriana* (DC.)Merr	*Dawung* (Tree bean)	Seed	Pounded, then boiled	Accelerates skin healing, heals wounds	●	●	Yogyakarta	70,000/kg
Fabaceae	*Senna Alexandrina* Mill.	*Jati Cina* (Chinese teak)	Leaf	Brewed	Improves bowel movements	●	●	Yogyakarta	50,000/kg
Fabaceae	*Trigonella foenum-graecum* L.	*Klabet* (Fenugreek)	Seed	Soaked, then boiled	Lowering blood sugar levels, increases breast milk production, and supports digestive health	-	●	Yogyakarta	200,000/kg
Fabaceae	*Biancaea sappan* (L.) Tod.	*Secang* (Caesalpinia Sappan)	Bark	Boiled	improves blood circulation, is an antioxidant, refreshes the body	●	●	Yogyakarta	40,000/kg
Fagaceae	*Quercus infectoria* Olivier.	*Manjakani* (Oak Galls)	Gall	Boiled	Helps tighten the vaginal area and heal wounds	●	●	Yogyakarta	300,000/kg
Lamiaceae	*Ocimum basilicum* L.	*Biji selasih* (Basil seed)	Seed	Soaked	Improves digestion, relieves constipation	●	●	Wonosobo	70,000/kg
Lamiaceae	*Orthosiphon aristatus* (Blume)Miq.	*Kumis kucing* (kidney tea plants**)**	Leaf	Boiled	facilitates urination, treats urinary tract infections	●	●	Yogyakarta	20,000/kg
Lauraceae	*Litsea cubeba* (Lour.) Press.	*Krangean* (Pheasant pepper tree*)*	Seed and Stem	Boiled	Reduces fever, treats diarrhea	●	●	Yogyakarta	50,000/kg
Lauraceae	*Cinnamomum zeylanicum* Blume.	*Manis jangan* (Cinnamon)	Stem	Boiled	Treats cough, nausea, and stomach disorders	●	●	Yogyakarta	100,000/kg
Lauraceae	*Cryptocarya massoia* (Oken) Kosterm.	*Mesoyi* (Massoia)	Stem	Boiled	Calms nerves, relieves ulcers	●	●	Yogyakarta	300,000/kg
Malvaceae	*Hibiscus sabdariffa* L.	*Rosela* (Roselle)	Flower	Brewed	Lowering blood pressure, improves the immune system, and supports heart health	-	●	Yogyakarta	30,000/kg
Meliaceae	*Swietenia mahagoni* (L.) Jacq.	*Mahoni* (Mahagony tree)	Seed	Pounded, then boiled	Lowers blood pressure	●	●	Yogyakarta	45,000/kg
Menispermaceae	*Tinospora cordifolia* (Willd.) Miers	*Brotowali* (Bittervine)	Stem	Boiled	Increases appetite, reduces fever, treats diabetes	●	●	Wonosobo	10,000/kg
Moringaceae	*Moringa oleifera* L.	*Daun kelor* (Moringa leaf)	Leaf	Boiled	Containing antioxidants, helps lower blood sugar, and strengthens the immune system	●	●	Wonosobo	7,500/kg
Myristicaceae	*Myristica fragrans* Houtt.	*Pala* (Nutmeg)	Seed	Pounded, then brewed	Improves digestion, increases appetite, and relieves insomnia	●	●	Wonosobo	130,000/kg
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & Perry	*Cengkeh* (Cloves)	Flower	Boiled	Treats toothache, serves as a natural antiseptic	●	●	Wonosobo	160,000/kg
Myrtaceae	*Eucalyptus alba* Reinw. ex Blume	*Cepliksari* (White gum)	Flower	Boiled	Maintains liver health relieves menstrual pain, treats gout	●	●	Wonosobo	30,000/kg
Myrtaceae	*Syzygium polyanthum* (Wight) Walpers.	*Daun salam* (Bay Leaf	Leaf	Boiled	has antioxidant and anti-inflammatory properties, improves digestion, lowers blood sugar levels	●	●	Wonosobo	10,000/kg
Myrtaceae	*Melaleuca leucadendra* (L.) L.	*Kayu Putih* (Eucalyptus)	Leaf	Boiled	Treats colds, headaches, and is anti-inflammatory	●	●	Wonosobo	20,000/kg

Oleaceae	*Jasminum sambac* (L.) Aiton	*Melati* (Jasmine Flower)	Flower	Dried, then brewed	Calms the mind, relieves stress	●	●	Wonosobo	400,000/kg
Pandanaceae	*Pandanus amaryllifolius* Roxb	*Pandan* (Screwpine)	Leaf	Boiled	Serves as an antioxidant to optimize organ functions	●	●	Wonosobo	10,000/kg
Phyllanthaceae	*Phyllanthus urinaria* L.	*Meniran* (Gale of the wind)	Leaf	Boiled	Acts as an anti-inflammatory, boosts immunity	●	●	Yogyakarta	60,000/kg
Piperaceae	*Piper retrofractum* Vahl	*Cabe Jawa* (Java Chili)	Fruit	Pounded, then boiled	Solves digestive problems, stimulates appetite	●	●	Yogyakarta	180,000/kg
Piperaceae	*Piper cubeba* L.fil.	*Kemukus* (Cubeb)	Seed	Brewed	Solves digestive problems, stimulates appetite, treats asthma or respiratory issues	●	●	Yogyakarta	300,000/kg
Piperaceae	*Piper nigrum* L.	*Merica* (Pepper)	Seed	Pounded	Boosts metabolism, and fights infections, improves digestion	●	●	Wonosobo	90,000/kg
Piperaceae	*Piper betle* L.	*Sirih* (Betel Pepper)	Leaf	Boiled	Eliminates bad breath, serves as a natural antiseptic	●	●	Wonosobo	20,000/kg
Poaceae	*Imperata cylindrica* (L.) P. Beauv.	*Alang-alang* (Reeds)	Root	Boiled	Lowers blood pressure, reduces fever	●	●	Wonosobo	60,000/kg
Poaceae	*Cymbopogon citratus* (DC). Stapf	*Sereh* (Lemongrass)	Stem and Leaf	Boiled	Help digestion, lowers blood pressure, and relieves inflammation	●	●	Wonosobo	4,000/kg
Rosaceae	*Rosa damascena* Mill.	*Mawar* (Rose Flower)	Flower	Dried, then brewed	Relieves stress, treats skin irritation	●	●	Wonosobo	50,000/kg
Rutaceae	*Citrus limon* (L.) Osbeck	*Jeruk Lemon* (Lemon)	Fruit	Squeezed	Increase immunity, maintain body weight, and helps overcome coughs	●	●	Wonosobo	20,000/kg
Rutaceae	*Citrus aurantiifolia* Swingle.	*Jeruk Nipis* (Lime)	Fruit	Squeezed	Boosts the immune system, helps overcome coughs, and supports skin health	●	●	Wonosobo	7,000/kg
Rutaceae	*Citrus hystrix* DC.	*Daun Jeruk wangi* (Fragnant Orange)	Leaf	Boiled	Help sleep disorders and supports the immune system	●	●	Wonosobo	20,000/kg
Santalaceae	*Santalum album* L.	*Kayu Cendana* (Sandalwood)	Stem	Dried, then boiled	Calms the mind, treats skin infections	●	●	Yogyakarta	25,000/kg
Schisandraceae	*Illicium verum* hook. fil.	*Pekak* (Star Anise)	Fruit	Boiled	Acts as an antibacterial, solves stomach disorders	●	●	Yogyakarta	160,000/kg
Solanaceae	*Physalis angulata* L.	*Ceplukan* (Ground cherry)	Leaf	Boiled	Treats diabetes, reduces inflammation	●	●	Yogyakarta	70,000/kg
Thymelaeaceae	*Aquilaria malaccensis* Lamk.	*Kayu Gaharu* (Aloes Wood)	Wood	Brewed	Has antibacterial properties, helps relieve stress, and improves sleep quality	-	●	Yogyakarta	200,000/kg
Thymelaeaceae	*Phaleria macrocarpa* (Scheff.) Boerl.	*Mahkota Dewa* (Crown of God)	Fruit	Brewed	Boosts immunity, lowers blood sugar levels	●	●	Yogyakarta	60,000/kg
Usneaceae	*Usnea* sp.	*Rasuk Angin* (Beard Lichen)	Root	Boiled	Treats colds, strengthens the digestive system	●	●	Yogyakarta	70,000/kg
Zingiberaceae	*Zingiber purpureum* Roxb.	*Bangle* (cassumunar ginger)	Root	Boiled	Anti-inflammatory, helps with digestive problems, and reduces muscle and joint pain	-	●	Wonosobo	20,000/kg
Zingiberaceae	*Zingiber officinale* Rosc.	*Jahe* (Ginger)	Root	Boiled	Prevents heart disease, relieves joint and muscle pain, treats nausea	●	●	Wonosobo	35,000/kg
Zingiberaceae	*Elettaria cardamomum* (L.) Maton	*Kapulaga* (Cardamom)	Seed	Boiled	Antioxidant, improves blood circulation, lowers cholesterol, prevents cancer and canker sores	●	●	Yogyakarta	120,000/kg

Zingiberaceae	*Etlingera elatior* R.M.Sm.	*Kecombrang* (Torch Ginger)	Flower and Stem	Boiled	Act as an antioxidant and helps protect body cells from damage	●	-	Wonosobo	30,000/kg
Zingiberaceae	*Kaempferia galanga* L.	*Kencur* (Aromatic Ginger)	Root	Pounded, then boiled	Boosts stamina, treats cough.	●	●	Wonosobo	28,000/kg
Zingiberaceae	*Curcuma longa* L.	*Kunir* (Turmeric)	Root	Pounded	Helps smooth digestion, increases immunity, and treats inflamation	●	●	Wonosobo	15,000/kg
Zingiberaceae	*Curcuma zedoaria* (Christm.) Roscoe	*Kunir putih (*White Turmeric*)*	Root	Pounded	Antioxidant and anti-inflammatory properties, and good for treating digestive issues	●	●	Wonosobo	22,000/kg
Zingiberaceae	*Zingiber zerumbet* (L.) Roscoe ex Sm.	*Lempuyang* (Bitter ginger)	Root	Shredded, then boiled	Helps lower blood sugar, relieves fever, prevents ulcers	●	●	Wonosobo	7,000/kg
Zingiberaceae	*Alpinia galanga* (L.) Willd.	*Lengkuas* (Galangal)	Root	Crushed	Antioxidants that are beneficial for skin health, improves the digestive system, and relieves joint pain.	●	●	Wonosobo	10,000/kg
Zingiberaceae	*Curcuma aeruginosa* Roxb.	*Temu ireng* (Blue Turmeric)	Root	Boiled	Increases appetite, treats diabetes	●	●	Wonosobo	30,000/kg
Zingiberaceae	*Boesenbergia Rotunda* (L.) Mansf.	*Temu Kunci* (Fingerroot)	Root	Boiled	Acts as a tonic to strengthen the body and increases appetite.	●	●	Wonosobo	25,000/kg
Zingiberaceae	*Curcuma mangga* Roxb.	*Temu mangga* (Mango Ginger)	Root	Boiled	Help digestion, has anti-inflammatory properties, and supports liver health.	●	-	Wonosobo	20,000/kg
Zingiberaceae	*Curcuma zanthorrhiza* Roxb.	*Temulawak* (Curcuma)	Root	Boiled	Boosts immunity, treats inflammation, improves liver function,	●	●	Wonosobo	10,000/kg

Notes: ● **:** avaible, -: not avaible, KM: Kretek Market, IM: Wonosobo Induk Market

Figure 2. Various plants are used as herbal medicine at the Kertek Traditional Market and Wonosobo Induk Traditional Market, Wonosobo, Central Java, Indonesia. A. *Kulit Manggis* (*G. mangostana*); B. *Bangle* (*Z. purpureum*); C. *Klabet* (*T. foenum-graecum*); D. *Secang* (*B. sappan*); E. *Jati Cina* (*S. Alexandrina*); F. *Pulosari* (*A. Stellata*); G. *Bunga Telang* (*C. ternatea*); H. *Jinten* (*C. cyminum*); I. *Cengkeh* (*S. aromaticum*); J. *Manis Jangan* (*C. zeylanicum*); K. *Mahkota Dewa* (*P. macrocarpa*); L. *Manjakani* (*Q. infectoria*); M. *Kapulaga* (*E. cardamomum*); N. *Cabe Jawa* (*P. retrofractum*); O. *Mesoyi* (*C. massoy*); P. *Brotowali* (*T. cordifolia*); Q. *Mahoni* (*S. mahagoni*); R. *Kembang Seruni* (*C. morifolium*); S. *Pinang* (*A. catechu*); T. *Kemukus* (*P. cubeba*)

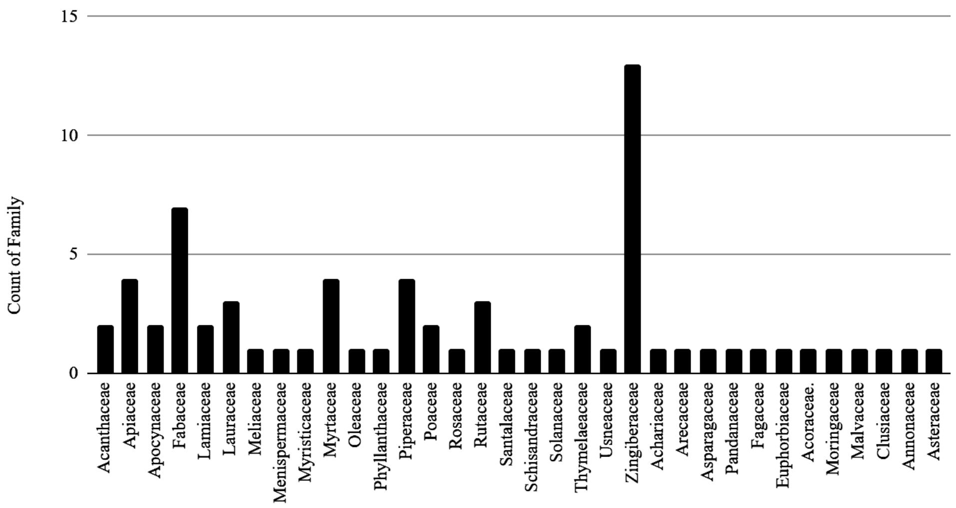


Figure 3. Family of medicinal plants

Research on the diversity of medicinal plants in the traditional markets of Wonosobo District showed that 59 species of medicinal plants were discovered in Kertek Traditional Market and 66 species in Wonosobo Induk Market. Documentation of various plants used as herbal medicine in Kertek Traditional Market and Wonosobo lnduk Market can be seen in Figure 2. The identification of families from all species of medicinal plants resulted in 34 families, as shown in Figure 3. The diversity of medicinal plants traded in the traditional markets of Wonosobo District is consistent with the research conducted by Deanova et al. (2021), who found 28 families and 105 species of medicinal plants in the Ir. Soekarno Market in Sukoharjo. Another study by Nguyen et al. (2019) found 57 families and 99 species of medicinal plants in traditional markets of Son La province, Vietnam. Meanwhile, a study by Iskandar et al. (2020) found 23 families and 35 species of medicinal plants in the traditional village markets of Karangwangi Village, Southern Cianjur, West Java, Indonesia. This diversity reflects the important role of traditional markets in providing the necessary medicinal plant materials to the community and serving as a center for the exchange of culture and knowledge about natural medicine.

Based on Table 2, Zingiberaceae is the family with the highest number of medicinal plant species in Kertek Traditional Market and Wonosobo Induk Market. This family consists of various species that are widely used as medicinal plants. Zingiberaceae is a perennial herbaceous plant with rhizomes containing volatile oils with a strong aroma. According to research conducted by Tran-Tung et al. (2024) in Vietnam, Zingiberaceae is one of the families that contain many essential oils, such as ginger with monoterpenes and sesquiterpenes derivatives, which are widely used in medicine, food, and flavor industries. The dominance of Zingiberaceae family medicinal plants sold by traders in the Wonosobo Traditional Market is supported by the ease of cultivation, especially in the Wonosobo District.

Part of the medicinal plants used

Based on Figure 4, the most commonly used parts of medicinal plants sold at the Kertek Traditional Market and Wonosobo Induk Market are leaves, seeds, and roots which is 15 species each. According to Acharya et al. (2015), leaves are the easiest part of medicinal plants to find. Leaves are also easy to find because almost every medicinal plant has plant parts (Wubu et al. 2023). Leaves are easy to harvest without special techniques (Valdez et al. 2024). This is due to their easy accessibility in the surrounding environment (Ayele et al. 2024). The leaves have a soft texture and are easily extracted for use as medicine (Khan et al. 2014). According to the research by Constantine et al. (2024), leaves are the most commonly used plant part for making medicine by traditional healers in Kyerwa District. These healers, with their deep understanding of the local flora, have identified the seeds as the dominant use of other parts of medicinal plants is the seeds. These seeds are used in traditional medicine to strengthen the immune system and promote general health. Seeds also contain bioactive compounds, including alkaloids, flavonoids, and essential oils that act as anti-inflammatory, antibacterial, or anticancer agents (Sharma et al. 2021). In many cultures, medicinal plant seeds are also considered an important source of nutrients, providing essential vitamins and minerals for good health. In addition, roots are also a part of the plant that is often utilised as medicine. This is because the roots contain active compounds such as alkaloids, phenolics, glycosides as anti-bacterial immunomodulators. These components are useful for maintaining body freshness, improving blood circulation, preventing and healing diseases and restoring health (Adriadi et al. 2022).

Making process of medicinal plants

Based on Figure 5, the use of medicinal plants for consumption involves several processing methods. Observations of 70 species of medicinal plants identified 14 processing methods. Research findings indicate that boiling is the most common method, accounting for 55.7% of all processes. According to Ssenku et al. (2021), boiling is the most commonly used method in the preparation of medicinal plants. Boiling increases the extraction and the concentration of active compounds from medicinal plants. In addition, boiling helps to preserve herbal medicines for a longer time. Boiling also makes the active compounds more easily absorbed by the body, thereby increasing the effectiveness of the medicine.

Medicinal plant suppliers

Based on Figure 6, the suppliers of medicinal plants in Wonosobo Induk Market and Kertek Market come from two areas, namely Wonosobo District (51.4%) and Yogyakarta Province (48.6%). Wonosobo District can serve as a supplier of medicinal plants due to its high and evenly distributed rainfall throughout the year, a crucial factor for plant growth. This is especially true for rhizomatous plants such as *empon-empon* (Nurhayati and Yusof 2022). According to research by Musa et al. (2023), in developing countries, medicinal plants have an important role in sustaining rural livelihoods. By cultivating medicinal plants, people can use them for medicinal purposes but also sell them to generate additional income. In addition, medicinal plants can be processed into products such as sachet drinks, increasing their commercial value. In addition to Wonosobo District, 48.6% of the medicinal plants in Wonosobo Induk Market and Kertek Market come from Yogyakarta Province.

Yogyakarta is known as one of the provinces in Indonesia rich in *empon-empon* or medicinal plants. One factor that supports Yogyakarta as a supplier of medicinal plants is its geographical conditions. In general, the soil conditions in Yogyakarta are fertile, making it suitable for the cultivation of various agricultural and plantation crops, including medicinal plants. This can be demonstrated through soil samples taken from agricultural land in the vicinity of Mount Merapi, a rural area influenced by volcanic ash deposits (Ramdhani et al. 2024.). Not only for shipment to other cities, but the people of Yogyakarta also have a long tradition of using medicinal plants for traditional medicine (Laplante 2016). The Yogyakarta government often conducts programs to support the development of medicinal plant cultivation, such as providing seeds, training, and processing facilities (Widowati and Wakid 2024). As a result, Kulon Progo is known as the "herbal medicine regency," where its residents regularly consume traditional herbal remedies (Arifin et al. 2021). It also encourages people to plant and develop medicinal plants in their respective areas. For example, Kiringan Herbal Tourism Village, located in Kiringan Hamlet, Canden Village, Jetis Subdistrict, Bantul Regency, Yogyakarta Province, plays a significant role in promoting herbal medicine and regional development. It is a center for herbal medicine in Bantul Regency with 132 herbal craftsmen, and it also serves as a tourist attraction, showcasing the rich tradition of herbal medicine in the region (Dewi et al. 2022).

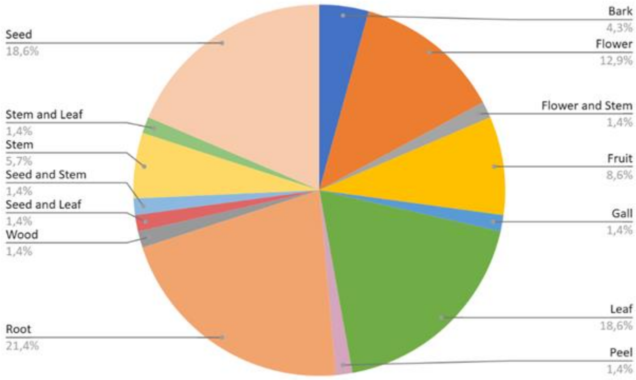


Figure 4. Used parts of medicinal plants

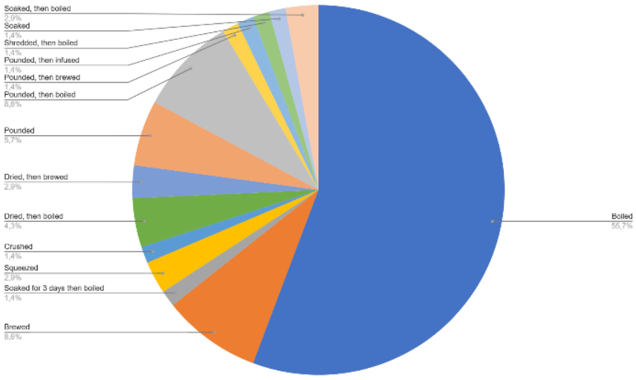


Figure 5. The making process of herbal medicine

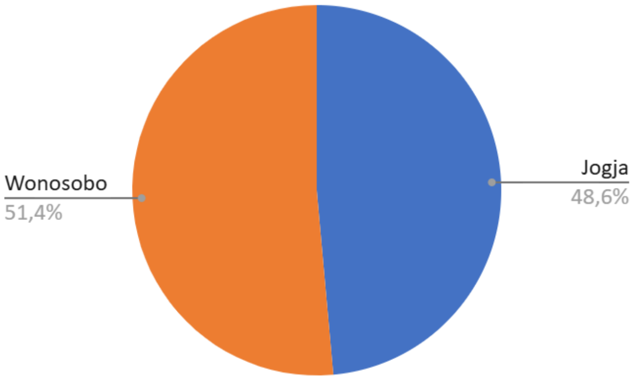


Figure 6. Medicinal plant suppliers

Price of medicinal plants

Based on Figure 6, the selling prices of medicinal plants in the Wonosobo Traditional Markets vary widely, ranging from IDR 2,000 to IDR 400,000/kg (1 USD = 15,500 IDR). The presence of suppliers from Yogyakarta influences the market prices in the Wonosobo area. This is because medicinal plants vary from one place to another due to the influence of local plant species, which affect the medicinal properties of the plants due to the complexity of their components and different characteristics (Wei et al. 2020).

In addition, some medicinal plants are difficult to find in Wonosobo, necessitating supplies from outside the area. As a result, plants sourced from outside regions, such as Yogyakarta, tend to have higher market values. For example, jasmine flowers are among the most expensive plants, with a price tag of IDR 400,000/kg. In addition to its aesthetic value and medicinal properties, the price of jasmine is high due to transportation costs and the specific cultivation techniques practiced in Yogyakarta. *kemukus (P. cubeba)*, sold at IDR 300,000/kg, is also classified as an expensive plant; this spice has significant health benefits, especially in traditional medicine, and requires optimal growing conditions, which are difficult to find in Wonosobo. Another example is *cengkeh (S. aromaticum)*, which is sold at IDR 160,000/kg; this spice has health benefits, and its superior quality is often sourced from Yogyakarta, where it is grown with appropriate techniques and climate. The high price also reflects distribution costs that are added when the product reaches Wonosobo. *biji selasih (O. basilicum)*, at IDR 70,000/kg, and *cabe jawa* (*P. retrofractum)*, at IDR 180,000/kg, are also imported from other regions and command relatively high prices due to quality factors and high demand.

In contrast, some medicinal plants that are easily found in Wonosobo are sold at much lower prices. For example, *sereh* (*C. citratus)*. Start at only IDR 4,000/kg, and *daun kelor* (*M. oleifera)*, at IDR 7,500/kg, are affordable plants that can be easily grown in Wonosobo without the need for distribution from outside the area. *Jahe* (*Z. officinale)*, priced at IDR 35,000/kg, and *temu ireng* (*C. aeruginosa)*, priced at IDR 10,000/kg, are also very affordable as both can thrive in the surrounding areas of Wonosobo. The cool highland geography makes this area ideal for the cultivation of various medicinal plants (Suhesti et al. 2021). These price variations show that while many high-value products are sourced from Yogyakarta, Wonosobo still offers a variety of locally available plants at budget-friendly prices. This range of price options allows consumers to choose plants according to their budget and needs, whether from high-value or affordable categories readily available in the local market (Putri and Mariana 2022).

Benefits of medicinal plants

Medicinal plants have significant health benefits that are often used in traditional medicine for various diseases and provide a natural alternative. The results of this study indicate that 70 species of medicinal plants sold at Kertek Market and Wonosobo Induk Market have various health benefits, as shown in Table 2. Medicinal plants that have properties for women are *kayu rapet (P. Laevigata)*, to treat postpartum wounds, overcome vaginal discharge, and a*das pulowaras (F. Vulgare)* to increase breast milk production. *das pulowaras (F. Vulgare)* is rich in organic acids, proteins, choline, trigonelline, and antioxidants, especially flavonoids (Agarwal et al. 2018). *sambiroto (A. Paniculata)*, *temu ireng (C. aeruginosa)*, and *brotowali (T. Cordifolia)* have antipyretic properties and help control blood sugar levels in the body, making them beneficial for people with diabetes. *Jati cina* (*C. ternatea*), *keji beling* (*I. cylindrica*), and *kumis kucing* (*P. angulata*), can help overcome problems in the urinary system, such as urinary tract infections and facilitate urination. According to research conducted by Muliana (2024), the *kumis kucing (O. Aristatus)* plant can treat high blood pressure and is used to treat heart and liver diseases.

Plants that can be used to overcome respiratory problems such as cough, asthma, and other problems related to the respiratory system are *cabe jawa* (*C. cyminum*), *cipir* (*T. cordifolia*), *manis jangan* (*P. tetragonolobus*), *mahkota dewa* (*A. moluccanus*), *meniran* (*C. hystrix*), and *pulosari* (*A. Stellata*) have immunomodulatory properties that help strengthen the immune system and fight inflammation. In addition, *C. longa* can also help overcome inflammation and maintain immunity. In research by Alburyhi and El-Shaibany (2023), C. *longa* is used as a remedy for various diseases and conditions, including problems related to the skin, respiratory system, and digestive system, as well as to treat pain, wounds, sprains, and liver problems. Plants that help smooth digestion or treat constipation and other health problems related to the digestive system is *ketumbar (C. sativum)*. This is shown in research conducted by Shahrabajian and Sun (2023) *ketumbar (C. sativum)* have been used as a remedy for digestive issues and rheumatism, as well as for treating worm infestations and joint pain. *Kayu cendana (S. album)* can threaten skin infections, and *cengkeh* (*S. aromatikum*) is a natural antiseptic for threatening toothache.

Plants that help lower high blood pressure, maintain heart health, and improve blood vessel function are *mahoni* (S. *mahagoni*), *alang-alang* (*I. cylindrica*), and *rosela* (*H. sabdariffa*). Plants that have anti-inflammatory properties that help relieve inflammation in joints and muscles are *bangle* (*Z. purpureum*), *jahe* (*Z. officinale*), and *lempuyang* (*Z. zerumbet*). Some plants also have a relaxing effect that helps calm the mind and overcome stress and anxiety, such as *melati* (*J. sambac*), *kenanga* (*C. odorata*), and *kayu gaharu (A. malaccensis*). Finally, some plants contain antioxidants that can help protect the body's cells from oxidative damage and maintain the body's health, such as *secang* (*B. sappan*), *kulit manggis* (*G. mangostana*), and *kecombrang* (*E. elatior*).

Medicinal plant traders at Kertek Market and Wonosobo Traditional Market not only sell medicinal plants separately, but some offer herbal concoctions in packaged form to be brewed into herbal drinks. These herbal concoctions *(jamu)*, which include remedies for diabetes, hypertension, cholesterol, rheumatism, and rheumatic pain, are a practical solution. They not only combine ease of use but also provide significant health benefits, reassuring our well-being.

Wedang uwuh is a traditional beverage made from a blend of natural ingredients, including wood shavings, twigs, rhizomes, or dried leaves, along with ginger, clove leaves, cloves, cinnamon, cardamom, sappan wood shavings, and sugar crystal, providing beneficial properties; it tastes delicious and health benefits (Syamsuri et al. 2020). According to Setyowati et al. (2023), *wedang uwuh* is a drink rich in antioxidants, which helps to fight free radicals, strengthen the immune system, and assist in overcoming various diseases such as influenza, colds, digestive problems, diabetes, and hypertension. It reflects the wealth of local knowledge and biodiversity of medicinal plants in Wonosobo District.

The role of medicinal plants in the daily lives of the Wonosobo people is reflected in their use as part of an ancestral tradition that is still preserved, namely the *kembang sawanan*. The use of flower concoctions in Javanese society is rooted in mythology and spiritual beliefs, continuing to this day. It has evolved into knowledge about health remedies, including the use of fruits for nutrition, phytochemicals, pharmacological benefits, and ethnomedicinal practices (Nardiati et al. 2023). According to Fadhillah (2022), the *sawan* phenomenon in Javanese culture is considered to be the result of interference from spirits who are healed through bathing using a mixture of several medicinal plants. The composition of the mixture for bathing *kembang sawanan*, which consists of *boreh bubuk* (made from *C. zanthorrhiza* and *O. sativa*), *bangle* (*Z. purpureum*), *bunga kanthil* (*M. alba*), *daun pandan* (*P. ammaryllifolius*), *daun sirih* (*P. betle*), *dlingo* (*A. calamus*), *jahe* (*Z. officinale*), *kunir* (*C. longa*), *mawar merah* (*R. multiflora*), and *mawar putih* (*R. alba*). From a health perspective, the *Sawanan* flower tradition has benefits such as aromatherapy, which helps improve or maintain health, raise the spirit, refresh and calm, and rejuvenate the body and mind. The combination of the aroma of these medicinal plants will cause a reaction to human feelings because the aroma sends certain signals to the part of the brain that regulates emotions. Inhaling essential oils from aromatic plants can directly stimulate the olfactory system and send signals to the brain (Cui et al. 2022).

Research on the diversity of medicinal plants in the Wonosobo Traditional Markets revealed 70 species with 34 families, i.e. 59 species at Kertek Market and 66 species at Wonosobo Induk Market, with the dominant family being Zingiberaceae. The most commonly used parts of medicinal plants for consumption are leaves and seeds, with boiling being the most common preparation method. The most expensive plant found is the jasmine flower, with a price of IDR 400,000/kg (1 USD = 15,500 IDR). As developments progress, traditional markets continue to offer these economically accessible resources of medicinal plants in the form of medicinal concoctions such as *jamu*, *wedang uwuh*, and *kembang sawanan.*

ACKNOWLEDGEMENTS

We extend our gratitude and appreciation to all those who have guided, inspired, and supported us in completing this article. In particular, we would like to thank all the traders and vendors at Kertek Market and Wonosobo Induk Market, Central Java, Indonesia, for their willingness to contribute as research participants and share data that supports the analysis in this article.

REFERENCES

Acharya R, Marasini D, Acharya DP. 2015. Traditional knowledge on medicinal plants used for the treatment of domestic cattle in Dhikura village of Arghakhanchi district, Nepal. Adv J Med Plant Res 2(1):6-16. DOI: 10.13057/NUSBIOSCI%2FN130105

Adriadi A, Asra R, Solikah S. 2022. Studi etnobotani tumbuhan obat masyarakat Kelurahan Kembang Paseban Kecamatan Mersam Kabupaten Batanghari. Jurnal Belantara 5(2) : 191-209. DOI: 10.29303/jbl.v5i2.881

Agarwal D, Saxena SN, Sharma LK, Lal G. 2018. Prevalence of essential and fatty oil constituents in fennel (Foeniculum vulgare Mill) genotypes grown in semi arid regions of India. Journal of Essential Oil Bearing Plants 21(1) :40-51. DOI: 10.1080/0972060X.2018.1433072

Ahmad M, Zafar M, Shahzadi N, Yaseen G, Murphey TM, Sultana S. 2018. Ethnobotanical importance of medicinal plants traded in Herbal markets of Rawalpindi-Pakistan. Journal of Herbal Medicine 11 (2a) : 78-89. DOI: https://doi.org/10.1016/j.hermed.2017.10.001

Alburyhi MM, El-Shaibany A. 2023. Formulation and Evaluation of Anti-peptic Ulcer Capsules of Curcuma Longa Herbal Product. World Journal of Pharmaceutical Research 12(22) : 76-96. DOI: http://dx.doi.org/10.20959/wjpr202322-30741

Arifin HS, Irwan SNR, Faisal B, Dahlan MZ, Nadhiroh SR, Wahyuni TS, Ali MS. 2021. Landscape management strategy of pekarangan to increase community immunity during the covid-19 pandemic in Java Indonesia–inductive research. In IOP Conference Series: Earth and Environmental Science 918: 1-14. DOI:10.1088/1755-1315/918/1/012029

Ayele A, Seid HA, Mekonnen AB, Adnew WW, Yemat G. 2024. Ethnobotanical study of the traditional use of medicinal plants used for treating human diseases in selected districts of West Gojjam zone, Amhara Region, Ethiopia. Phytomedicine Plus 4(3): 1-14. DOI: https://doi.org/10.1016/j.phyplu.2024.100620

Babajide A, Osabuohien E, Tunji-Olayeni P, Falola H, Amodu L, Olokoyo F, Adegboye F, Ehikioya B. 2023. Financial literacy, financial capabilities, and sustainable business model practice among small business owners in Nigeria. Journal of Sustainable Finance & Investment 13(4): 1670-1692. DOI: 10.1080/20430795.2021.1962663

Che CT, George V, Ijinu PT, Pushpangadan P, Andrae-Marobela K. 2024. Traditional medicine. In Pharmacognosy Academic Press 30(15): 11-28. DOI: http://dx.doi.org/10.1016/B978-0-12-802104-0.00002-0

Cui J, Li M, Wei Y, Li H, He X, Yang Q, Qin D. 2022. Inhalation aromatherapy via brain-targeted nasal delivery: Natural volatiles or essential oils on mood disorders. Frontiers in pharmacology 13: 1-15. DOI: 10.3389/fphar.2022.860043

Deanova AK, Pristiawati CM, Aprilia D, Solikah I., Nurcahayati M, Liza N, Himawan W, Partasasmita R, Setyawan AD. 2021. The diversity of edible plants traded in Ir. Soekarno Market, a traditional market in Sukoharjo District, Indonesia. Biodiversitas Journal of Biological Diversity, 22(9). 4095-4105. DOI: 10.13057/biodiv/d220958

Dewi MP, Hartawaty AD, Masitos D, Safitri D. 2022. Sosialisasi dan pelatihan pembibitan tanaman obat keluarga di desa wisata jamu kiringan, kabupaten bantul, provinsi daerah istimewa yogkarta. Jurnal Vokasi 6(3): 180-184. DOI: 10.30811/vokasi.v6i3.2648

Diniz do Nascimento L AAB, Moraes K, Cost SD, JM Pereira Galúcio, Taube PS, Costa CML, Neves Cruz J, de Aguiar Andrade, Faria LJG. 2020. Bioactive natural compounds and antioxidant activity of essential oils from spice plants: New findings and potential applications. Biomolecules 10(7): 988. DOI: https://doi.org/10.3390/biom10070988

Elkordy AA, Haj-Ahmad RR, Awaad SA, Zaki MR. 2021. An overview on natural product drug formulations from conventional medicines to nanomedicines: Past, present and future. Journal of Drug Delivery Science and Technology 63(1): 1-9 DOI: https://doi.org/10.1016/j.jddst.2021.102459

Fadhillah FS, Sulistiono S, Sulistiyowati TI, Primandiri PR, Santoso AM. 2022. Etnobotani Tumbuhan Obat di Desa Sugihwaras, Kecamatan Ngancar, Kabupaten Kediri. In Prosiding Seminar Nasional Kesehatan, Sains dan Pembelajaran 2(1): 536-542. DOI: 10.29407/seinkesjar.v2i1.3071

Fakchich J, Elachouri M. 2021. An overview on ethnobotanico-pharmacological studies carried out in Morocco, from 1991 to 2015: Systematic review (part 1). Journal of Ethnopharmacology 267 (1) :1-32. DOI: 10.1016/j.jep.2020.113200

Igustita I, Fatikha LAY, Astikasari L, Kusuma D, Nugraheni RS, Muryanto BS, Anshory, DA, Hidayat S, Sujarta P, Yasa A, Naim DMD, Setyawan, AD. 2023. Ethnobotany of medicinal plants in homegarden of Menoreh Karst Area, Purworejo District, Indonesia. Asian Journal of Ethnobiology 6(2): 171-181. DOI: 10.13057/asianjethnobiol/y060208

Iskandar BS, Iskandar J, Irawan B, Partasasmita R. 2018. Traditional markets and diversity of edible plant trading: Case study in Ujung Berung, Bandung, West Java, Indonesia. Biodiversitas Journal of Biological Diversity 19(2):437-452. DOI: 10.13057/biodiv/d190211

Iskandar BS, Iskandar J, Partasasmita R, Irawan, B. 2020. Various medicinal plants traded in the village market of Karangwangi Village, Southern Cianjur, West Java, Indonesia. Biodiversitas Journal of Biological Diversity, 21(9). DOI: 10.13057/biodiv/d210963

Jadid NE, Kurniawan, Himayani SEC, Andriyani I, Prasetyowati, Purwani IK, Tjahjaningrum DTI. 2020. An ethnobotanical study of medicinal plants used by the Tengger tribe in Ngadisari village, Indonesia. Plos one. 15(7): 1-16. DOI: https://doi.org/10.1371/journal.pone.0235886

Khan I, AbdElsalam NM, Fouad H, Tariq A, Ullah R, Adnan M. 2014. Application of ethnobotanical indices on the use of traditional medicines against common diseases. Evidence-Based Complementary and Alternative Medicine 2014(1): 1-21. DOI: 10.1155/2014/635371

Khasanah R, Hermawan H. 2020. Perancangan Wajah Pasar Tradisional Kempul di Desa Gadingrejo dengan Pendekatan Ekologi. Journal of Economic, Business and Engineering (JEBE) 2(1):188-194. DOI: 10.32500/jebe.v2i1.1474

Laplante, J. 2016. Becoming-plant: jamu in Java, Indonesia. Plants and health: new perspectives on the health-environment-plant nexus 1: 17-65. DOI: 10.1007/978-3-319-48088-6_2.

Liu C. X. 2021. Overview on development of ASEAN traditional and herbal medicines. Chinese Herbal Medicines 13(4): 441-450. DOI: https://doi.org/10.1016/j.chmed.2021.09.002

Liu Y, Hu R, Shen S, Zhang Z, Zhang J, Song X, Qiang S. 2020. Plant diversity in herbal tea and its traditional knowledge in Qingtian County, Zhejiang Province, China. Plant diversity 42(6): 464-472. DOI: 10.1016/j.pld.2020.12.002

Mais M, Simbala HE, Koneri R. 2018. The utilization of medicinal plants by the Sahu and Loloda Ethnic Groups in West Halmahera, North Maluku. Jurnal MIPA 1 (8): 8-11. DOI:10.13057/biodiv/d25062

Muliana GH. 2024. Exploring the Potential of Orthosiphon Stamineus: A Literature Review. Jurnal Serambi Engineering 9(4): 10835-10842.

Musa FI, Sahoo UK, Eltahir ME, Magid TDA, Adlan OE, Abdelrhman HA, Abdelkarim AA. 2023. Contribution of non-wood forest products for household income in rural area of Sudan–A review. Journal of Agriculture and Food Research 14: 1-10. DOI: 10.1016/j.jafr.2023.100801

Muyumba, NW, Mutomb CS, Sheridan H, Nachtergael A, Duez P. 2021. Quality control of herbal drugs and preparations: The methods of analysis, their relevance and applications. Talanta Open 4: 1-14. DOI: 10.1016/j.talo.2021.100070

Nardiati S, Hardaniwati M, Murdowo DA, Winarti S. 2023. Javanese Flowers Concoction Lexicon and Their Functions for Healing in Javanese Language: An Ethnolinguistic Study. Eurasian Journal of Applied Linguistics 9(3): 185-195. DOI: http://dx.doi.org/10.32601/ejal.903016

Nguyen TS, Xia NH, Chu TV, Sam HV. 2019. Ethnobotanical study on medicinal plants in traditional markets of Son La province, Vietnam. Forest and Society 3(2): 171. DOI: https://doi.org/10.24259/fs.v3i2.6005

Nurhayati DR, Ts MP, Yuso SFB. 2022. Herbal dan rempah. Scopindo Media Pustaka, Surabaya.

Nursamsu N, Nuraini N, Sarjani TM, Mardudi M. 2024. The use of medicinal plants in the Aneuk Jamee tribe in Kota Bahagia, South Aceh District, Indonesia. Biodiversitas Journal of Biological Diversity 25(6): 2524-2540. DOI: 10.13057/biodiv/d250622

Palash MS, Amin MR, Ali MY, Sabur SA. 2021. Medicinal plant business in Bangladesh: Exploring the performance of supply chain actors. Journal of Agriculture and Food Research 6(1) : 1-8. DOI: https://doi.org/10.1016/j.jafr.2021.100230

Pant P, Pandey S, Dall'Acqua S. 2021. The influence of environmental conditions on secondary metabolites in medicinal plants: A literature review. Chemistry & Biodiversity 18(11) : 1-14. DOI: 10.1002/cbdv.202100345

Pratama BE, Lestarini W. 2021. Analisa Lalu Lintas Simpang Tak Bersinyal Untuk Simpang Jalan Pasar Kertek. Teras 11(2): 7-15. DOI: https://ojs.unsiq.ac.id/index.php/teras/article/view/2536

Ramdhani TI, Suryana Y, Rochmadi T, Aziz A, Kamaruddin A, Ghazal N, Nuraini L. 2024. Predictive soil nutrient modeling with spectral data and machine learning in four major Indonesian Provinces located on the island of java. In IOP Conference Series: Earth and Environmental Science 1419(1): 1-15. DOI:10.1088/1755-1315/1419/1/012007

Santana BF, Santos-Neves SP, Voeks AR, Funch SL. 2024. Urban ethnobotany in local markets: A review of socioeconomic and cultural aspects. South African Journal of Botany. 170: 401-416. DOI: https://doi.org/10.1016/j.sajb.2024.05.041

Setyowati N, Mulyo JH, Yudhistira B. 2023. The hidden treasure of wedang uwuh, an ethnic traditional drink from Java, Indonesia: Its benefits and innovations. International Journal of Gastronomy and Food Science 31: 1-11. DOI: 10.1016/j.ijgfs.2023.100688

Shahrajabian MH, Sun W. 2023. Five important seeds in traditional medicine, and pharmacological benefits. Seeds. 2(3): 290-308. DOI: 10.3390/seeds2030022

Sharma N, Tan MA, An SSA. 2021. Mechanistic aspects of Apiaceae family spices in ameliorating Alzheimer's disease. Antioxidants 10(10) :1-18. DOI: 10.3390/antiox10101571 .

Silalahi M, Walujo EB, Supriatna J, Mangunwardoyo W. 2015. The local knowledge of medicinal plants trader and diversity of medicinal plants in the Kabanjahe traditional market, North Sumatra, Indonesia. Journal of ethnopharmacology 175(2). 432-443. DOI: 10.1016/j.jep.2015.09.009

Ssenku JE, Okurut SA, Namuli A, Kudamba A, Tugume P, Matovu P, Wasige G, Kafeero HM, Walusansa A. 2022. Medicinal plant use, conservation, and the associated traditional knowledge in rural communities in Eastern Uganda. Tropical Medicine and Health 50(1) :39. DOI: 10.1186/s41182-022-00428-1

Supriyani D, Baehaqi I, Mulyono M. 2019. Istilah-istilah sesaji ritual jamasan kereta kanjeng nyai jimat di museum kereta keraton Yogyakarta. Jurnal Sastra Indonesia 8(1): 6-11. DOI: https://doi.org/10.15294/jsi.v8i1.29852

Tran-Trung H, Le DG, Hoang VT, Vu DC, Thang TD, Ngoc HN, Van CT, Nguyen TT, Tuan NH, Nguyen THD. 2024. Essential Oils of Two Species of Zingiberaceae Family from Vietnam: Chemical Compositions and α-Glucosidase, α-Amylase Inhibitory Effects. Natural Product Communications. 2024;19(2). DOI:10.1177/1934578X241232281

Uzun P, Koca C. 2020. Ethnobotanical survey of medicinal plants traded in herbal markets of Kahramanmaraş. Plant Diversity 42(6): 443-454. DOI: https://doi.org/10.1016/j.pld.2020.12.003

Valdez BT, Mory G, Kadiatou CA, Talasson BS, Kerfala CM, Séré D, Sahar TM, Saidou BE. 2024. Ethnobotanical survey of medicinal plants used to treat icterus in Labé administrative district (Republic of Guinea). Journal of King Saud University-Science 36(9): 1-6. DOI: https://doi.org/10.1016/j.jksus.2024.103350

Widayat W , Purwanto H. 2020. Pengaruh kualitas pelayanan, harga, keberagaman produk, suasana toko dan lokasi terhadap minat beli konsumen di Pasar Tradisional Wonosobo. Journal of Economic, Business and Engineering (JEBE) 2(1): 123-132. DOI: https://doi.org/10.32500/jebe.v2i1.1458

Widowati A, Wakid M. 2024. Integrating ethnoscience: Enhancing culture, technology, and sustainable economic development through design and education. In SHS Web of Conferences 197: 1-11. DOI: 10.1051/shsconf/202419701003

Wubu KA, Ngatie AH, Haylie TA, Osman AD. 2023. Ethnobotanical study of traditional medicinal plants in Kebridehar and Shekosh districts, Korahi zone, Somali Region, Ethiopia. Heliyon 9(12): 1-16. DOI: 10.1016/j.heliyon.2023.e22152

Wungo GL, Ghozali A, Rahmanida LF, Nahari AN, Wahyono DN. 2024. Embracing the digital era: the integration of urban design management in smart city concepts on Kertek Urban Area. In IOP Conference Series: Earth and Environmental Science. 1394(1): 1-13. DOI: 10.1088/1755-1315/1394/1/012031

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025 E-ISSN: 2580-4510
Pages: 26-39 DOI: 10.13057/asianjethnobiol/y080103

Biocultural roles of naturalized alien plants in highland communities of Central Java, Indonesia

AINI MAR'ATUSH SHOLEKHA[1], ARLINDA DWI RESTANTI[1], CAHYA MAULIDTA ROHMAN[1], FADIA AULIANISSA AINAYA[1], NUR ROHMAYANI ANGGELIKA PUTRI[1], AISYAH PUTRI[2], ARU DEWANGGA[1], SURAPON SAENSOUK[3], AHMAD DWI SETYAWAN[1,4,♥]

[1]Department of Environmental Sciences, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375. ♥email: volatileoils@gmail.com
[2]Department of Public Health, Faculty of Public Health, University of Tadulako. Jl Soekarno Hatta Km.9, Palu Central Sulawesi, Indonesia
[3]Diversity of Family Zingiberaceae and Vascular Plant for Its Applications Research Unit, Program of Biodiversity, Walai Rukhavej Botanical Research Institute, Mahasarakham University. Kantarawichai, Maha Sarakham 44150, Thailand
[4]Biodiversity Research Group, Sebelas Maret University. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia

Manuscript received: 18 December 2023. Revision accepted: 20 March 2025.

Abstract. *Sholekha AM, Restanti AD, Rohman CM, Ainaya FA, Putri NRA, Putri A, Dewangga A, Saensouk S, Setyawan AD. 2025. Biocultural roles of naturalized alien plants in highland communities of Central Java, Indonesia. Asian J Ethnobiol 8: 26-39.* Naturalized alien plant species (NAPS) are often perceived as threats to biodiversity and ecosystem stability. However, in many rural communities, these species may also serve important roles in food systems, healthcare, rituals, and livelihood strategies. This study explores the ethnobotanical utilization and cultural significance of NAPS in five highland villages in Central Java, Indonesia, based on interviews with 125 respondents and field observations. A total of 143 species were documented, with the majority being used for food (39.2%) and medicinal purposes (34.5%). The Index of Cultural Significance (ICS) revealed that certain species—such as *Cosmos caudatus*, *Curcuma longa*, and *Psidium guajava*—are highly valued across multiple dimensions and locations. Cross-village comparisons highlighted distinct biocultural filtering processes, shaped by local ecology, demographic structure, and cultural preferences. While some NAPS were shared across villages, many were site-specific, suggesting localized knowledge systems and adaptive use patterns. The findings underscore the need for a more nuanced, culturally grounded approach to invasive species management, one that balances ecological concerns with the needs of rural livelihoods and cultural heritage. Integrating local knowledge and community participation into plant governance frameworks is essential for achieving sustainable and socially just conservation outcomes.

Keywords: Cultural significance index, ethnobotany, invasive species management, rural livelihoods, traditional knowledge

INTRODUCTION

Naturalized alien plant species (NAPS) represent a critical yet underexplored dimension in biodiversity conservation and rural livelihood systems. Unlike invasive alien species (IAS), which are widely recognized for their ecological threats, NAPS refer to alien species that have established self-sustaining populations in new environments without continuous human intervention (Richardson et al. 2000; Pyšek et al. 2020). In tropical developing countries like Indonesia, where ecological resilience intersects with socio-cultural complexity, the distinction between naturalized and invasive species becomes both ecologically and culturally significant.

Indonesia, one of the world's mega-diverse countries, hosts over 30,000 plant species, with more than 1,900 identified as alien (Tjitrosoedirdjo 2005; Sayfulloh et al. 2020). Among these, many have naturalized over decades due to historical introductions through agriculture, trade, colonial botanical exchange, and landscape ornamentation (Abywijaya et al. 2014; Shackleton et al. 2019). While some species transition into invasive behavior, others integrate into local agroecosystems and cultural practices, often without formal recognition in national botanical inventories. Their dual nature—being simultaneously beneficial and potentially harmful—calls for a nuanced understanding that combines ecological science with ethnobotanical perspectives (Shrestha and Shrestha 2019; Rai and Singh 2020).

Generations of ecological adaptation, experimentation, and the transmission of traditional knowledge shape the cultural use of alien plant species in highland communities. In remote or semi-remote villages, where access to formal healthcare and market economies may be limited, naturalized plants often substitute or supplement native biodiversity in food, medicine, ritual, and domestic utility (Turner 1988; Heinrich et al. 2009). However, most national and regional conservation frameworks treat alien species as uniformly negative, disregarding localized contexts of cultural utility and livelihood dependency (Shackleton et al. 2007, 2019; Carneiro et al. 2024). A significant scientific and policy gap remains in integrating cultural significance assessments into invasive species management, particularly in biodiversity hotspots such as Java's uplands.

The use of the Index of Cultural Significance (ICS) offers a systematic method to quantify how much a given species contributes to local livelihoods and belief systems. Originally proposed by Turner (1988) and further developed by researchers in ethnobotany and conservation (e.g., González et al. 2010; Maruapey et al. 2022), the ICS incorporates qualitative variables such as frequency of use, diversity of utility, and cultural preference. Applying ICS to naturalized alien plants allows researchers to differentiate between culturally embedded species and those that pose significant ecological threats, facilitating management strategies that are both ecologically sound and culturally respectful (Supiandi et al. 2019).

This study investigates the cultural utilization and management implications of NAPS in five highland villages of Central Java: Gondosuli, Berjo, Sewurejo, Polokarto, and Balerante. These sites are situated in the transitional agro-ecological zones of the Lawu and Merapi mountains, characterized by diverse altitudes, land-use systems, and cultural histories. All five villages demonstrate varying degrees of interaction with alien plant species, influenced by local agriculture, tourism, and traditional medicine systems. Previous localized studies have documented the use of naturalized species, such as *P. guajava, Chromolaena odorata,* and *C. caudatus*; however, no regional synthesis has yet linked these data across multiple communities to assess broader patterns and implications (Nahdi and Kurniawan 2019; Handayani et al. 2021; Kusumawati et al. 2022).

Understanding how highland communities use NAPS is particularly important in the face of global climate change and increasing landscape fragmentation. Highland regions are often biodiversity refugia, but they are also highly vulnerable to biological invasions due to land-use conversion, tourism influx, and climate-driven shifts in species distribution (Seebens et al. 2018; Cuthbert et al. 2022). In Java, these challenges are compounded by population pressure and the ongoing degradation of upland forests and agroforests (Mokany et al. 2022). Documenting and interpreting local plant use—especially when it involves non-native species—can thus inform community-based conservation and sustainable land management initiatives that are responsive to both ecological and cultural priorities.

Therefore, this study aims to document the diversity and origin of naturalized alien plant species (NAPS) utilized by local communities in five highland villages of Central Java, quantify their cultural significance using the Index of Cultural Significance (ICS), and explore the implications of NAPS utilization for future conservation strategies, particularly in reconciling invasive species control with the preservation of traditional ecological knowledge. The results are expected to contribute to policy dialogues on adaptive co-management of plant resources, offering a case for the inclusion of cultural dimensions in managing alien flora in tropical highland systems.

MATERIALS AND METHODS

Study area

The research was conducted across five highland villages located in Central Java Province, Indonesia (Figure 1): Gondosuli, Berjo, and Sewurejo (Karanganyar District), Polokarto (Sukoharjo District), and Balerante (Klaten District). These villages are situated along the foothills of Mount Lawu and Mount Merapi, within altitudes ranging from 400 to 1,500 meters above sea level (Table 1). The regions are characterized by temperate tropical climates with high annual rainfall and heterogeneous land use, including agroforestry, homegardens, roadside vegetation, and secondary forest margins, which support the spontaneous or intentional growth of alien plant species.

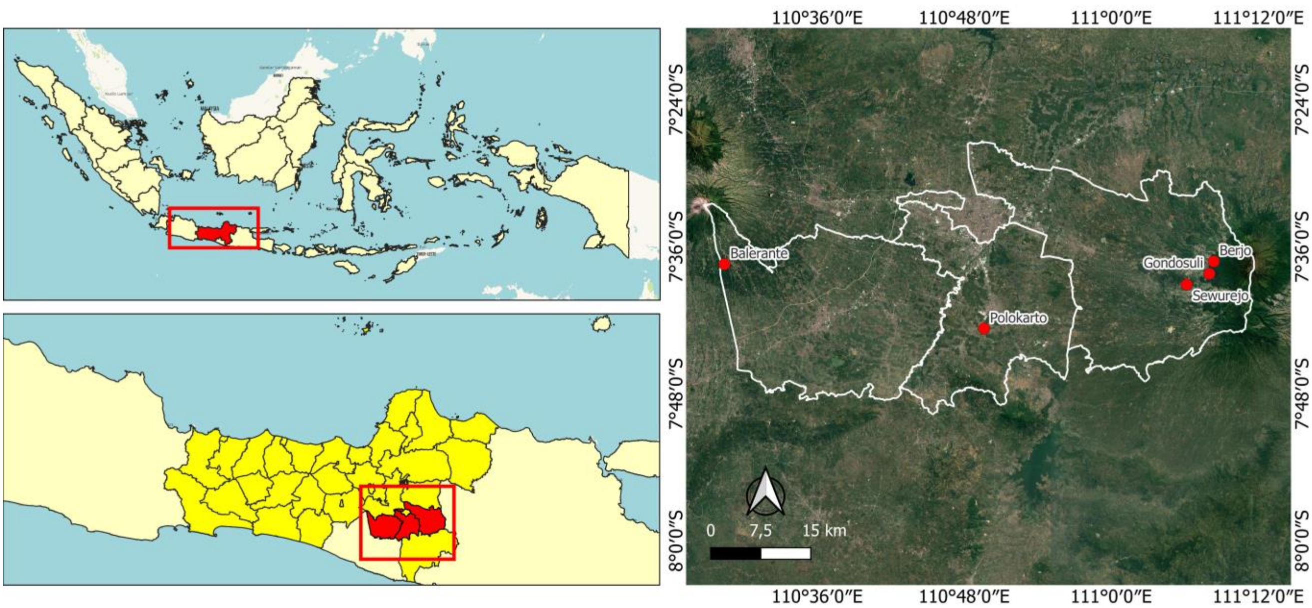


Figure 1. Map of study sites in five highland villages of Central Java, Indonesia

Table 1. Environmental and geographic characteristics of the five study villages.

Village	District	Coordinates	Altitude (masl)	Dominant Land Use	Climatic Context
Gondosuli	Karanganyar	7°38'12"S, 111°8'01"E	~1,150	Agroforestry, homegardens, rice	Humid tropical highland
Berjo	Karanganyar	7°37'11"S, 111°8'22"E	~870	Mixed gardens, rice, and fruit trees	Moist subtropical upland
Sewurejo	Karanganyar	7°39'05"S, 111°6'10"E	~650	Homegardens, secondary forest	Transitional tropical zone
Polokarto	Sukoharjo	7°42'40"S, 110°49'38"E	~120	Settlements, fields, roadside flora	Lower tropical lowland
Balerante	Klaten	7°37'45"S, 110°27'17"E	~530	Rainfed fields, forest margins	Volcanic foothill climate

Gondosuli and Berjo are located in the Tawangmangu highlands, an ecotourism and vegetable farming region that has long interacted with introduced plants via tourism and horticulture. Sewurejo, in Mojogedang Subdistrict, is a peri-rural settlement with widespread mixed homegarden systems. Polokarto, in Sukoharjo District, is among the largest and most agriculturally intensive low-montane villages in the region, with alien species often growing along irrigation dikes and marginal plots. Balerante lies adjacent to the Merapi National Park and represents a transitional zone between conservation forest and agricultural land, frequently exposed to seed dispersal via floods, livestock, and road networks.

These five villages were selected to represent ecological variation, land-use diversity, and contrasting levels of exposure to alien plant species due to factors such as elevation, tourism intensity, agricultural dependence, and proximity to forested areas.

Data collection

This study employed a combination of qualitative and quantitative data collection techniques, including structured interviews, field observations, and literature triangulation, to document the cultural utilization of naturalized alien plant species (NAPS) by local communities. Respondents were selected through purposive sampling based on long-term residence and demonstrated knowledge of plant use, followed by simple random sampling to ensure demographic representativeness across age and gender. The criteria included a minimum age of 20 years, at least five years of residence, and familiarity with the use of local or naturalized plant species. A total of 230 individuals participated in the interviews: 46 from Gondosuli, 52 from Berjo, 40 from Sewurejo, 47 from Polokarto, and 45 from Balerante. Demographic data—such as age, gender, and educational background—were collected to assess potential patterns in the distribution of ethnobotanical knowledge.

Data collection involved semi-structured interviews using a standardized questionnaire, conducted individually and face-to-face in either Javanese or Indonesian, according to respondent preference. Interviews included open-ended questions related to the plant's local name, parts used (leaves, roots, stems, flowers, fruits, or whole plant), categories of use (e.g., food, medicinal, ornamental, ritual, fuel, forage), methods of application (e.g., raw, boiled, decoction, topical), usage frequency, and presence of substitutes or exclusivity of function. Each session lasted approximately 20-30 minutes, and responses were recorded on tally sheets, which were then digitized after each interview to ensure accuracy and consistency. Oral informed consent was obtained, and respondent identities were anonymized for confidentiality.

Field observations were conducted simultaneously to validate species presence and observe habitat context. Plants mentioned during interviews were photographed and described based on their growth habit (cultivated, wild, or naturalized) and habitat type (homegardens, field edges, roadsides, or forest fringes). Where needed, voucher specimens were collected for herbarium verification.

To support triangulation and ecological interpretation, secondary data sources were also consulted, including official village monographs, land-use records, climate data from BMKG (2023), and land classification data from BPS (2022). Relevant floristic and ethnobotanical literature specific to Central Java (Darmastuti et al. 2024; Nurcahyo et al. 2024) further contextualizes the distribution patterns of species and possible introduction pathways.

Plant identification and taxonomic standardization

Plant species mentioned by respondents were identified through a combination of vernacular name verification, field observations, and consultation with standard botanical references. Whenever possible, respondents directly showed the plants in their natural settings, allowing for in situ identification and photographic documentation. For unfamiliar or ambiguous specimens, voucher samples were collected for further verification using regional floras and herbarium materials.

Taxonomic identification and standardization relied on reputable references, including Setyawati et al. (2015) and global databases such as Plants of the World Online (POWO, https://powo.science.kew.org), Global Biodiversity Information Facility (GBIF, https://www.gbif.org), World Flora Online (WFO, http://www.worldfloraonline.org), and iNaturalist (https://www.inaturalist.org). Scientific names followed binomial nomenclature with author citation, and family classifications adhered to the APG IV system. Where species-level identification was not feasible, taxa were noted at the genus level using "cf." (e.g., *Amaranthus cf. hybridus*).

To determine alien status, each species was evaluated based on three main criteria: being introduced from outside Indonesia, forming self-sustaining populations without continued human intervention, and reproducing naturally in rural or disturbed habitats. Native geographic origins were identified using POWO and WFO and grouped by continent or floristic region.

Table 2. Scoring criteria used in the ICS calculation

Variable	Score	Description
Quality (q)	5	Staple food or primary medicinal use
	4	Secondary food, key ingredient, or widely used remedy
	3	Occasional use for nutrition, health, or functional household use
	2	Ritualistic, recreational, or symbolic use
	1	Known to be used but not actively applied
Intensity (i)	5	Used daily or very frequently
	4	Used regularly (weekly/monthly)
	3	Used occasionally (seasonally or when available)
	2	Used rarely
	1	Very low frequency, used in the past or only by specific individuals
Exclusivity (e)	2	No substitute available; culturally preferred or unique species
	1	Has alternatives but is still commonly used
	0.5	Substitutable and not culturally unique

Note: Adapted from Turner (1988) and Maruapey et al. (2022)

Cultural significance assessment (ICS calculation)

To assess the cultural importance of each naturalized alien plant species (NAPS), this study applied the Index of Cultural Significance (ICS) method, adapted from Turner (1988). This semi-quantitative approach evaluates species based on their perceived social, economic, and ritual value using three weighted variables: quality of use (*q*), intensity of use (*i*), and exclusivity of use (*e*). The ICS for each species was calculated using the formula:

$$ICS = \sum (q \times i \times e)$$

Where: the summation applies across all identified use categories (*k*). Each variable was scored according to standardized criteria (see Table 2).

Final ICS values were then grouped into five interpretive categories: very high (ICS≥100), high (50-99), moderate (20-49), low (5-19), and very low (<5). This classification enabled comparative analysis across villages and helped highlight species with enduring or declining cultural roles.

To ensure scoring consistency, two researchers independently coded all interview responses, and discrepancies were resolved through a consensus process. Additionally, a third-party audit was conducted on 10% of the data to validate reliability. The ICS results were compiled and visualized using Microsoft Excel, supporting the identification of culturally significant species in the five study locations. Each use category (e.g., food, medicine, fodder, ornament) was treated as an individual unit of cultural interaction, contributing separately to the overall ICS score of the species.

Data analysis and visualization

Data from interviews and field observations were analyzed using both quantitative and qualitative approaches to interpret cultural patterns in the use of naturalized alien plant species (NAPS) across the five study villages. Quantitative variables—such as the number of cited species, categories of use, plant parts utilized, and Index of Cultural Significance (ICS) scores—were processed using Microsoft Excel and SPSS to generate frequency distributions, percentages, and cross-tabulations. Analyses focused on species richness at the village and family levels, distribution of use categories (e.g., food, medicinal, ornamental), variation in ICS scores, and the influence of demographic factors including age, gender, and education.

To explore spatial and cultural variability, overlaps and distinctiveness in species use among villages were examined, along with differences in usage intensity and perceived cultural value. Meanwhile, qualitative data—particularly those concerning ritual functions, symbolic meanings, and plant-related narratives—were compiled to complement the ICS framework. These insights captured non-material aspects of plant use and provided context for observed trends, such as shifts in traditional knowledge or the persistence of intergenerational practices.

Visual representations were generated to facilitate interpretation, including bar graphs for use category frequency, pie charts for plant parts and dominant families, and scatter plots or boxplots for village-level variation in ICS values. Venn diagrams illustrate shared and unique species among communities. All visual outputs were integrated into the Results section to support data-driven insights.

To ensure validity and consistency, a triangulation approach was applied. Statements from respondents were cross-verified with field observations, and local plant names were validated using vernacular dictionaries and expert input. The species origin was confirmed through global taxonomic databases, including Plants of the World Online (POWO), GBIF, and World Flora Online (WFO). This multi-source verification reinforced the reliability of taxonomic identification and ethnobotanical classification across study sites.

RESULTS AND DISCUSSION

Socio-demographic characteristics of respondents

A total of 230 respondents were interviewed across five highland villages in Central Java, with demographic details summarized in Table 3. Of these, 53.9% were female and 46.1% were male (n=106), resulting in a relatively balanced gender distribution across locations. Polokarto and Balerante had slightly more male participants, while Berjo and Sewurejo recorded a higher proportion of women. In terms of age, the largest group (41.3%) was between 41 and 60 years old—an age range commonly associated with strong traditional ecological knowledge. The youngest group (20-30 years) accounted for only 9.1%, raising concerns about the potential for generational gaps in the transmission of ethnobotanical knowledge.

Educational levels among respondents were generally low to moderate. Nearly half (46.5%) had completed only elementary school, 27.0% had attended junior high school, and just 3.9% had received tertiary education. Notably, Balerante and Berjo reported the highest numbers of individuals with no formal schooling or limited literacy, likely linked to geographic isolation and limited institutional access. These socio-demographic characteristics are crucial for understanding the distribution and retention of ethnobotanical knowledge, as education, age, and gender significantly influence both the acquisition and intergenerational transmission of plant-related cultural practices.

Diversity of naturalized alien plant species

A total of 143 naturalized alien plant species (NAPS) were recorded across the five study villages, representing 52 plant families. These 143 species represent non-redundant taxa observed across all sites, while site-level richness includes overlapping species that occur in multiple villages. Species richness varied notably across sites, as illustrated in Figure 2, with Sewurejo recording the highest number (62 species), followed by Berjo (51), Gondosuli (50), Polokarto (31), and Balerante (26). These differences likely reflect variations in land-use intensity, disturbance regimes, and cultural exposure to introduced flora.

The most frequently represented families were Asteraceae (14 species), Fabaceae (11 species), Poaceae (10 species), Zingiberaceae (9 species), and Amaranthaceae (6 species). These families are widely recognized for their ecological plasticity, ethnobotanical versatility, and broad dispersal patterns in tropical regions. Their dominance is evident in both cultivated and spontaneous contexts, as shown in the family-level distribution of species across villages (Figure 3). Asteraceae, for example, was present in all sites and included both intentionally cultivated plants, such as *C. caudatus* and *Tagetes erecta*, as well as opportunistically utilized weeds, including *C. odorata*.

In terms of growth habit, herbs made up the majority of recorded species (59.4%), followed by shrubs (24.5%), climbers (9.8%), and trees (6.3%). Herbaceous species were especially prevalent in homegardens and roadside habitats, aligning with the preference for easily accessible, fast-growing plants in subsistence-oriented agroecosystems. This trend is clearly depicted in the graphical summary of growth forms (Figure 4). Climbing species such as *Sechium edule* and *Phaseolus vulgaris* were typically cultivated, while trees were underrepresented unless they offered additional value as food, fuel, or multipurpose resources.

Regarding the plant parts used, a total of 931 use-reports were recorded across all five study villages. Leaves were the most frequently mentioned part, accounting for 34.4% of all reports (n=320), followed by fruits (26.9%, n=250), roots or rhizomes (19.4%, n = 180), flowers (12.9%, n = 120), whole plants (9.8%, n = 91), and stems (9.7%, n = 90). A few species—such as *Portulaca oleracea*—were used in their entirety, particularly in medicinal and ornamental contexts, highlighting the multifunctionality and adaptability of many naturalized alien plant species (NAPS) in local ethnobotanical systems. The predominance of leaf use aligns with traditional Javanese practices, where leafy materials are commonly prepared as salads, decoctions, or poultices. These patterns are visually summarized in Figure 5.

In terms of floristic origin, the majority of naturalized alien plant species (NAPS) recorded in the study originated from Tropical America (48 species, 33.6%), followed by Southeast Asia (26 species, 18.2%), and the Indian Subcontinent (24 species, 16.8%), with smaller contributions from Africa (12 species, 8.4%), Temperate Asia (10 species, 7.0%), Europe (8 species, 5.6%), and Australia-Pacific (5 species, 3.5%); an additional 10 species (7.0%) had uncertain origins. These source regions reflect a complex history of plant introductions driven by trade, colonization, and cultural exchange, particularly during the colonial and post-colonial periods. The prominence of American taxa such as *P. guajava* and *Annona muricata* illustrates the legacy of transoceanic diffusion, while the substantial number of species from Southeast and South Asia indicates strong regional agroecological connectivity. The distribution of floristic origins is illustrated in Figure 6, emphasizing the global integration of introduced species into the subsistence systems and daily lives of highland communities in Central Java. For a consolidated summary of the data visualized in Figures 2-6, including exact species counts and proportions, see Table 4.

Utilization categories of NAPS

Naturalized alien plant species (NAPS) recorded across the five study villages were classified into seven main utilization categories based on respondent interviews: food, medicine, ornamental, fodder, fuelwood, ritual and recreational, and other uses, such as cleaning agents or insect repellents. Among these, food uses accounted for the largest proportion of citations (33.5%), as shown in Table 5. Commonly cited food species included *C. caudatus*, *S. edule*, *P. oleracea*, and *P. guajava*, which are often integrated into homegardens or cultivated seasonally for soups, salads, or snacks.

Table 3. Demographic characteristics of respondents in the five study villages of Central Java, Indonesia (n = 230)

Village	n	Male (%)	Female (%)	Mean age (years)	Households farming (%)	Mean years of residence
Berjo	45	51.1	48.9	49.2	88.9	33.5
Balerante	48	50.0	50.0	47.8	91.7	32.8
Gondosuli	46	54.3	45.7	50.5	89.1	34.1
Sewurejo	45	48.9	51.1	48.6	93.3	31.6
Polokarto	46	52.2	47.8	49.9	87.0	33.2
Total	230	51.3	48.7	49.2	90.0	33.1

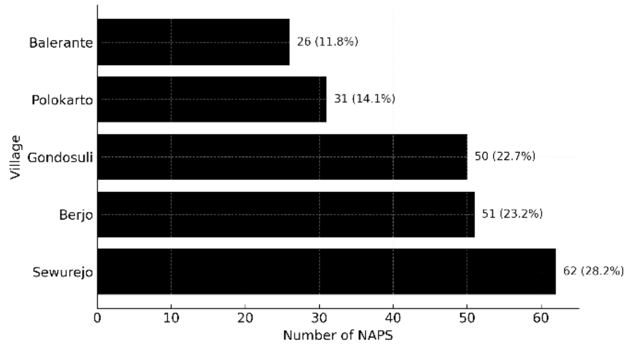


Figure 2. Species richness of naturalized alien plant species (NAPS) (n=143 species)

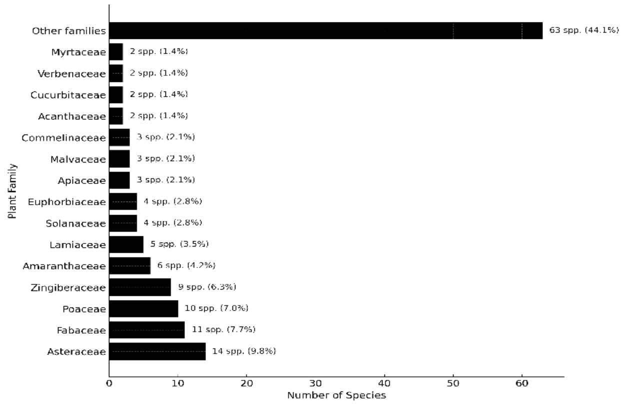


Figure 3. Distribution of naturalized alien plant species (NAPS) by plant family across five study villages in Central Java (n=143)

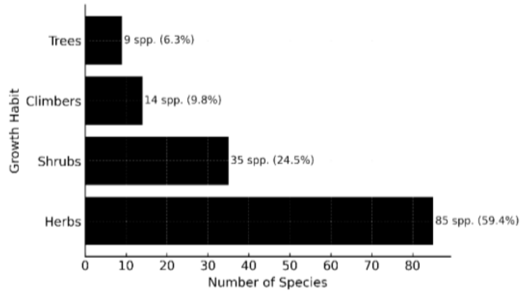


Figure 4. Growth habit of naturalized alien plant species (NAPS) in highland agroecosystems of Central Java (n=143)

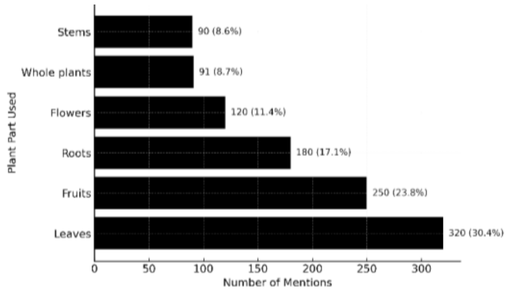


Figure 5. Parts of the plant used and their frequency of mention across all villages (n=931)

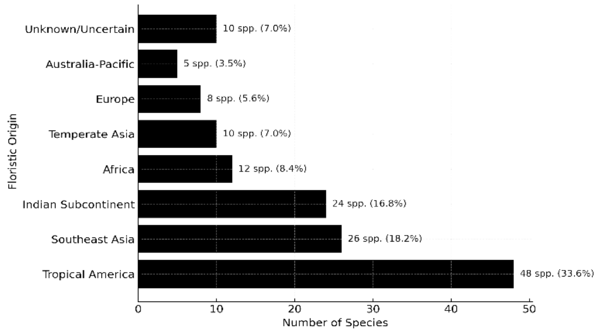


Figure 6. Floristic origin of naturalized alien plant species (NAPS) in highland communities of Central Java, Indonesia (n=143)

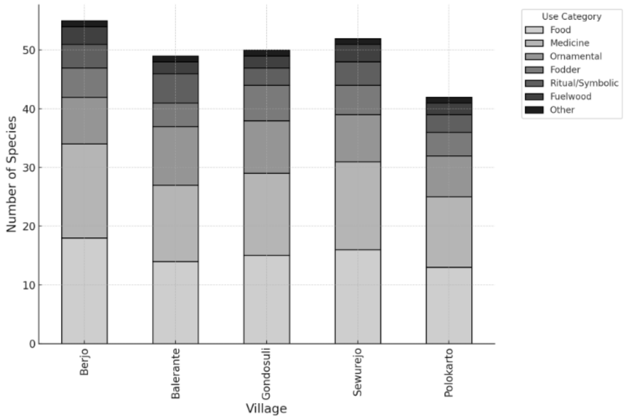


Figure 7. Number of species per use category across villages

Medicinal uses represented 29.9% of total use reports, reflecting the continued reliance on traditional remedies. Species such as *Ageratum conyzoides*, *C. longa*, *Kaempferia galanga*, and *A. muricata* were widely used in decoctions, infusions, or topical applications to treat fever, inflammation, and digestive disorders. Several species, including *Zingiber officinale*, *Amaranthus hybridus*, and *Punica granatum*, were recognized for both nutritional and medicinal properties, highlighting the integrated view of health and diet in rural Javanese culture.

Ornamental purposes accounted for 11.8% of citations, comprising visually appealing species such as *Cuphea hyssopifolia*, *Dracaena fragrans*, *T. erecta*, and *Tradescantia spathacea*, typically cultivated around dwellings or sacred spaces. Fodder uses (6.4%) involved opportunistic harvesting of species like *C. odorata*, *A. conyzoides*, and *Stachytarpheta jamaicensis* from disturbed habitats. Fuelwood applications were less common (3.5%) and generally involved pruning residues of *P. guajava* and *Chimonobambusa quadrangularis*.

Ritual and symbolic uses (4.2%) included symbolic flower offerings (*T. erecta*), protective charms (*Ricinus communis*), and materials for traditional games. A small fraction of species (0.6%) was reported for other applications, such as natural insect repellents, cleaning agents, or dye sources. The multifunctionality of many NAPS is further illustrated in Figure 7, where overlapping roles—particularly between food and medicine—underscore their cultural integration despite their alien origin.

Table 4. Summary of key descriptive metrics on naturalized alien plant species (NAPS): Species richness, family representation, growth forms, used parts, and floristic origins

Visualization description	Variable	Count (species/mentions)	(%)
Species richness per village	Sewurejo	62	43.4
	Berjo	51	35.7
	Gondosuli	50	35.0
	Polokarto	31	21.7
	Balerante	26	18.2
	Total	143	100.0
Species count per most represented families	Asteraceae	14	9.8
	Fabaceae	11	7.7
	Poaceae	10	7.0
	Zingiberaceae	9	6.3
	Amaranthaceae	6	4.2
	Lamiaceae	5	3.5
	Solanaceae	4	2.8
	Euphorbiaceae	4	2.8
	Apiaceae	3	2.1
	Malvaceae	3	2.1
	Commelinaceae	3	2.1
	Acanthaceae	2	1.4
	Cucurbitaceae	2	1.4
	Verbenaceae	2	1.4
	Myrtaceae	2	1.4
	Other families	63	44.1
	Total	143	100.0
Growth habits of NAPS	Herbs	85	59.4
	Shrubs	35	24.5
	Climbers	14	9.8
	Trees	9	6.3
	Total	143	100.0
Parts of plants used	Leaves	320	34.4
	Fruits	250	26.9
	Roots/rhizomes	180	19.4
	Flowers	120	12.9
	Whole plants	91	9.8
	Stems	70	6.4
	Total	931	100.0
Floristic origin of NAPS	Tropical America	48	33.6
	Southeast Asia	26	18.2
	Indian Subcontinent	24	16.8
	Africa	12	8.4
	Temperate Asia	10	7.0
	Europe	8	5.6
	Australia-Pacific	5	3.5
	Total	143	100.0

Further details on the typical plant parts used and preparation methods across each use category are provided in Table 5. For instance, leaves and fruits are predominant in food and medicinal preparations, while stems and branches are more commonly used in fodder and fuelwood contexts. This variation reflects functional specialization and the practical knowledge embedded in everyday resource use.

Cultural significance values (ICS)

To evaluate the cultural relevance of naturalized alien plant species (NAPS) within local communities, the Index of Cultural Significance (ICS) was calculated for each species using three weighted variables: quality, intensity, and exclusivity of use, based on respondent interviews. Of the total 143 species recorded across the five villages, 121 species (84.6%) yielded valid ICS scores, while 22 species lacked sufficient data to support calculation.

The ICS values varied significantly among the villages, reflecting differences in ethnobotanical knowledge and cultural attachment. Berjo and Sewurejo exhibited the highest average ICS scores per species, indicating stronger and more diversified cultural engagement with NAPS. In contrast, Polokarto and Balerante recorded lower ICS averages, suggesting more limited utilization or transmission of knowledge. This village-level variation is visualized in Figure 9, which illustrates the range and central tendencies of ICS values per species across sites. Notably, Berjo recorded eight species with ICS≥100, including *C. caudatus*, *S. edule*, and *C. longa*, whereas Polokarto had none in this highest category.

Figure 8 summarizes the number of species-use assignments across the seven utilization categories, highlighting the multifunctionality of many NAPS. A total of 193 functional assignments were recorded, exceeding the number of unique species with valid ICS scores, as multiple uses were often reported for a single species (e.g., food and medicine). This figure reflects cumulative cultural functions, not discrete species counts, and underscores the versatility and adaptive value of alien plants in local traditions. A complementary view is offered by Figure 8, which illustrates the overall frequency distribution of species across the seven categories, reinforcing the predominance of food and medicinal uses in the cultural landscape—particularly in Berjo and Sewurejo.

Table 5. Number of plant parts used and modes of preparation for each use category across all villages (n=931 use reports)

Use Category	Main Plant Parts Used	Common Modes of Preparation	Frequency of Mentions (%)
Food	Leaves, Fruits, Stems	Raw (salads), Boiled, Cooked in dishes	312 (33.5%)
Medicinal	Leaves, Roots/Rhizomes, Whole plant, Flowers	Decoction, Topical application, Infusion, Poultice	278 (29.9%)
Ornamental	Whole plant, Flowers, Stems	Grown around homes, ceremonial arrangement	110 (11.8%)
Fodder	Leaves, Stems	Fresh cut and fed to livestock	60 (6.4%)
Ritual/Symbolic	Flowers, Whole plant, Fruits	Used in offerings, charms, and spiritual uses	39 (4.2%)
Fuelwood	Stems, Branches	Firewood, a by-product of pruning	33 (3.5%)
Other Uses	Whole plant, Leaves	Natural cleaners, insect repellents, and dyes	6 (0.6%)

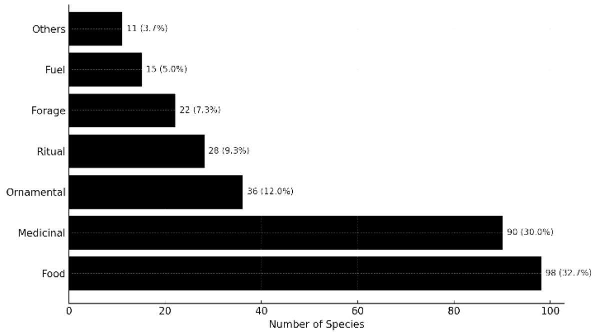


Figure 8. Number of use assignments per utilization category among NAPS (n=193 total use assignments; 121 species with valid ICS scores). Note: The numbers reflect functional assignments rather than unique species; overlaps between categories are expected

Based on ICS scores, species were grouped into five tiers of cultural significance. As shown in Table 6, 37 species (30.6%) were classified as having high to very high cultural importance (ICS≥50), while 41 species (33.9%) had moderate importance (ICS=20-49). The remainder were of low or very low importance, revealing a divide between alien species that are deeply integrated into local practices and those occupying marginal or incidental roles.

Species with the highest ICS values were typically multifunctional, widely available, and embedded in daily and ritual practices. For instance, *C. caudatus* (ICS=126) was cited for its culinary use, postpartum ritual significance, and purported blood-purifying properties. *C. longa* (ICS=115) was a staple in herbal remedies and symbolic rituals, while *P. guajava* (ICS = 98) served both dietary and medicinal purposes. *T. erecta* (ICS=90) combined ornamental, ritual, and insect-repelling functions. These species, consistently reported across sites and demographic groups, exemplify how certain alien taxa have become "local exotics"—non-native yet culturally assimilated elements of traditional ecological knowledge systems. A complete list of high-ranking species, their primary uses, and village distribution is presented in Table 7.

Cross-village comparison of NAPS usage

The comparative analysis of naturalized alien plant species (NAPS) utilization across the five study villages revealed distinct differences in species richness, usage patterns, and cultural value, influenced by both ecological and socio-cultural factors. Sewurejo recorded the highest richness (62 species), followed by Berjo (51) and Gondosuli (50), likely due to their complex agroecosystems and openness to cultivation and experimentation. In contrast, Polokarto (31) and Balerante (26) exhibited lower diversity, possibly due to more restricted land use or limited exposure to plant introductions.

Despite being located within the same regional landscape, the cultural value assigned to specific NAPS varied across villages. Figure 9 presents the Index of Cultural Significance (ICS) values of the top 15 most culturally embedded species, highlighting taxa such as *C. caudatus*, *C. longa*, and *P. guajava*, which consistently rank highly due to their multifunctional uses in food, medicine, and rituals.

Only 17 species (11.9%) were shared across all villages, including multifunctional plants such as *C. caudatus*, *P. guajava*, *C. longa*, and *T. erecta*. Many other species were unique to one or two sites, indicating localized adoption and knowledge transmission. The inter-village comparison of ICS scores is further visualized in Figure 10, which shows the distribution and variation of cultural importance for individual species across villages. Berjo and Sewurejo show higher overall median and upper range values, reflecting their richer ethnobotanical interaction with NAPS.

Table 6. Classification of NAPS based on ICS score and frequency across the five villages (n = 121 species)

ICS score category	Description	Number of species	(%)
Very High (≥100)	Culturally indispensable	11	9.1%
High (80-99)	Widely used and locally important	26	21.5%
Moderate (50-79)	Functional and context-specific	34	28.1%
Low (20-49)	Occasionally used or declining	30	24.8%
Very Low (<20)	Marginal or little known	20	16.5%
Total	—	121	100%

Table 7. Top culturally significant naturalized alien plant species (ICS≥80), their primary uses, and distribution across villages

Scientific Name	Local Name	Primary Use(s)	ICS Score	Village Presence*
Curcuma longa L.	*Kunyit*	Medicine, Ritual	120	All villages
Cosmos caudatus Kunth	*Kenikir*	Food, Medicine	115	GON, SEW, BAL
Psidium guajava L.	*Jambu biji*	Food, Medicine	110	BER, GON, POL
Sechium edule (Jacq.) Sw.	*Labu siam*	Food	105	BER, BAL, SEW
Kaempferia galanga L.	*Kencur*	Medicine, Ritual	102	All villages
Annona muricata L.	*Sirsak*	Food, Medicine	101	GON, POL
Tagetes erecta L.	*Bunga kenikir*	Ritual, Ornamental	100	BAL, POL, BER
Portulaca oleracea L.	*Gulang-gulang*	Food, Medicine	98	GON, SEW
Ricinus communis L.	*Jarak*	Medicine, Ritual	95	BAL, SEW, POL
Tithonia diversifolia (Hemsl.) A.Gray	*Paitan*	Fodder, Soil ameliorant	91	POL, BAL
Piper betle L.	*Sirih*	Ritual, Medicine	90	BER, GON, BAL

Note: *Village codes: BER: Berjo, BAL: Balerante, GON: Gondosuli, SEW: Sewurejo, POL: Polokarto

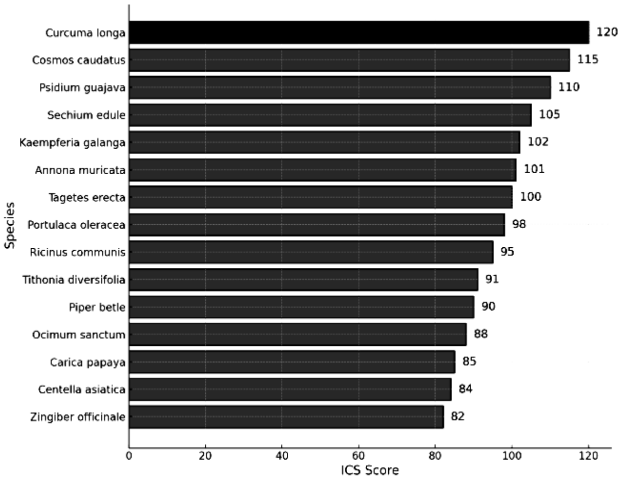


Figure 9. Cultural significance index (ICS) values of the top 15 NAPS

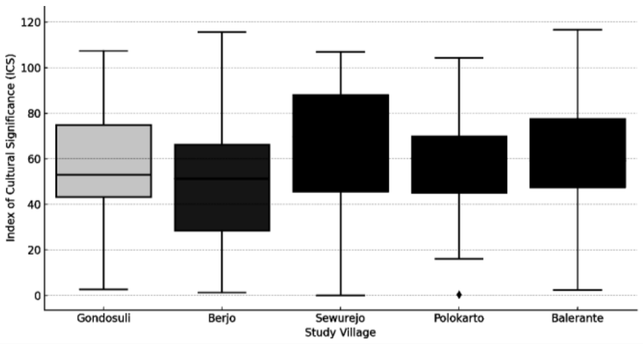


Figure 10. Boxplot of ICS scores per species in each study village

Patterns of use also varied. Berjo emphasized medicinal applications, linked to its reliance on traditional healing. Sewurejo and Gondosuli prioritized food uses, particularly homegarden species like *S. edule* and *P. oleracea*. Polokarto favored ornamental and fodder species, such as *A. conyzoides* and *S. jamaicensis*, while Balerante, near Merapi National Park, reported more ritual uses, including *R. communis* and *D. fragrans*.

Village-specific preferences were evident. *Tagetes erecta* was culturally important in Berjo and Balerante, while *Cnidoscolus aconitifolius* (chaya) was cited mostly in Gondosuli and Sewurejo, reflecting recent agricultural outreach. Interestingly, *C. odorata*, although invasive, was harvested in Polokarto as livestock fodder. A summary of the most dominant species per village, based on ICS score and primary use, is provided in Table 8, illustrating how different villages culturally prioritize different species depending on ecological opportunities, proximity to forests, or institutional interventions.

These variations highlight the nuanced integration of alien plants into local ecosystems, which is influenced by environmental, cultural, and institutional factors. Recognizing such patterns is crucial for developing context-sensitive management and community-based conservation strategies that align ecological impacts with social benefits.

Visual representation of NAPS data

The comparative analysis of naturalized alien plant species (NAPS) across the five study villages revealed marked differences in species richness, usage focus, and cultural valuation. Sewurejo recorded the highest richness (62 species), followed by Berjo (51) and Gondosuli (50), likely reflecting more diverse agroecosystems and greater openness to incorporating new plants. In contrast, Polokarto (31) and Balerante (26) had fewer species, possibly due to more limited land use, proximity to conservation zones, or reduced exposure to agricultural innovation. These differences are summarized visually in Figure 11, which presents a stacked bar chart comparing the number of NAPS per use category across villages. The chart highlights how food and medicinal plants dominate in Sewurejo and Gondosuli, while ornamental and ritual species are more emphasized in Polokarto and Balerante.

Despite shared regional ecology, inter-village species overlap was low. Only 17 species (11.9%) were found in all villages, including culturally embedded plants such as *C. caudatus*, *P. guajava*, *C. longa*, and *T. erecta*. Many species were confined to one or two sites, reflecting localized diffusion and selective adoption shaped by cultural preferences and environmental familiarity. The extent of overlap and uniqueness is depicted in Figure 12, a Venn diagram comparing culturally important NAPS among Berjo, Balerante, and Gondosuli. The diagram reveals that while certain culturally significant species are shared, each village retains a distinct ethnobotanical identity.

Utilization patterns also varied. Berjo emphasized medicinal uses (over 40%), likely due to reliance on traditional health practices. Sewurejo and Gondosuli prioritized food plants such as *S. edule* and *P. oleracea*, reflecting strong homegarden traditions. Polokarto favored ornamental and fodder species such as *A. conyzoides* and *S. jamaicensis*. At the same time, Balerante, adjacent to Mount Merapi National Park, showed higher frequencies of ritual and symbolic uses, including *R. communis* and *D. fragrans*.

Table 8. Village-specific dominant NAPS based on the highest ICS score and primary use

Village	Dominant species (Scientific name)	Local name	Primary use(s)	ICS Score
Berjo	*Curcuma longa* L.	*Kunyit*	Medicine, Ritual	120
Balerante	*Tagetes erecta* L.	*Bunga kenikir*	Ritual, Ornamental	100
Gondosuli	*Cosmos caudatus* Kunth	*Kenikir*	Food, Medicine	115
Sewurejo	*Sechium edule* (Jacq.) Sw.	*Labu siam*	Food	105
Polokarto	*Ricinus communis* L.	*Jarak*	Medicine, Ritual	95

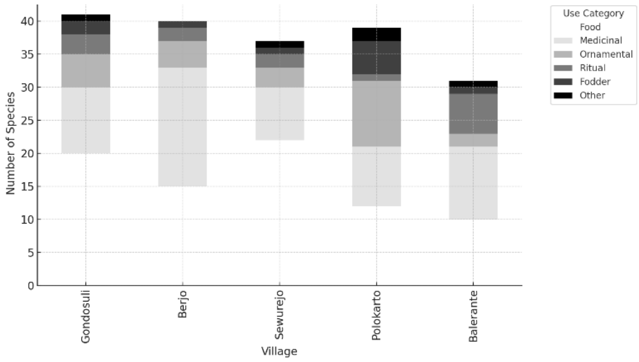


Figure 11. Cross-village overlap of NAPS (stacked bar)

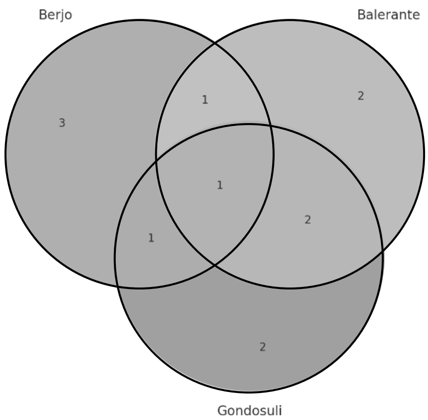


Figure 12. Venn diagram of culturally important NAPS in three villages, among Berjo, Balerante, and Gondosuli

Village-specific preferences emerged clearly. *Tagetes erecta* was especially valued in Berjo and Balerante for ornamental and ceremonial purposes. *Cnidoscolus aconitifolius*, introduced through agricultural extension, was reported mainly in Gondosuli and Sewurejo, indicating successful localized adoption. Interestingly, *C. odorata*, despite its invasive status, was harvested in Polokarto for livestock fodder, illustrating practical local adaptation.

The cultural valuation of key NAPS also varied significantly across villages. Figure 13 presents a heatmap of ICS (Index of Cultural Significance) scores for dominant species across all five sites. This visual illustrates the differing degrees to which the same species are culturally valued in different communities, confirming that the same alien plant may be deeply embedded in one context and marginal in another.

These findings underscore the complex, place-based integration of alien species shaped by environmental conditions, cultural norms, and external influences, emphasizing the need for context-specific management and community-based plant governance.

Multifunctionality and use patterns

Naturalized alien plant species (NAPS) recorded in the study villages exhibit varying degrees of multifunctionality, with several species playing dual or even multiple roles across distinct use categories. While some plants are strictly associated with a single function (e.g., food or medicinal), others bridge across domains such as ritual, ornamentation, and health.

Among the top culturally significant species, *C. longa* is primarily used for medicinal purposes but also features in ritual offerings and culinary preparations. *P. guajava* is widely consumed for its fruit (food use), while its leaves are employed in traditional remedies for gastrointestinal disorders. *Tagetes erecta*, known for its ornamental value, also holds ritual significance in several villages. Similarly, *C. caudatus* serves both dietary and medicinal roles, especially in daily household practices.

Ricinus communis and *P. oleracea* further exemplify this multifunctionality. *Ricinus communis* is valued for its medicinal oil and ritual symbolism, whereas *P. oleracea* is appreciated both as a foraged leafy vegetable and for its therapeutic properties. The widespread occurrence of multifunctional uses highlights how NAPS have been culturally integrated and adapted to meet multiple household needs. These relationships are illustrated in Figure 14, which shows a visual typology of selected multifunctional NAPS, linking each species to both its primary and secondary use categories. The distribution suggests that cultural acceptance and functional diversity are key drivers behind the persistence and proliferation of NAPS in local agroecosystems.

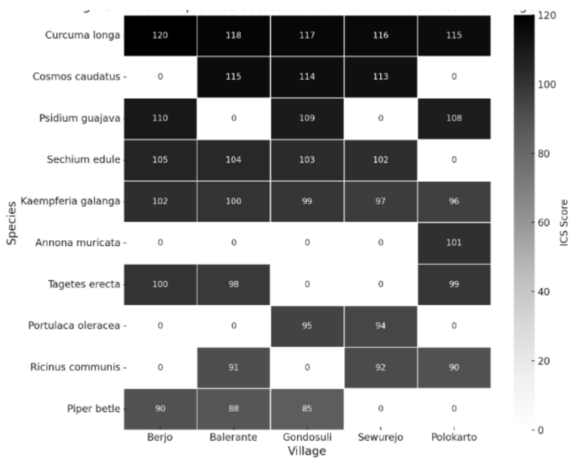


Figure 13. Heatmap showing village-wise ICS scores for dominant species

Figure 14. Visual typology of multifunctional NAPS by primary and secondary uses

Discussion

The ethnobotanical value of naturalized alien plants

Naturalized alien plant species (NAPS) are frequently portrayed within ecological narratives as drivers of biodiversity loss and environmental disturbance (van Kleunen et al. 2018; Pyšek et al. 2020). Yet, this study highlights the diverse and meaningful roles NAPS now play in the daily lives of highland communities in Central Java. Far from being purely invasive, many NAPS have become culturally embedded, fulfilling essential functions in subsistence, healthcare, and ritual life. This integration is reflected in high Index of Cultural Significance (ICS) values, demonstrating their functional and symbolic relevance.

Species such as *C. caudatus*, *C. longa*, and *P. guajava* exemplify how alien plants can become staple vegetables, medicinal ingredients, and ritual symbols. Their incorporation results from intentional selection, local experimentation, and the intergenerational transmission of knowledge—what Howard (2003), Pardo-de-Santayana et al. (2007), and Sõukand et al. (2024) describe as cultural filtering.

Multifunctionality is a key attribute driving their retention. Several NAPS are valued for their combined nutritional, medicinal, ornamental, and symbolic roles, reinforcing their cultural salience (Albuquerque et al. 2006). In Java, where food traditions, *jamu* (herbal medicine), and ritual practices are deeply intertwined, such plants are more likely to persist despite their non-native origins.

Nonetheless, cultural integration does not equate to ecological safety. *Chromolaena odorata* and *R. communis*, though recognized as invasive (Setyawati et al. 2015), are utilized locally for fodder, protection, or ritual functions. Their dual identity illustrates the limits of blanket classifications and supports more nuanced perspectives (Shackleton et al. 2007; Kueffer and Hirsch Hadorn 2008). These findings call for culturally grounded management approaches. Understanding NAPS as embedded within local livelihoods and knowledge systems is critical for ensuring that invasive species strategies remain context-sensitive and socially just (Shrestha and Shrestha 2019).

Socio-cultural drivers of NAPS utilization

The adoption and continued use of naturalized alien plant species (NAPS) in the five highland villages studied are shaped by more than just ecological availability. A complex set of socio-cultural drivers—including historical interactions, food practices, gendered knowledge systems, and livelihood strategies—influence how these species are integrated, adapted, or excluded from daily life.

Customary food systems are among the most prominent drivers. NAPS like *S. edule* and *A. hybridus* are closely tied to seasonal diets and household food security. The cultural preference for *sayuran lalapan* (wild or semi-cultivated vegetables) provides a niche for adaptable alien species. This pattern reflects broader trends where food heritage and agrobiodiversity are closely interlinked (Reyes-García et al. 2006; Zimmerer et al. 2019; Britwum and Demont 2022).

Traditional health systems also play a vital role. Plants such as *C. longa*, *K. galanga*, and *A. muricata* are commonly used in *jamu* (herbal medicine) to treat ailments and promote wellness. Their use is often maintained through oral transmission, particularly by older women, who serve as key knowledge holders (Sosef et al. 2017; Mji 2019). Similar gendered and age-based patterns have been observed elsewhere in Indonesia (Peltzer and Pengpid 2018).

In some villages, NAPS are also maintained for ritual or symbolic roles. *Tagetes erecta* is used in offerings, while *R. communis* serves protective purposes. These functions persist even when native alternatives are available, suggesting that symbolic importance can shield certain alien plants from displacement. The concept of "cultural keystone species" (Garibaldi and Turner 2004) is applicable in these contexts.

Institutional interventions have also shaped NAPS adoption. Programs such as school gardens and seed distribution have introduced species like *C. aconitifolius*, now integrated into Gondosuli and Sewurejo. The success of such introduction hinges on community acceptance, not just agronomic suitability. NAPS utilization reflects ongoing cultural negotiation, shaped by belief systems, gender roles, and policy. For management strategies to be effective, they must consider these cultural dynamics to avoid undermining local resilience in food and health systems.

Functional versatility and local adaptation

The cultural embeddedness of many naturalized alien plant species (NAPS) in Central Java is closely linked to their functional versatility—their ability to serve multiple roles across household, agro-ecological, and ritual contexts. This multifunctionality increases their perceived value and supports their persistence amid shifting environmental and socio-economic conditions. Plants that meet various needs are more likely to be retained, cultivated, and passed on through generations, a trend echoed in other ethnobotanical studies (Albuquerque et al. 2006; Galluzzi et al. 2010).

Several NAPS documented in this study reflect such multifunctionality. *Cosmos caudatus*, for example, serves as a vegetable, postpartum tonic, and digestive aid. *Curcuma longa* is used as a spice, herbal remedy, and ritual ingredient. Their ability to span culinary, medicinal, and symbolic domains elevates them from functional plants to cultural assets (Nabhan 2009; Peredo Parada and Barrera Salas 2023).

Ecological adaptability further supports NAPS retention. Many are fast-growing, herbaceous species capable of thriving in marginal soils, fallow plots, and disturbed areas like roadsides or homegarden fringes. This plasticity is particularly valuable in resource-limited settings where native species may be seasonal or labor-intensive to grow. The prevalence of pioneer species such as *P. oleracea* and *S. jamaicensis* reflects this opportunistic use of accessible greenery.

Adaptation often involves cultural reinterpretation. Over time, introduced species may acquire Javanese or hybrid vernacular names, signifying symbolic and linguistic assimilation. Some are no longer perceived as foreign but have become "local exotics" through deep cultural integration—an observation also reported in other tropical regions (Shackleton et al. 2007; de Medeiros et al. 2021).

Importantly, multifunctional NAPS also support household resilience. During periods of food scarcity or illness, such plants offer affordable, accessible buffers. Their role in coping with stress and uncertainty mirrors patterns found in broader agrobiodiversity and climate adaptation literature (Zimmerer et al. 2019). The persistence of NAPS reflects both ecological suitability and cultural functionality. Management efforts must therefore consider their embedded role in local livelihoods and resilience systems—not just their ecological footprint.

Knowledge distribution and demographic correlates

The utilization of naturalized alien plant species (NAPS) across the five highland villages is unevenly distributed, reflecting demographic variation in ecological knowledge shaped by factors such as age, gender, education, land access, and livelihood roles. These variables influence not only who knows which plants, but also how knowledge is accessed, interpreted, and transmitted.

Age emerged as a key correlate of familiarity with NAPS. Respondents above 40 years consistently reported greater awareness of alien species and their uses. This generational gradient aligns with findings from other ethnobotanical contexts in Southeast Asia and Latin America, where traditional ecological knowledge (TEK) tends to accumulate with age and is rarely formalized (Paniagua-Zambrana et al. 2014; Sumarwati et al. 2022). As younger generations shift away from subsistence farming and ritual practices, their reliance on—and exposure to—non-commercial plants declines, raising concerns about knowledge discontinuity.

Gender also shaped knowledge domains. Women, who oversee food preparation and family healthcare, were more familiar with leafy vegetables, culinary herbs, and *jamu* species. Men more often cited NAPS related to fodder, fuelwood, and live fences. These patterns reflect gendered divisions of labor in rural Java and suggest complementary, rather than exclusive, knowledge systems (Howard 2003; Pfeiffer and Butz 2005; Kreager and Schröder-Butterfill 2014).

Education exerted a more complex influence. While formal schooling often correlates with reduced TEK (Reyes-García et al. 2006), this study found that respondents with basic education—especially those completing primary or junior high school—were often more articulate about both traditional and contemporary plant uses. Those without schooling demonstrated experiential depth but less analytical expression, while highly educated individuals tended to be disconnected from homegarden-based practices.

Land access and farming participation further influenced NAPS knowledge. Households maintaining active homegardens exhibited higher familiarity with multifunctional species, especially for food and medicine. In contrast, those with limited land or employed off-farm were less engaged in plant-based practices and more reliant on markets or packaged goods.

These patterns show that TEK is both stratified and dynamic, embedded in broader socio-economic realities. As rural transitions continue, valuable knowledge about alien plant uses and their risks may erode. Management strategies must therefore support knowledge revitalization through intergenerational learning, participatory documentation, and culturally responsive agroecological education. Recognizing the demographic structure of knowledge is essential for socially inclusive and ecologically sound conservation policy.

Cross-village differences and biocultural filtering

Although the five study villages are geographically located within the same region of Central Java, the results reveal marked inter-village differences in species richness, use intensity, and the cultural salience of naturalized alien plant species (NAPS). These variations are not incidental; they are shaped by a process of biocultural filtering—whereby communities selectively adopt, adapt, or exclude species based on ecological suitability, cultural values, and collective experience (Pardo-de-Santayana et al. 2007; Reyes-García et al. 2009).

Sewurejo and Berjo, for example, exhibited the highest NAPS diversity and ICS values. Both villages possess more extensive agroforestry systems and stable land tenure, which support a variety of microhabitats and encourage experimentation with multifunctional species. Their broader range of NAPS usage—encompassing food, medicine, ornamentals, and rituals—suggests that ecological opportunity and cultural openness intersect to foster greater ethnobotanical diversity. In contrast, Polokarto and Balerante reported lower NAPS richness and narrower use types, with a stronger emphasis on ornamental or symbolic roles. This pattern may reflect ecological constraints (e.g., smaller garden plots, drier soils) as well as selective cultural retention practices.

The appearance of village-specific species—those cited only in one or two locations—further underscores localized ethnobotanical trajectories. These species are not necessarily ecologically excluded elsewhere but may have failed to gain cultural relevance, were previously associated with negative experiences, or were replaced by more familiar alternatives. For instance, *C. aconitifolius* appeared only in Gondosuli and Sewurejo, despite identical institutional introductions, highlighting the role of cultural acceptance alongside agronomic feasibility.

Only 17 of 143 recorded NAPS were found in all five villages, emphasizing that even within closely related communities, plant use is highly heterogeneous. This supports observations by Shackleton et al. (2007), who note that alien species may be celebrated in one context and reviled in another, depending on how communities have historically engaged with them.

Biocultural filtering thus operates as an informal governance mechanism, selectively reinforcing species that align with local needs, values, and management capacity. This underscores the need for conservation and invasive species strategies to recognize—not override—place-based ecological knowledge and cultural preferences. The distinct patterns of NAPS use across villages reflect the dynamic interaction of ecological diversity and culturally embedded decision-making processes.

Risks and opportunities of NAPS integration

While the cultural integration of naturalized alien plant species (NAPS) provides tangible benefits to rural communities—such as food security, accessible healthcare, and symbolic continuity—it simultaneously raises important concerns regarding ecological risk, dependence, and long-term sustainability. The core challenge lies in reconciling the dual nature of NAPS as both culturally valued resources and potential ecological disruptors.

Many NAPS recorded in this study, such as *C. longa*, *P. guajava*, and *S. edule*, illustrate cases of positive coexistence. These species are often grown in controlled settings like homegardens, exhibit non-invasive tendencies, and help compensate for the declining availability of native species. Their integration into local agroecosystems enhances food diversity and supports low-cost healthcare, particularly in remote or economically marginal areas. In such cases, NAPS contribute constructively to ecological function and local resilience. Conversely, other NAPS—especially those occupying disturbed or unmanaged habitats—present clear ecological risks. *C. odorata*, though occasionally used as livestock fodder, is a globally notorious invasive capable of suppressing native flora, altering fire regimes, and degrading habitats (Setyawati et al. 2015). *R. communis*, widely grown for ornamental or protective functions, may spread rapidly and produce toxic compounds hazardous to livestock and human health.

These contrasting outcomes highlight the importance of context in assessing NAPS. A species seen as invasive in one location may be perceived as beneficial elsewhere, depending on how it is managed, its ecological behavior, and cultural framing. This reinforces arguments by Kueffer and Hirsch Hadorn (2008) and Shackleton et al. (2019) for localized, participatory assessment models rather than generalized ecological judgments. At the same time, current NAPS practices offer pathways toward culturally attuned conservation. Non-invasive, multifunctional alien species could be integrated more systematically into homegarden programs, school-based agroecology, or local food security initiatives. This approach would recognize their ethnobotanical value while embedding sustainability principles in rural development planning.

However, such integration must be accompanied by critical reflection. There is a risk that overreliance on alien species—particularly through top-down promotion or market incentives—may erode attention to native biodiversity and traditional crop systems. If younger generations grow up prioritizing introduced species, cultural homogenization and biotic substitution may occur over time. Hence, managing NAPS effectively requires adaptive, culturally grounded strategies, including intergenerational learning, participatory risk mapping, and community-informed governance.

Implications for invasive species management and conservation

The findings of this study emphasize the need for more nuanced strategies in managing naturalized alien plant species (NAPS). Conventional approaches typically focus on eradication or containment, guided by ecological risk assessments and global databases (van Kleunen et al. 2018; Pyšek et al. 2020). However, these strategies may be socially and ethically problematic when applied to species that are deeply embedded in local food systems, traditional healing practices, or cultural traditions. A rigid application of such models can marginalize rural knowledge systems and disrupt long-established relationships between people and plants.

One important implication is the need for context-specific classification. Not all alien species are invasive or harmful in every setting; some have been intentionally introduced and selectively retained for their utility or cultural significance. Species like *C. longa* and *C. caudatus* have become essential to daily life without showing invasive tendencies. Therefore, ecological assessments should be complemented by evaluations of cultural significance and local benefits (Shackleton et al. 2019).

The study also highlights the value of local knowledge and participatory approaches in managing alien species. Communities in Central Java have already adopted informal mechanisms to distinguish between useful and problematic species. Recognizing and incorporating these practices into policy—through participatory mapping, community-based monitoring, or co-management—can improve sustainability and local legitimacy (Kueffer and Hirsch Hadorn 2008; Shrestha and Shrestha 2019).

Additionally, alien plants should not be dismissed outright but viewed within a resilience-based framework. In marginal or degraded areas, some alien species offer important ecosystem services, from soil stabilization to supplementary food or medicine. With proper management, such species can complement native biodiversity rather than threaten it. Their integration into conservation-compatible land use plans may support both ecological and social goals.

Ultimately, a coordinated policy across the agriculture, conservation, and cultural heritage sectors is essential. Disjointed agendas, such as promoting a species through agricultural extension while targeting it for removal under conservation law, lead to inefficiencies and local resistance. A transdisciplinary and culturally sensitive approach will ensure that alien species management aligns with rural realities and supports sustainable resource governance.

In conclusion, this study shows that naturalized alien plant species (NAPS) are deeply integrated into the cultural, medicinal, and nutritional life of highland communities in Central Java. Species like *C. caudatus*, *C. longa*, and *P. guajava* scored high in cultural significance, reflecting biocultural naturalization. Village-specific use patterns reflect ecological and socio-cultural filtering. The findings call for more nuanced invasive species management, recognizing that some NAPS provide vital benefits. Sustainable use of low-risk alien plants, informed by both science and tradition, can support biodiversity conservation while enhancing cultural resilience and rural livelihoods.

REFERENCES

Abywijaya IK, Hikmat A, Widyatmoko D. 2014. Keanekaragaman dan pola sebaran spesies tumbuhan asing invasif di Cagar Alam Pulau Sempu, Jawa Timur. Jurnal Biologi Indonesia 10 (2): 221-235. [Indonesian]

Albuquerque UP, Lucena RFP, Monteiro JM, Florentino ATN, Almeida CFCBR. 2006. Evaluating two quantitative ethnobotanical techniques. Ethnobot Res Appl 4: 51-60.
BMKG. 2023. Climate Outlook 2023. Badan Meteorologi Klimatologi dan Geofisika, Jakarta. [Indonesian]
BPS. 2022. Luas Penggunaan Lahan dan Luas Kawasan Hutan Menurut Kabupaten/Kota di Provinsi Jawa Tengah (Km2), 2021. Badan Pusat Statistik, Semarang. [Indonesian]
Britwum K, Demont M. 2022. Food security and the cultural heritage missing link. Glob Food Secur 35: 100660. DOI: 10.1016/j.gfs.2022.100660.
Carneiro L, Hulme PE, Cuthbert RN, Kourantidou M, Bang A, Haubrock PJ, Bradshaw CJA, Balzani P, Bacher S, Latombe G, Bodey TW, Probert AF, Quilodrán CS, Courchamp F. 2024. Benefits do not balance costs of biological invasions. BioScience 74 (5): 340-344. DOI: 10.1093/biosci/biae010.
Cuthbert RN, Diagne C, Hudgins EJ et al. 2022. Biological invasion costs reveal insufficient proactive management worldwide. Sci Total Environ 819: 153404. DOI: 10.1016/j.scitotenv.2022.153404.
Darmastuti SA, Nazar IA, Setyawan AD. 2024. Plant diversity and its use in Javanese urban home garden: An ethnobotanical study in Central Java, Indonesia. Asian J Ethnobiol 7 (1): 32-42. DOI: 10.13057/asianjethnobiol/y070104.
de Medeiros PM, Dos Santos GMC, Barbosa DM, Gomes LCA, Santos ÉMDC, da Silva RRV. 2021. Local knowledge as a tool for prospecting wild food plants: experiences in northeastern Brazil. Sci Rep 11 (1): 594. DOI: 10.1038/s41598-020-79835-5.
Galluzzi G, Eyzaguirre P, Negri V. 2010. Home gardens: neglected hotspots of agro-biodiversity and cultural diversity. Biodivers Conserv 19: 3635-3654. DOI: 10.1007/s10531-010-9919-5.
Garibaldi A, Turner N. 2004. Cultural keystone species: implications for ecological conservation and restoration. Ecol Soc 9 (3): 1. DOI: 10.5751/ES-00669-090301.
González JA, García-Barriuso M, Amich F. 2006. Ethnobotanical study of medicinal plants traditionally used in the Arribes del Duero, western Spain. J Ethnopharmacol 107 (3): 324-341. DOI: 10.1016/j.jep.2006.03.032.
Handayani A, Zuhud EAM, Junaedi DI. 2021. Assessing the utilization of naturalized alien plant species by community to inform its management strategy: A case study in Cibodas Biosphere Reserve, West Java, Indonesia. Biodiversitas 22 (7): 2579-2588. DOI: 10.13057/biodiv/d220705.
Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. 2009. Medicinal plants in Mexico: healers' consensus and cultural importance. Soc Sci Med 47 (11): 1859-1871. DOI: 10.1016/S0277-9536(98)00281-6.
Howard PL. 2003. Women and plants: gender relations in biodiversity management and conservation. Zed Books, London.
Kreager P, Schröder-Butterfill E. 2014. Ageing and Gender Preferences in Rural Indonesia. In: Devasahayam TW (eds.). Gender and Ageing: Southeast Asian Perspectives. ISEAS Publishing, Singapore.
Kueffer C, Hirsch Hadorn G. 2008. How to achieve effectiveness in problem-oriented landscape research: the example of research on biotic invasions. Living Rev Landsc Res 2 (2): 1-21. DOI: 10.12942/lrlr-2008-2.
Kusumawati IA, Mardiani MO, Purnamasari E, Batoro J, van Noordwijk M, Hairiah K. 2022. Agrobiodiversity and plant use categories in coffee-based agroforestry in East Java, Indonesia. Biodiversitas 23 (10): 5412-5422. DOI: 10.13057/biodiv/d231052
Maruapey A, Ohorella S, Karepesina S. 2022. Nilai kepentingan budaya keanekaragamaan jenis sayuran indegenous dalam kehidupan masyarakat di Kampung Sire Distrik Mare Timur Kabupaten Maybrat Papua Barat. Jurnal Agrohut 13 (1): 11-24. DOI: 10.51135/agh.v13i1.119. [Indonesian]
Mji G. 2019. Women as healers and indigenous knowledge systems and its holders: An intertwined epistemological and ontological struggle for recognition. In: Mji G (eds.). The Walk Without Limbs: Searching for Indigenous Health Knowledge in a Rural Context in South Africa. AOSIS, Cape Town. DOI: 10.4102/aosis.2019.BK98.03.
Mokany K, Ware C, Woolley SN, Ferrier S, Fitzpatrick MC. 2022. A working guide to harnessing generalized dissimilarity modelling for biodiversity analysis and conservation assessment. Glob Ecol Biogeogr 31 (4): 802-821. DOI: 10.1111/geb.13459.
Nabhan GP. 2009. Where our food comes from: retracing Nikolay Vavilov's quest to end famine. Island Press, Washington DC.
Nahdi MS, Kurniawan AP. 2019. The diversity and ethnobotanical study of medicinal plants in the southern slope of Mount Merapi, Yogyakarta, Indonesia. Biodiversitas 20 (8): 2279-2287. DOI: 10.13057/biodiv/d200824
Nurcahyo FD, Zen HM, Rahma HS, Triyanto A, Yasa A, MD Naim D, Setyawan AD. 2024. Ethnobotanical study of medicinal plants used by local communities in the Upper Bengawan Solo River, Central Java, Indonesia. Intl J Bonorowo Wetlands 14 (1): 25-36. DOI: 10.13057/bonorowo/w140104.
Paniagua-Zambrana NY, Cámara-Leret R, Bussmann RW, Macía MJ. 2014. The influence of socioeconomic factors on traditional knowledge: A cross scale comparison of palm use in northwestern South America. Ecol Soc 19 (4): 9. DOI: 10.5751/ES-06934-190409.
Pardo-de-Santayana M, Tardío J, Blanco E, Carvalho AM, Lastra JJ, San Miguel E, Morales R. 2007. Traditional knowledge of wild edible plants used in the northwest of the Iberian Peninsula (Spain and Portugal): a comparative study. J Ethnobiol Ethnomed 3: 27. DOI: 10.1186/1746-4269-3-27.
Peltzer K, Pengpid S. 2019. Traditional health practitioners in Indonesia: Their profile, practice and treatment characteristics. Complement Med Res 26 (2): 93-100. DOI: 10.1159/000494457.
Peredo Parada S, Barrera Salas C. 2023. Multifunctional plants: ecosystem services and undervalued knowledge of biocultural diversity in rural communities—local initiatives for agroecological transition in chile. Land 13 (1): 39. DOI: 10.3390/land13010039.
Pfeiffer JM, Butz RJ. 2005. Assessing cultural and ecological variation in ethnobiological research: the importance of gender. J Ethnobiol 25 (2): 240-278. DOI: 10.2993/0278-0771(2005)25[240:ACAEVI]2.0.CO;2.
Pyšek P, Hulme PE, Simberloff D, Bacher S, Blackburn TM, Carlton JT, Dawson W, Essl F, Foxcroft LC, Genovesi P, Jeschke JM. 2020. Scientists' warning on invasive alien species. Biol Rev 95 (6): 1511-1534. DOI: 10.1111/brv.12627.
Rai PK, Singh JS. 2020. Invasive alien plant species: Their impact on environment, ecosystem services and human health. Ecol Indic 111: 106020. DOI: 10.1016/j.ecolind.2019.106020.
Reyes-García V, Broesch J, Calvet-Mir L, Fuentes-Peláez N, McDade TW, Parsa S, Tanner S, Huanca T, Leonard WR, Martínez-Rodríguez MR, TAPS Bolivian Study Team. 2009. Cultural transmission of ethnobotanical knowledge and skills: An empirical analysis from an Amerindian society. Evol Human Behav 28 (5): 274-285.
Reyes-García V, Vadez V, Byron E, Apaza L, Leonard WR, Perez E, Wilkie D. 2006. Market economy and the loss of folk knowledge of plant uses: estimates from the Tsimane of the Bolivian Amazon. Curr Anthropol 46 (4): 651-656. DOI: 10.1086/432777.
Richardson DM, Pyšek P, Rejmánek M, Barbour MG, Panetta FD, West CJ. 2000. Naturalization and invasion of alien plants: concepts and definitions. Divers Distrib 6 (2): 93-107. DOI: 10.1046/j.1472-4642.2000.00083.x.
Sayfulloh A, Riniarti M, Santoso T. 2020. Invasive alien species plants in Sukaraja Atas Resort, Bukit Barisan Selatan National Park. Jurnal Sylva Lestari 8 (1): 109-120. DOI: 10.23960/jsl18109-120.
Seebens H, Blackburn TM, Dyer EE, Genovesi P, Hulme PE, Jeschke JM, Essl F. 2018. Global rise in emerging alien species results from increased accessibility of new source pools. Proc Natl Acad Sci USA 115 (10): E2264-E2273. DOI: 10.1073/pnas.1719429115.
Setyawati T, Narulita S, Bahri IP, Raharjo GT. 2015. A guide book to invasive alien plant species in Indonesia. Ministry of Environment and Forestry, Jakarta. [Indonesian]
Shackleton CM, McGarry D, Fourie S, Gambiza J, Shackleton SE, Fabricius C. 2007. Assessing the effects of invasive alien species on rural livelihoods: Case examples and a framework from South Africa. Hum Ecol 35: 113-127. DOI: 10.1007/s10745-006-9095-0.
Shackleton RT, Shackleton CM, Kull CA. 2019. The role of invasive alien species in shaping local livelihoods and human well-being: A review. J Environ Manag 229: 145-157. DOI: 10.1016/j.jenvman.2018.05.007.
Shrestha UB, Shrestha BB. 2019. Climate change amplifies plant invasion hotspots in Nepal. Divers Distrib 25 (10): 1599-1612. DOI: 10.1111/ddi.12963.
Sosef MS, Dauby G, Blach-Overgaard A, van Der Burgt X, Catarino L, Damen T, Deblauwe V, Dessein S, Dransfield J, Droissart V, Duarte MC. 2017. Exploring the floristic diversity of tropical Africa. BMC Biol 15: 15. DOI: 10.1186/s12915-017-0356-8.
Sõukand R, Kalle R, Prakofjewa J, Sartori M, Pieroni A. 2024. The importance of the continuity of practice: Ethnobotany of Kihnu island (Estonia) from 1937 to 2021. Plants People Planet 6 (1): 186-196. DOI: 10.1002/ppp3.10423.
Sumarwati S. 2022. Traditional ecological knowledge on the slope of Mount Lawu, Indonesia: All about non-rice food security. J Ethn Foods 9 (1): 9. DOI: 10.1186/s42779-022-00120-z.
Supiandi MI, Mahanal S, Zubaidah S, Julung H, Ege B. 2019. Ethnobotany of traditional medicinal plants used by Dayak Desa Community in Sintang, West Kalimantan, Indonesia. Biodiversitas 20 (5): 1264-1270. DOI: 10.13057/biodiv/d200516
Tjitrosoedirdjo SS. 2005. Inventory of the invasive alien plant species in Indonesia. Biotropia 25: 60-73.
Turner NJ. 1988. The importance of a rose: Evaluating the cultural significance of plants in Thompson and Lillooet Interior Salish. Am Anthropol 90 (2): 272-290.
van Kleunen M, Essl F, Pergl J et al. 2018. The changing role of ornamental horticulture in alien plant invasions. Biol Rev 93 (3): 1421-1437. DOI: 10.1111/brv.12402.
Zimmerer KS, de Haan S, Jones AD, Creed-Kanashiro H, Tello M, Carrasco M, Meza K, Amaya FP, Cruz-Garcia GS, Tubbeh R, Olivencia YJ. 2019. The biodiversity of food and agriculture (Agrobiodiversity) in the anthropocene: Research advances and conceptual framework. Anthropocene 25: 100192. DOI: 10.1016/j.ancene.2019.100192.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025
Pages: 40-48

E-ISSN: 2580-4510
DOI: 10.13057/asianjethnobiol/y080104

Ethnoveterinary medicine on preserving traditional knowledge for animal health in the Chumoukedima District of Nagaland in India

TONGTIKALA KICHU, TEMSURENLA JAMIR♥, IMLINUNGLA
Department of Botany, St. Joseph University. Chumoukedima 797115, Nagaland, India. Tel.: +91-87877-58112, ♥email: arentem123@gmail.com

Manuscript received: 31 January 2025. Revision accepted: 23 April 2025.

Abstract. *Kichu T, Jamir T, Imlinungla. 2025. Ethnoveterinary medicine on preserving traditional knowledge for animal health in the Chumoukedima District of Nagaland in India. Asian J Ethnobiol 8: 40-48.* Animals have always been integral to human life, serving various purposes from companions to agriculture and livelihood. Indigenous knowledge and traditional plant-based healing practices remain vital for maintaining animal health offering natural and old-age remedies passed down through generations. The present study aims to document ethnoveterinary medicinal plants and practices in the Chumoukedima District of Nagaland, India using semi-structured interviews. A total of 50 plants belonging to 48 genera and 35 families were recorded, with Asteraceae being the most frequently reported family (5 species, 10%). Leaves (50%) were the most utilized plant part, favored for their abundance, ease of collection and sustainability. Herbs with 42% were the most favored growth form, while paste with 30.36% was the preferred preparation method. Medicinal remedies were used to treat a variety of animals, with pigs (39.7%) being the most frequently treated. Among the health issues addressed, injuries (21.7%) were the most commonly reported, followed by skin problems and dysentery (17.4%). The primary route of medicine administration was internal, with remedies either given in raw form or combined with other plants and fodder. This study will safeguard indigenous knowledge and could contribute to the development of effective plant-based remedies to address various livestock diseases and health issues.

Keywords: Asteraceae, diseases and health issues, indigenous knowledge, livestock, plants

INTRODUCTION

Livestock production provides food security and reduces poverty along with support for many cultural rituals (Wendimu et al. 2024). It also serves as a source of employment, manure and draft power for farming and goods transportation in most developing countries (Eiki et al. 2022). Animals may be at risk of exposure to various diseases, with the potential for economic disruption, which may be severe, and for more widespread consequences if disease cannot be well managed, the impact can extend further, potentially affecting other animals and the surrounding environment. Since ancient times, animal keepers have closely observed their animals, gaining valuable knowledge about various illnesses, their causes and management. The utilization of such indigenous knowledge and traditional beliefs in protecting animal health and treating various animal ailments or diseases is known as Ethnoveterinary Medicine (EVM). The use of diagnostic procedures, animal husbandry practices and surgical methods are also included in EVM (Oda et al. 2024).

EVM is extensively used as a primary source of medicine to treat livestock diseases in rural regions of developing countries (Asfaw et al. 2022). Developed by farmers in fields and barns rather than by scientists in laboratories and clinics, EVM offers more affordable, locally sourced, and easily accessible alternatives to western drugs (Verma 2014). Plants being rich in diverse phytochemicals are promising candidates for developing medicines and other active products essential for managing health issues in livestock. Medicinal plants are being widely used by farmers and pastoralists belonging to different ethnic communities of different states in India in the management of livestock health (Kalita et al. 2024). EVM has been practiced in India since ancient times, with texts like the Atharvaveda and other scriptures, documenting the use of medicinal plants for treating animal diseases (Sikarwar and Tiwari 2020). Despite their role in the primary healthcare of animals, ethnoveterinary practices are declining because of habitat loss of plants from environmental degradation and overexploitation of medicinal plants, coupled with the reliance on oral transmission of knowledge instead of in recorded forms, which accelerates their decline in the absence of proper documentation and analysis (Asfaw et al. 2022).

North East India is often regarded as the geographic gateway for the majority of India's flora and fauna owing to its highly dynamic ecosystems and a relatively complex biogeography (Jain and Das 2022). It comprises Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim falling under the category of Himalayan and Indo-Myanmar biodiversity hotspots. Nagaland is a small state with varied climatic conditions that greatly influence its flora and fauna diversity. It is also home to various tribes, each with its unique cuisines, traditional attires and rich folklore. There are variations in plant usage among the tribes which highlight the depth and richness of their traditional knowledge. These communities have been relying on traditional medicines not only for their health but also for treating their livestock. Despite the fact that many households in the region raise animals, whether as pets or for economic purposes such as livestock farming or poultry, the survey and documentation of EVM remain a largely neglected area of research in Nagaland.

Furthermore, the traditional knowledge of EVM in the state is rapidly fading, mainly due to modernization and the growing dominance of synthetic drugs. This calls for an urgent need to document the EVM practices of the Naga people before they are lost forever. Recognizing the importance of traditional knowledge in the healthcare of animals, the potential benefits of documenting these practices and the rapid decline in EVM practices in the state, this study was conducted to document the ethnoveterinary knowledge on plants and information on the preparation of remedies in the Chumoukedima District of Nagaland for treating livestock diseases and ailments.

MATERIALS AND METHODS

Study area

The Chumoukedima is a new district of Nagaland in India that was created on 18th December, 2021. It is situated at 23°3'N latitude and 93°30'30''E longitude, with an elevation of approximately 2000 meters above sea level. The district covers an area of approximately 6,110 square kilometers, including 81 villages and a population of 166,911 (https://chumoukedima.nic.in/demography/).

Fieldwork and data collection

The study on ethnoveterinary medicinal plants was conducted in the Chumoukedima District of Nagaland between September 2023 and April 2024. The study involved interviews with 11 participants (six males and five females) aged between 20 and 75 using a semi-structured questionnaire. The interviews were conducted at the informants homes or farms and were complemented by open discussions. Before data collection, each participant was provided with a consent form and verbal informed consent was obtained to ensure ethical compliance. Information such as the local name of plants, parts used, mode of preparation and dosage given, disease treated and duration of the treatment were recorded. The collected medicinal plants were identified using available literature and online sources (Hajra et al. 1995; Deorani and Sharma 2007; Changkija 2014; Changkija and Gurung 2017; WFO 2025). Herbarium was prepared and voucher specimens of the collected plants were deposited in the Department of Botany at St. Joseph University, Nagaland, India.

Data analysis

Microsoft Office Excel 2016 was used to calculate the percentage and other data of the collected information. Ethnobotanical data calculated were Use Value (UV) of the plant species and Factor Informant Consensus (FIC).

Use value

UV of plant species was calculated using the following formula:

$$UV = \Sigma U_i/N$$

Where: U_i represents the number of uses recorded for a given species by each informant and N indicates the number of total informants (Siddique et al. 2021).

Factor informant consensus

FIC was calculated to study the uniformity of knowledge about the medicinal plants used by the informants. It was calculated using the formula:

$$FIC = (Nur - Nt)/(Nur - 1)$$

Nur indicates number of use-report in each category and Nt is the number of species used for particular category by all informants (Bhatia et al. 2014).

RESULTS AND DISCUSSION

Plants used in ethnoveterinary medicine

Informants in the study area rely heavily on plants, as a source of food for their animals and as medicine for treating various animal diseases. All participants had experience in animal husbandry and veterinary practices and had acquired their knowledge of traditional medicine through generations of experience passed down by parents, grandparents, or earlier practitioners. Plants produce a diverse range of phytoconstituents, which help them defend against harsh environmental conditions and herbivores. These natural compounds also play crucial role in managing disorders and diseases in animals. In recent years, the use of herbal and plant-based medicine in livestock production has increased due to concerns over the side effects of modern drugs, high input costs, toxic residues in food, resistant against microbes, and the growing adoption of organic livestock production systems (Kuralkar and Kuralkar 2021). In the present study, 50 plant species belonging to 48 genera and 35 families are used as EVM by informants. Details regarding the reported ethnoveterinary medicinal plants including their botanical and vernacular names, families, uses, parts used, preparation methods, dosages used and modes of administration to treat various disorders of livestock in Chumoukedima were recorded (Table 1).

These plants were used to treat various livestock ailments, including parasite infections, poisoning, fractures, bleeding, cuts and wounds, flu, stomach disorders and inflammation among others. Verma (2014) documented the presence of several plants in another region of India including *Azadirachta indica* A.Juss., *Ficus racemosa* L., *Hibiscus rosa-sinensis* L., *Musa ×paradisiaca* L., *Tagetes erecta* L., *Trigonella foenum-graecum* L. and *Zingiber officinale* Roscoe among other plants. *Artocarpus heterophyllus* Lam., *Allium sativum* L., *A. indica*, *Centella asiatica* (L.) Urb., *Citrus ×limon (L.)* Osbeck, *Curcuma longa* L., *Cymbopogon nardus* (L.) Rendle, *Christella parasitica* (L.) H.Lév., *Euphorbia hirta* L., *M. ×paradisiaca*, *Ocimum tenuiflorum* L., *T. erecta*, *Zea mays* L., *Z. officinale* were among the plants used by another study by other ethnic community in northeast India for treating livestock ailments (Bhat et al. 2023). This signifies the rich traditional and medicinal importance of these plants and suggests their potential for novel drug discoveries. It was interesting to note that people of the study area not only use plants as EVM but also as fodder for livestock, including the fruits of *Carica papaya* L., stem and leaves of *M.* ×*paradisiaca*, fruits of *A. heterophyllus*, tubers and leaves of *Manihot esculenta* Crantz and leaves of *Spilanthes acmella* A.Chev., 1920. along with several other locally available plants that serve as beneficial nutrition for animals.

Asteraceae and Moraceae were the highest reported families concerning species numbers where the Asteraceae family had five plant species, followed by Moraceae with four plant species accounting for 10 and 8% respectively (Figure 1). Euphorbiaceae, Fabaceae, Liliaceae, Malvaceae, Piperaceae, Poaceae, Rutaceae, and Zingiberaceae were represented by two species each (4%). The other 25 families were represented by only one species each (2%). The Asteraceae family encompasses a wide range of well-known species such as coreopsis, sunflower, chicory, lettuce, daisy and dahlias, along with medicinally significant plants like dandelion, chamomile and wormwood, with most of the members of this family recognized for their therapeutic applications while also serving as vital protective agents against infectious diseases in animals (Abd-Alla 2022). The family Asteraceae also dominated among EVM in another study (Wendimu et al. 2023). With 32,913 accepted species allocated in 1,911 genera in 13 subfamilies, the Asteraceae family is one of the largest and most economically significant plant families that comprises a diverse range of aromatic, annual or perennial herbs, sub-shrubs and shrubs and is highly rich in bioactive compounds, making it popularly used in medicine than many other plant families (Rustaiyan and Faridchehr 2021). The Moraceae family, commonly known as the mulberry or fig family, comprises 50 genera and 1,400 species, which are rich in diverse chemical compounds such as polyphenols, including flavonoids, anthocyanins and carotenoids, which contribute to a wide range of pharmacological activities (Basnett et al. 2023). The higher number of plant species within the Asteraceae and Moraceae in this study could be attributed to the suitability of climatic and soil conditions as well as the adaptability of this family in the study area, which support their widespread distribution and growth. Additionally, their medicinal properties might also be well-recognized by local people.

Habit and plant parts utilized

Herbs with 42% were the most frequently exploited among habit, followed by trees at 30% and shrubs and climbers at 18 and 10%, respectively (Figure 2). Other studies also reported the highest usage of herbs in preparation of herbal remedies (Feyisa et al. 2021; Rehman et al. 2022). Herbs are noted for their applications in gynaecological, surgical and bovine mastitis treatments, as well as in addressing various infections through their acaricidal and anthelmintic properties, and their use is particularly advantageous due to their typically higher concentrations of bioactive compounds compared to shrub or tree species (Umair et al. 2024).

Informants rely on various plant parts to prepare remedies but leaves with 50% were the most commonly utilized parts (Figure 3). This observation agrees with findings from another study, which highlight leaves as the most frequently used plant part in formulating treatments for animal ailments (Pratama et al. 2021; Wendimu et al. 2024).

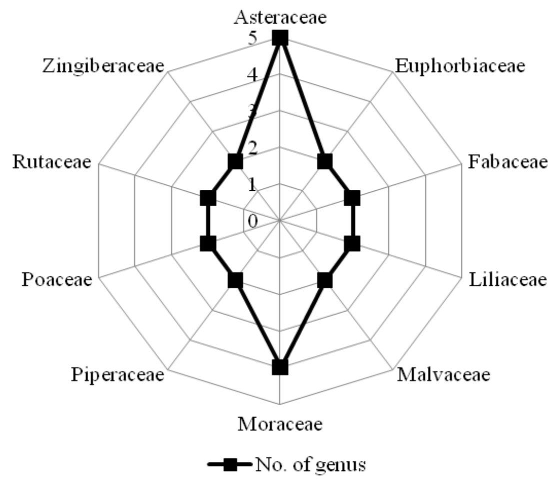


Figure 1. Dominant families of ethnoveterinary medicinal plants

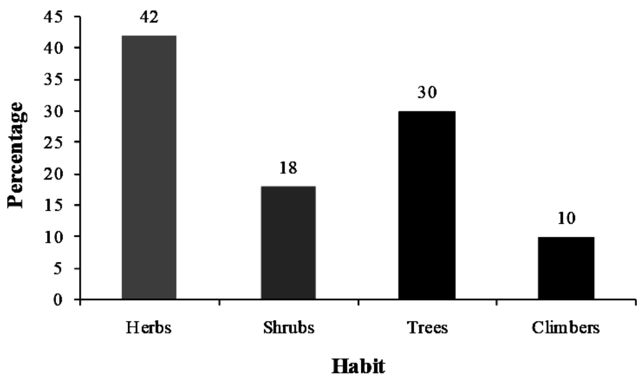


Figure 2. Habit of recorded ethnoveterinary plants

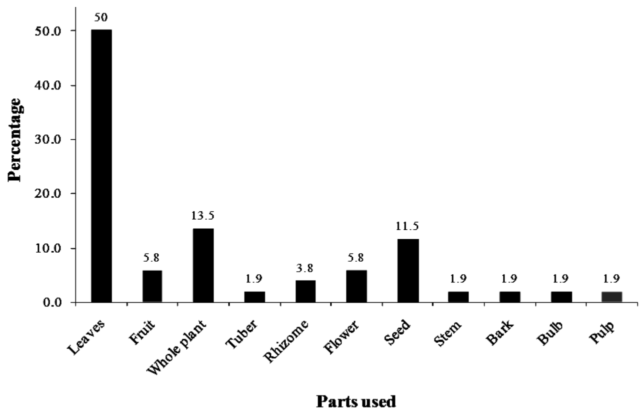


Figure 3. Percentage contribution of plant parts in ethnoveterinary medicine

Table 1. Plants used in various ethnoveterinary medicinal purposes by the Naga people of Chumoukedima District in Nagaland, Indonesia

Scientific name	Family	Local name	GH	AA	Purpose	PU	DT	Preparation	Application	UV
Amaranthus spinosus L.	Amaranthaceae	Aru	H	Cow	Lactagogue	Wp	60 days	Co	Cooked with fodder and given for consumption (In).	0.27
Rhus semialata	Anacardiaceae	Tangmoh	T	Pig	Food poisoning	Se	Two to three days	Co	Mixed with the fodder for consumption (In).	1.43
Calotropis gigantean (L.) W.T.Aiton .	Apocynaceae	Kutjak	S	Cow	Joint pain	Le	Four to five times a day for ten days	Ra	Cover the damaged area (Ex).	0.27
Ageratum conyzoides L.	Asteraceae	Imchenriza	H	Cow	Bleeding, cuts and wounds	Le	Until effect	Pa	Applied over cuts and wounds (Ex).	0.55
Chromolaea odorata (L.) R.M.King & H.Rob.	Asteraceae	Pongalai	S	Cow, pig	Cuts and wounds	Le	Until effect	Pa	Applied over cuts and wounds (Ex).	0.64
Mikania cordata (Burm.fil.) B.L.Rob.	Asteraceae	Ekobazu	C	Pig	Internal parasite	Wp	Four to five months	Ra, Co	Given orally (or) chopped and mixed along with the fodder (In).	0.18
Spilanthes acmella A.Chev.	Asteraceae	Tefumozitong	H	Cow	Tongue infection	FI	Two weeks	Pa	Applied over the infected part (Ex).	0.45
Tagetes erecta L.	Asteraceae	Kitsungnaro	H	Hen	Bird flu	FI	Until effect	Pa	Mixed with food and then given to consume (In).	0.45
Centella asiatica (L.) Urb.	Apiaceae	Longsokorok	H	Cow, pig	Skin infection	Wp	Until effect	Pa	Applied over the infected part (Ex).	0.36
Basella alba L.	Basillaceae	Zua aobaonu	C	Cow	Cuts and wounds	Le	One week	Pa	Applied on the cuts and wounds (Ex).	0.09
Begonia picta Sm.	Begoniaceae	Onsurup	H	Cat, dog	Cuts and wounds	Le	Two to three days	Pa	Applied over injured areas (Ex).	0.45
Tamarindus indica L.	Caesalpiniaceae	Emlitenga	T	Cow, goat	Diarrhoea	Fr	Three days	Ju	Mixed with water and then given to consume (In).	0.45
Cannabis sativa L.	Cannabaceae	Ganja	H	Cow	Dysentery	Le	Five days	In, Co	Infusion for drinking or powder mixed along with fodder (In).	0.45
Carica papaya L.	Caricaceae	Mamazu	T	Pig	Lactagogue	Fr	Two months	Co	Cooked with fodder and then given to consume to lactating pig (In).	0.45
Terminalia chebula Retz.	Combretaceae	Nangkah	T	Pig	Dysentery	Ba	Twice a day for one week	Po	Given orally in small quantities (In).	0.18
Commelina benghalensis L.	Commelinaceae	Asurmechi	H	Pig	Internal parasite	Wp	Two weeks	Ra, Co	Given raw or chopped and mixed with fodder for consumption (In).	0.09
Ipomoea batatas (L.) Lam.	Convolvulaceae	Tazushe	C	Pig	Constipation	Le	Until effect	Ra, Co	Given raw or cooked along with fodder and given for consumption (In).	0.18
Brassica campestris var. mana Makino	Cruciferae	Chipi	H	Hen	Mouth and eye infection	Se	Until effect	Ra	Spread in the poultry rearing areas (Ex).	0.27
Euphorbia hirta L.	Euphorbiaceae	Asthma tong	H	Pig	Dysentery	Wp	Until effect	Ra, Co	Given orally or mixed with fodder and given to consume (In).	0.36
Manihot esculenta Crantz	Euphorbiaceae	Alishi	S	Pig	Loss of appetite	Tu	Until effect	Co	Mixed along with warm fodder (In).	0.09
Trigonella foenum-graecum L.	Fabaceae	Methi	H	Cow	Lactagogue	Se	20 days	Po	Cooked with fodder and given for consumption (In).	0.18
Senna alata (L.) Roxb.	Fabaceae	Napong chami	S	Cow, pig	Skin disease	Le	Until effect	Pa	Applied on the infected area (Ex).	0.36
Psidium guajava Linn.	Myrtaceae	Moterem	T	Goat, cow	Diarrhoea	Le	Three days	Pa	Diluted with water and given for drinking (In).	0.45
Ocimum tenuiflorum L.	Lamiaceae	Nangpera	H	Dog	Food poisoning	Le, FI	Two to three days	Co	Dried sample is mixed with *Rhus semilata* is in lukewarm water and given to consume (In).	0.64

Allium sativum L.	Liliaceae	Lahsung	H	Hen	Cough	Bu	Two to three days	Co	Paste made with raw mustard oil, mixed with rice and given to consume (In).	0.18
Aloe vera (L.) Burm. f.	Liliaceae	Tanulah o	H	Cow	Udder infection	Pu	One week	Co	Prepared with the mustard oil for massaging (Ex).	0.18
Hibiscus rosa-sinensis L.	Malvaceae	Yimpangnaro	S	Pig	Constipation	Le	Until effect	Ra	For consumption (In).	0.55
Hibiscus sabdariffa L.	Malvaceae	Tzrimartasentsu/ Ensturep	S	Cow	Dysentery	Fr	Twice a day for one week	In	Soaked in water for 3 hours and given for drinking (In).	0.73
Azadirachta indica A.Juss.	Meliceae	Neem	T	Pig	Skin rashes and infection	Le	Two weeks	De	For bathing (Ex).	0.18
Artocarpus heterophyllus Lam.	Moraceae	Polong	T	Pig	Dysentery	Le	Until effect	Ra	For consumption (In).	0.09
Broussonetia papyrifera (L.) L'Hér. ex Vent.	Moraceae	Kagritong	T	Pig	Lactagogue	Le	Two months	Ra	For consumption (In).	0.45
Ficus racemosa L.	Moraceae	Munguzuno	T	Pig	Lactagogue	Le	Two months	Ra	For consumption (In).	0.09
Morus alba L.	Moraceae	Menaklashi	T	Pig	Constipation	Le	Until effect	Ra	For consumption (In).	0.45
Moringa oleifera Lam.	Moringaceae	Sajina	T	Cow	Mumps	Le	Until effect	Pa	Warmed for few minutes, transferred to cloth and gently pressed around the swollen area (Ex).	0.18
Mutingia calabura	Muntingiaceae	Thosu	T	Pig	Dysentery	Le	Until effect	Ra	Given in pure form or mixed with fodder (In).	0.18
Musa ×paradisiaca L.	Musaceae	Somomo	H	Pig	Dysentery	St, Le	Until effect	Co	Cooked with fodder then, given to consume (In).	0.09
Piper betle L.	Piperaceae	Patio	C	Dog	Cuts and wounds	Le	Until effect	Pa	Applied over cuts and wounds (Ex).	0.45
Piper nigrum L.	Piperaceae	Gol morich	C	Cow	Dysentery	Se	Three to four days	Co	Grinded with rhizome of *Zingiber officinale* and mixed in the drinking water to consume (In).	0.45
Cymbopogon nardus (L.) Rendle	Poaceae	Citronella	H	Pig	Skin rashes	Le	Twice a day for one week	De	As a disinfectant for bathing (Ex).	0.18
Zea mays L.	Poaceae	Menti	H	Pig	Lactogogue	Se	Two months	Co	Dried powder is mixed with warm fodder and given for consumption (In).	0.27
Ziziphus mauritiana Lam.	Rhamnaceae	Peenok	T	Cow, dog	Burns on skin	Le	Until effect	Pa	Applied over damaged area (Ex).	0.36
Citrus ×limon (L.) Osbeck	Rutaceae	Ongshe	T	Cow	External mouth Infection	Le	Until effect	Pa	Rubbed around the infected parts of the mouth (Ex).	0.64
Murraya koenigii Linn.	Rutaceae	Curry tu	S	Cow, dog	Cuts and wounds	Le	Until effect	Ra	Few leaves are crushed thoroughly and then applied (Ex).	0.73
Houttuynia cordata Thunb.	Saururaceae	Azuponhsmydu/ Nokna	H	Pig	Internal parasites	Wp	Two weeks	Ra	For consumption (In).	0.18
Solanum trilobatum L.	Solanaceae	Koyalilok	S	Hen	Eye infection	Se	Until effect	Pa	Applied around the infected eye (Ex).	0.09
Camellia sinensis (L.) Kuntze	Theaceae	Sungoh	S	Dog	Cuts and wounds	Le	Until effect	Pa	Applied on the infected part (Ex.)	0.27
Christella parasitica (L.) H.Lév.	Thelypteridaceae	Jakemtsu	H	Hen	Lice repellent	Wp	Until effect	Ra	Spread in the poultry rearing areas (Ex).	0.45
Aquilaria malaccensis Lam.	Thymelaeaceae	Sungya	T	Dog	Allergy and wounds	Le	Thrice a week	De, Pa	Water from leaves boiled is used in bathing. Paste is applied on the body after bathing (Ex).	0.27
Curcuma longa L.	Zingiberaceae	Wakong	H	Cow	Cuts and wounds	Rh	Until effect	Co	Crushed with raw mustard oil and applied on the infected part (Ex).	1.57
Zingiber officinale Roscoe	Zingiberaceae	Sungmok	H	Pig	Cough and cold	Rh	One week	Pa	Paste made with *Allium sativum* are warm food and then given to consume (In).	1.43

Note: AA: Affected animal; DT: Duration of the treatment; PU: Parts used; WP: Whole plant; Fl: Flowers; Le: Leaves; Rh: Rhizome; Bu: Bulb; Fr: Fruit; Tu: Tubers; Se: Seeds; Pu: Pulp; GH: Growth habitat; H: Herb; T: Tree; S: Shrub; C: Climber; Pa: Paste; In: infusion; Po: Powdered; Co: Concoction; De: Decoction; Ju: Juice; Ra: Raw; (In): Internal; (Ex): External; (UV): Use value

Contrary to this, other studies reported that leaves are among the less frequently utilized parts of medicinal plants instead roots were more widely recognized and commonly used within communities (Xiong and Long 2020; Rafique Khan et al. 2021). The preference for leaves in this study could be attributed to several factors, including their abundance, ease of harvest, and high concentration of bioactive compounds. Besides being easier to collect compared to fruits, flowers and underground parts, leaves play a crucial role from a scientific perspective as they are actively involved in photosynthesis and the production of secondary metabolites (Kumar and Nagayya 2017). Moreover, harvesting leaves rather than other plant parts is a more sustainable approach to resources, as it is typically less destructive when compared with other plant parts such as roots and barks. The use of stems and roots may lead to the complete destruction of the medicinal plant due to the dysfunction of the xylem and phloem in its vascular system (Mthi et al. 2023).

Preparation method

The methods of preparation differed depending on the basis of ailments treated. Although herbal remedies were prepared through various methods, paste, accounting for 30% was the most common method. This was followed by concoction, direct/raw and decoction with 28.6, 25, and 5.4% respectively (Figure 4). Informants attributed the popularity of paste to their ease of preparation, which was prepared by crushing the plant sample alone or combined with oil or water and was either applied directly over the wounds or administered orally. Several methods of medicinal preparations for treating various ailments were recorded in other studies as well where, the paste was reported as the major mode of preparation for the treatment of livestock (Sundharakumar et al. 2020; Bhat et al. 2023; Shinde et al. 2024). In ethnoveterinary practices, paste is commonly used one of the major forms of drug preparation due to its ease of preparation using a pestle and mortar, either with or without water (Jayakumar et al. 2018). Infusion, juice and powder were the least utilized methods, each making up 3.57% of the recorded formulations. This finding contradicts another study where infusion was the most commonly prepared method for treating animals (Chaachouay et al. 2024). Medicinal preparations were often made by combing two plants to enhance their effectiveness (Table 1). For instance, a paste of *Z. officinale* rhizome mixed with *A. sativum* is considered a warm remedy and is given to treat cough and cold. To heal cuts and wounds, rhizome of *C. longa*. is mixed and with crushed with raw mustard oil before application. For dysentery, seeds of *Piper nigrum* L. is grounded with the rhizome of *Z. officinale* and added to drinking water. Likewise, leaves and flowers of *O. tenuiflorum* are mixed with *Rhus semilata* in lukewarm water and administered during food poisoning. These practices highlight the rich traditional knowledge of herbal medicinal preparation in the study area.

Animals treated

Individuals involved in animal rearing and livestock management have knowledge of the causes of various diseases and ailments, as well as effective methods for their prevention, control and treatment. Informants in this study cited the use of ethnoveterinary remedies for 11 animals, with pigs (39.7%) being the most frequently treated, followed by cows (34.5%) and dogs (12.1%) (Figure 5). This result aligns with another conducted in a different country where pigs and cattle were among the animals that accounted for more than 70% of domestic animals treated with herbal medicines (Romero et al. 2022). In Nagaland, pork and beef are widely consumed and pork, in particular, holds cultural importance, being an essential part of tribal festivals, marriages and other celebrations. This led to a significant number of pig and cow farmers who rely on these livestock as a source of income. Additionally, dogs are popular pets among the Naga people, further contributing to the higher prevalence of traditional medicines used for treating these animals. Remedies for treating other animals such as hens (8.6%), goats (3.4%) and cats (1.7%) were also cited showcasing the adaptability and extensive application of indigenous veterinary knowledge in the study area.

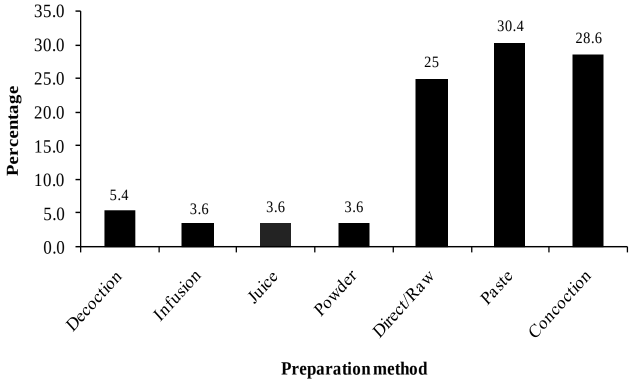


Figure 4. Percentage contribution of various preparation methods in ethnoveterinary medicines

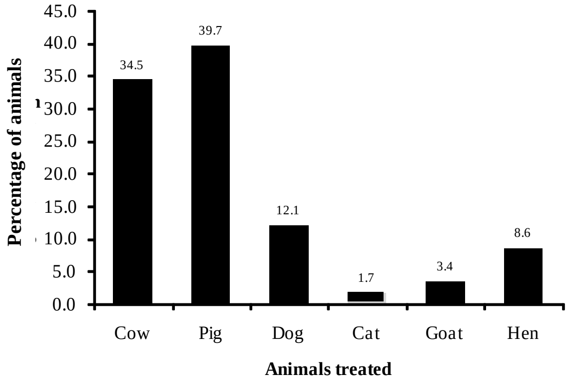


Figure 5. Animals treated using ethnoveterinary medicinal plants

Ailments treated

Livestock diseases negatively impact the production system, triggering a cascading effect that leads to reduced production, low income and subsistent livelihood and could also extend beyond immediate effects on producers (Jayakumar et al. 2018). Injuries including bleeding, burns, cuts and wounds (21.7%) were the most common problem issues in the study area, which was followed by skin problems and dysentery (17.4%) (Figure 6). According to informants, the high prevalence of injuries is largely due rearing of most animals in open areas, where they are more exposed to environmental hazards. Plants, rough terrain and other natural obstacles frequently lead to cuts and wounds. Additionally, insect bites are a common source of injuries, as animals tend to scratch or rub against rough surfaces to relieve itching, which can further aggravate wounds and increase the risk of infection. Informants attributed the main reason for skin issues to insect bites and poor sanitation, both of which create a favorable environment for infections and other dermatological issues. Plants were also used for other issues such as lactagogue, food poisoning, joint pain, internal parasites, flu, diarrhea, lice attack, mumps, constipation and cough and cold. A similar trend was recorded in another study where the plants were used for the treatment of various veterinary ailments including gastrointestinal disorders, infections and infestations, lactation and muscular-skeletal system disorders among others (Uprety et al. 2022). Informants in the present study revealed the use of one or more plants to address specific ailments, indicating the rich diversity of traditional knowledge and the therapeutic potential of medicinal plants.

Routes of medicine administration and dosage

Medicines were administrated through two means namely, external and internal. Internal methods included the consumption of medicines in the form of powders, raw or cooked or mixed with other things while, external methods involved bathing, rubbing or covering the damaged area, applying treatments to infected part, injured area, cuts and wounds, or pressing on swollen areas. The most common route of administration was internal (56%) as compared to external (44%) (Figure 7). Another study also found that the oral mode of delivery was the most common route for treating cattle ailments, compared to topical routes and the combined use of both methods (Bhat et al. 2023). The oral route of administration is cosy-effective, convenient and generally safe and in some cases, animals can be trained to cooperate voluntarily, based on the compound being given (Turner et al. 2011). Internal administration was given either in their raw form or mixed with other plants and fodder. Similarly, medicines were applied to animals externally either in their raw form or after mixing with other plants.

Proper dosage is crucial in administrating medicines, as it ensures that the appropriate quantity is used for effectively treating ailments and diseases. However, it was noted that there was a lack of standardized measurement units for administrating medicines in the study area, as dosages were determined based on the personal judgment and satisfaction of the individual preparing the remedies. This issue has been observed in other studies as well, as it has been noted that ethnomedicine requires standardization, with veterinarians frequently complaining about non-standardized dosages in traditional medicines (Aziz et al. 2018). Standardizing herbal medicine dosage presents a formidable challenge due to the vast diversity of plant species and the inherent variation in their bioactive compounds (Busia 2024). Medicinal plants contain pharmacologically active compounds, but their effects can vary depending on dosage, as limited intake may have no impact, while excessive consumption can lead to harmful consequences. Addressing this gap by establishing standardized measurement systems and dosage guidelines could significantly improve the accuracy, safety and efficacy of ethnoveterinary practices and better animal health outcomes in the future.

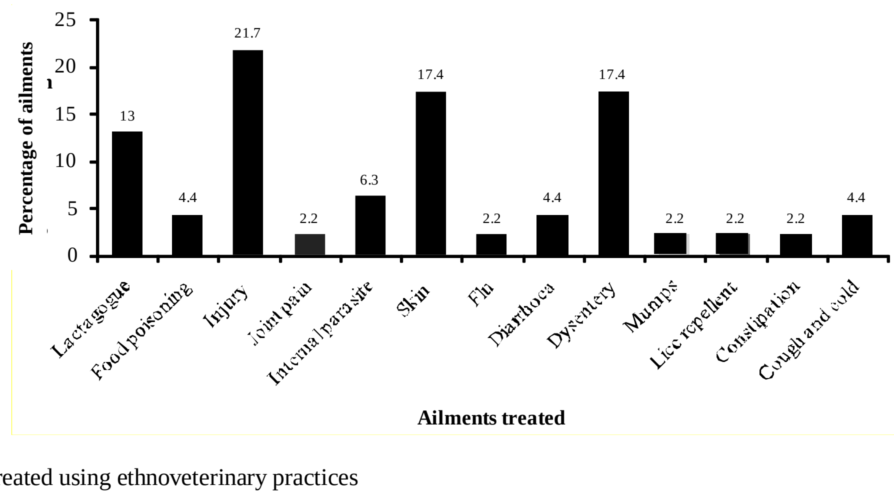


Figure 6. Ailments treated using ethnoveterinary practices

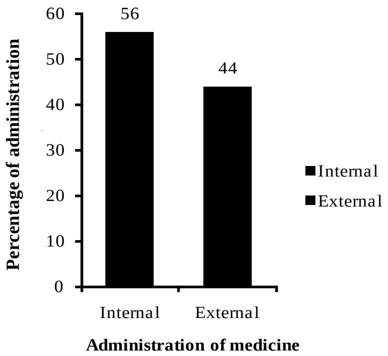


Figure 7. Mode of medicine administration

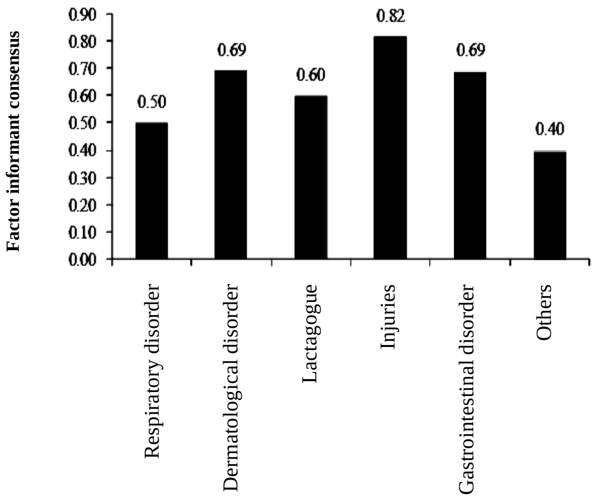


Figure 8. Factor informant consensus for ailment categories

Factor informant consensus

The FIC was evaluated after traditional remedies and corresponding diseases were grouped into six categories. FIC values are considered low if they are close to 0 and it indicates that there is no exchange of information about plant use among informants but the value approach 1 if information is shared among informants (Sharma et al. 2022). The FIC values ranged from 0.40 to 0.82, with the highest level of consensus observed for injuries, followed by gastrointestinal and dermatological disorders, both of which had FIC of 0.69 each (Figure 8). This indicates the frequent occurrence of injuries in livestock, as well as gastrointestinal and dermatological issues. It also reflects the local knowledge of the therapeutic applications of plants for these conditions. A high FIC value suggests an effective sharing of ethnoveterinary medicinal knowledge among informants and the availability of plant species for treating these health issues.

Use value

The UV shows the relative importance of ethnoveterinary medicinal plant species based on the frequency of mentions by local informants. In this study, the UV ranged from 0.09 to 1.57 (Table 1). Among the species, *C. longa*. had a UV of 1.57, reflecting its high cultural and medicinal relevance. This was closely followed by *Rhus semialata* and *Z. officinale*, both with a UV of 1.43, indicating their significant role in the local ethnoveterinary practices. *C. longa* is a perennial herb under the Zingiberaceae family. It has been widely recognized for its medicinal properties for many years, largely due to the presence of various beneficial compounds. For instance, curcumin, a key polyphenolic compound found in the plant has been reported to offer numerous benefits in promoting the health and enhancing the performance of livestock and poultry (Sureshbabu et al. 2023). *Zingiber officinale*, another herb under the Zingiberaceae family also hold diverse medicinal values. The informants in the present study used rhizome of the plant to treat cough and cold in pigs highlighting its role in respiratory ailments. In another study, the crude extract of its powder has been shown to enhance renal and hepatic function and is recommended as an effective and safe treatment option for managing gastrointestinal nematode infections in pigs (Kiambom et al. 2022). *Rhus semialata*, a deciduous tree belonging to the Anacardiaceae family, has long been valued in traditional medicines for its therapeutic properties in treating ailments in humans, such as dysentery and diarrhoea (Bose et al. 2007). The high UV of the plant in this study reflects its effectiveness and indicates its potential as a valuable remedy not only in human healthcare but also in ethnoveterinary medicinal practices.

In conclusion, a total of 50 plant species from 35 families were recorded as being used for the treatment of various livestocks ailments in the Chumoukedima District of Nagaland. Herbs and leaves were the most utilized habit and plant parts. Pigs, cows and dogs were the primary animals treated, with injuries, skin problems and dysentery being the most prevalent issues. Remedies were prepared using various methods, with paste being the most common and administered both internally and externally. Despite the effectiveness of these practices, the lack of standardized dosage measurement poses challenges to safety and efficacy. Plants were documented from only one district of Nagaland but, the substantial number of medicinal plants in treating animals, emphasizes the importance of exploring and documenting EVM in other unexplored areas of the state. Preserving and scientifically validating this traditional knowledge can enhance veterinary practices and promote better animal health outcomes in the state.

ACKNOWLEDGEMENTS

The authors are grateful to the informants from the Chumoukedima area, Nagaland, India for generously sharing their valuable knowledge.

REFERENCES

Abd-Alla HI. 2022. The potential use of some members belong to Apiaceae and Asteraceae plant family as immune boosters in livestock production. Egypt J Anim Prod 59 (4): 45-55. DOI: 10.21608/ejap.2022.244951.

Asfaw A, Lulekal E, Bekele T, Debella A, Debebe E, Sisay B. 2022. Medicinal plants used to treat livestock ailments in Ensaro District, North Shewa Zone, Amhara Regional State, Ethiopia. BMC Vet Res 18 (1): 235. DOI: 10.1186/s12917-022-03320-6.

Aziz MA, Khan AH, Adnan M, Ullah H. 2018. Traditional uses of medicinal plants used by indigenous communities for veterinary practices at Bajaur Agency, Pakistan. J Ethnobiol Ethnomed 14 (1): 11. DOI: 10.1186/s13002-018-0212-0.

Basnett D, Banerjee M, Chowdhury SK. 2023. A review on medicinal values and pharmacological importance of Moraceae. Plant Sci Today 14719: 1-9. DOI: 10.14719/pst.2385.

Bhat NA, Jeri L, Karmakar D, Mipun P, Bharali P, Sheikh N, Nongkynrih CJ, Kumar Y. 2023. Ethnoveterinary practises of medicinal plants used for the treatment of different cattle diseases: A case study in East Khasi Hill District of Meghalaya, North East India. Heliyon 9 (7): e18214. DOI: 10.1016/j.heliyon.2023.e18214.

Bhatia H, Sharma YP, Manhas RK, Kumar K. 2014. Ethnomedicinal plants used by the villagers of district Udhampur, J&K, India. J Ethnopharmacol 151 (2): 1005-1018. DOI: 10.1016/j.jep.2013.12.017.

Bose SK, Dewanjee S, Sen Gupta A, Samanta KC, Kundu M, Mandal SC. 2007. In vivo evaluation of antidiarrhoeal activity of *Rhus semialata* fruit extract in rats. Afr J Tradit Complement Altern Med 5 (1): 97-102.

Busia K. 2024. Herbal medicine dosage standardisation. J Herb Med 46: 100889. DOI: 10.1016/j.hermed.2024.100889.

Chaachouay N, Azeroual A, Bencherki B, Benkhnigue O, Zidane L. 2024. Use of ethnoveterinary medicinal plants to treat cattle diseases by the Oulad Heriz farmers in the Chaouia region, Northwest of Morocco. Acta Bot Hung 66 (1-2): 1-24. DOI: 10.1556/034.66.2024.1-2.1.

Changkija S, Gurung PB. 2017. Flora of Nagaland (Vol-I and Vol-II). Department of forest, environment and climate change, government of Nagaland, Nagaland.

Changkija S. 2014. Biodiversity of Nagaland. Department of forest, ecology, environment and wildlife, Government of Nagaland, Nagaland.

Deorani C, Sharma GD. 2007. Medicinal plants of Nagaland. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Eiki N, Maake M, Lebelo S, Sakong B, Sebola N, Mabelebele M. 2022. Survey of ethnoveterinary medicines used to treat livestock diseases in Omusati and Kunene regions of Namibia. Front Vet Sci 9: 762771. DOI: 10.3389/fvets.2022.762771.

Feyisa M, Kassahun A, Giday M. 2021. Medicinal plants used in ethnoveterinary practices in Adea Berga District, Oromia Region of Ethiopia. Evid Based Complement Alternat Med 2021: 5641479. DOI: 10.1155/2021/5641479.

Hajra PK, Rao RR, Sing DK, Uniyal BP. 1995. Flora of India. Vols. 12 & 13, Asteraceae. Botanical Survey of India, Calcutta.

Jain A, Das A. 2022. North-East India: A unique biodiversity paradise unexplored or lost? Intl J Sci Res Pub 12 (4): 112-119. DOI: 10.29322/IJSRP.12.04.2022.p12417.

Jayakumar S, Baskaran N, Arumugam R, Sathiskumar S, Pugazhenthi M. 2018. Herbal medicine as a live practice for treating livestock ailments by indigenous people: A case study from the Konar community of Tamil Nadu. S Afr J Bot 118: 23-32. DOI: 10.1016/j.sajb.2018.06.002.

Kalita CK, Mili C, Deka MJ, Das P, Das SN. 2024. Study on ethnoveterinary medicinal plants used by local people inhabiting char area, Kamrup District, Assam, North-East India. Ecol Questions 35 (4): 1-18. DOI: 10.12775/EQ.2024.048.

Kiambom T, Kouam MC, Teguia A. 2022. The anthelmintic effect of ginger (*Zingiber officinale*) powder on the biochemical and haematological parameters of pigs experimentally infected with some gastrointestinal nematodes. AJVS 72 (1): 35-44. DOI: 10.5455/ajvs.132499.

Kumar GMP, Nagayya S. 2017. Utilization of ethno-veterinary medicinal plants in Hassan District of Karnataka, India. Intl J Pharm Pharm Sci 9 (4):107-114. DOI: 10.22159/ijpps.2017v9i4.16975.

Kuralkar P, Kuralkar SV. 2021. Role of herbal products in animal production – An updated review. J Ethnopharmacol 278: 114246. DOI: 10.1016/j.jep.2021.114246.

Mthi S, Rust J, Tokozwayo S, Dubeni Z. 2023. Ethnopharmacological assessment of medicinal plants used in the management of livestock ailments by resource-limited farmers in the Eastern Cape Province. Open J Vet Med 13 (6): 96-109. DOI: 10.4236/ojvm.2023.136009.

Oda BK, Lulekal E, Warkineh B, Asfaw Z, Debella A. 2024. Ethnoveterinary medicinal plants and their utilization by indigenous and local communities of Dugda District, Central Rift Valley, Ethiopia. J Ethnobiol Ethnomed 20 (1): 32. DOI: 10.1186/s13002-024-00665-0.

Pratama AM, Herawati O, Nabila AN, Belinda TA, Wijayanti AD. 2021. Ethnoveterinary study of medicinal plants used for cattle treatment in Bojonegoro district, East Java, Indonesia. Biodiversitas 22 (10): 4236-4245. DOI: 10.13057/biodiv/d221014.

Rafique Khan SM, Akhter T, Hussain M. 2021. Ethno-veterinary practice for the treatment of animal diseases in Neelum Valley, Kashmir Himalaya, Pakistan. PLoS ONE 16 (4): e0250114. DOI: 10.1371/journal.pone.0250114.

Rehman S, Iqbal Z, Qureshi R, Rahman IU, Sakhi S, Khan I, Hashem A, Al-Arjani AF, Almutairi KF, Abd Allah EF, Ali N, Khan MA, Ijaz F. 2022. Ethnoveterinary practices of medicinal plants among tribes of tribal district of North Waziristan, Khyber Pakhtunkhwa, Pakistan. Front Vet Sci 9: 815294. DOI: 10.3389/fvets.2022.815294.

Romero B, Susperregui J, Sahagún AM, Diez MJ, Fernández N, García JJ, López C, Sierra M, Díez R. 2022. Use of medicinal plants by veterinary practitioners in Spain: A cross-sectional survey. Front Vet Sci 9: 1060738. DOI: 10.3389/fvets.2022.1060738.

Rustaiyan A, Faridchehr A. 2021. Constituents and biological activities of selected genera of the Iranian Asteraceae family. J Herb Med 25: 100405. DOI: 10.1016/j.hermed.2020.100405.

Sharma R, Sharma YP, Hashmi SAJ, Kumar S, Manhas RK. 2022. Ethnomycological study of wild edible and medicinal mushrooms in district Jammu, J&K (UT), India. J Ethnobiol Ethnomed 18 (1): 23. DOI: 10.1186/s13002-022-00521-z.

Shinde SS, Narwade KB, Kharat VV, Swami SG, Raut SD. 2024. Ethnoveterinary medicinal plants for treatment of animal ailments by traditional healers in Nanded District (MS), India. Afr J Bio Sci 6 (9): 5542-5557. DOI: 10.48047/AFJBS.6.9.2024.5542-5557.

Siddique Z, Shad N, Shah GM, Naeem A, Yali L, Hasnain M, Mahmood A, Sajid M, Idrees M, Khan I. 2021. Exploration of ethnomedicinal plants and their practices in human and livestock healthcare in Haripur District, Khyber Pakhtunkhwa, Pakistan. J Ethnobiol Ethnomed 17 (1): 55. DOI: 10.1186/s13002-021-00480-x.

Sikarwar RLS, Tiwari AP. 2020. A review of plants used in ethnoveterinary medicine in Central India. Indian J Tradit Knowledge 19 (3): 617-634. DOI: 10.56042/ijtk.v19i3.40808.

Sundharakumar S, Aruna R, Shrinitha TM. 2023. An ethnoveterinary study on plants used for livestock diseases in Theni and Madurai Districts, Tamil Nadu, India. J Tradit Folk Practices 8 (2): 21-28. DOI: 10.25173/jtfp.2020.8.2.113.

Sureshbabu A, Smirnova E, Karthikeyan A, Moniruzzaman M, Kalaiselvi S, Nam K, Goff GL, Min T. 2023. The impact of curcumin on livestock and poultry animal’s performance and management of insect pests. Front Vet Sci 10: 1048067. DOI: 10.3389/fvets.2023.1048067.

Turner PV, Brabb T, Pekow C, Vasbinder MA. 2011. Administration of substances to laboratory animals: Routes of administration and factors to consider. J Am Assoc Lab Anim Sci 50 (5): 600-13.

Umair M, Altaf M, Ahsan T, Bussmann RW, Abbasi AM, Gatasheh MK, Elrobh M. 2024. Study of medicinal plants used in ethnoveterinary medical system in riverine areas of Punjab, Pakistan. J Ethnobiol Ethnomed 20 (1): 48. DOI: 10.1186/s13002-024-00686-9.

Uprety Y, Karki S, Poudel RC, Kunwar RM. 2022. Ethnoveterinary use of plants and its implications for sustainable livestock management in Nepal. Front Vet Sci 9: 930533. DOI: 10.3389/fvets.2022.930533.

Verma RK. 2014. An ethnobotanical study of plants used for the treatment of livestock diseases in Tikamgarh District of Bundelkhand, Central India. Asian Pac J Trop Biomed 4 (Suppl 1): S460-S467. DOI: 10.12980/APJTB.4.2014C1067.

Wendimu A, Bojago E, Abrham Y, Tekalign W. 2023. Practices of ethnoveterinary medicine and ethnobotanical knowledge of plants used to treat livestock diseases, Wolaita zone, Southern Ethiopia. Cogent Food Agri 9 (1). DOI: 10.1080/23311932.2023.2248691.

Wendimu A, Bojago E, Abrham Y. 2024. Medicinal ethnoveterinary plants used for treating livestock ailments in the omo-gibe and Rift valley basins of Ethiopia. BMC Vet Res 20 (1): 166. DOI: 10.1186/s12917-024-04019-6.

WFO. 2025. World flora online. http://www.worldfloraonline.org.

Xiong Y, Long C. 2020. An ethnoveterinary study on medicinal plants used by the Buyi people in Southwest Guizhou, China. J Ethnobiol Ethnomed 16 (1): 46. DOI: 10.1186/s13002-020-00396-y.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025 E-ISSN: 2580-4510
Pages: 49-55 DOI: 10.13057/asianjethnobiol/y080105

Local perception of traditional foods in Wonosobo Traditional Markets, Central Java, Indonesia

ALYNA FATKHIA HANUM[1], YASKA AZZAHRA[1], ZALDA ANIQOH NURSAFITHRI[1], SILVANIA DAS DORES[1], ADIES MAURIDZKA NATASYA[2], JOHAN ISKANDAR[3], SURAPON SAENSOUK[4], AHMAD DWI SETYAWAN[1,5,♥]

[1]Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: volatileoils@gmail.com
[2]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia
[3]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran. Jl. Raya Bandung-Sumedang Km 21, Jatinangor, Sumedang 45363, West Java, Indonesia
[4]Plant and Invertebrate Taxonomy and Its Applications Unit Group, Walai Rukhavej Botanical Research Institute, Mahasarakham University. Kantarawichai District, Maha Sarakham, 44150, Thailand
[5]Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

Manuscript received: 26 November 2024. Revision accepted: 29 April 2025.

Abstract. *Hanum AF, Azzahra Y, Nursafithri ZA, Dores SD, Natasya AM, Iskandar J, Saensouk S, Setyawan AD. 2025. Local perception of traditional foods in Wonosobo Traditional Markets, Central Java, Indonesia. Asian J Ethnobiol 8: 49-55.* Traditional markets are an important part of Indonesian culture due to their capacity to negotiate prices and provide affordable, everyday essentials as well as distinctive gastronomic experiences. Wonosobo has a rich culinary heritage that promotes both local culture and tourism, and it is well-known for its variety of traditional delicacies. This study aims to understand the Wonosobo people's perceptions of traditional food and its comparison with modernized food. This study focuses on the Kertek and Wonosobo Main Markets in Wonosobo District, Central Java, to investigate consumer preferences and perceptions of traditional food. In October 2024, 90 respondents, 46 women and 44 men, were interviewed as part of the data-gathering process. Results show that 68.4% of respondents strongly prefer traditional foods, valuing them for their health benefits and cultural significance. A smaller percentage (3.8%) noted that modernized food availability impacts traditional food choices. Younger respondents tended to modern food, highlighting a generational shift. This suggests a need for strategies to preserve traditional foods while balancing them with modern culinary trends. The difference in preference for traditional food and modernized food can be influenced by globalization. Therefore, special attention is needed to traditional food so that it remains sustainable. The importance of governmental and local initiatives in promoting and sustaining traditional foods has to meet evolving consumer preferences, ensuring their relevance in a modernizing food landscape.

Keywords: Culinary tourism, food preference, local perceptions, traditional food, Wonosobo District

INTRODUCTION

Indonesia is a country known for its traditional markets. Indonesian people tend to negotiate when shopping. Traditional markets play a significant role in socioeconomic, environmental, political, and administrative aspects at both local and regional levels (Dominique-Ferreira et al. 2021). These characteristics make traditional markets the main choice. One of the advantages of traditional markets is affordable prices, so they are cheaper for the community, in accordance with market functions in general. The use of traditional markets as shopping locations highlights the importance of research regarding market convenience (Klara 2023). Indonesian culinary heritage encompasses a variety of snacks commonly found as part of traditional cuisine (Nurhayati et al. 2014). Traditional foods have been utilized as a means to promote regional economic growth and are key components in communicating culture (Florek and Gazda 2021). Interest in traditional foods remains strong because they serve as the basis for nutrition across various cultures and societies (Aquino et al. 2021). Traditional foods are formed through an evolutionary process that involves the adaptation between the foods consumed and the various types of available ingredients, as well as the activities carried out by local communities (Mulyani et al. 2020). It's generally derived from nutrient-rich plants, playing a vital role in supporting ethnobotany. Unfortunately, many traditional foods are now at risk of extinction (Purba et al. 2018). According to Iskandar et al. (2023), there is a close relationship between biodiversity and cultural heritage related to the food sector. Culture cannot be viewed as a fixed material reality; rather, in the context of economic globalization, culture creates a reality that is continuously produced and reproduced, which in turn gives rise to new identities (Irianto 2016). Rapid developments in global trade, ethnic mobility, and the tourism sector have influenced the acceptance and understanding of traditional cuisine (Romulo and Surya 2021).

Wonosobo, a District in Central Java, is renowned not only for the stunning natural beauty of the Dieng mountains but also for its diverse array of traditional culinary offerings. Due to its strategic geographical location, Indonesia enjoys a significant advantage as a producer of various types of food sources and traditional dishes (Lestari and Christina

2018). The variety of food options available should receive greater attention from the government, especially considering the recent trend of culinary tourism gaining popularity (Harsana et al. 2022). The abundance of culinary recommendations in a particular region has demonstrated this fact, as they are promoted through various media and travel guides that typically showcase the region's distinctive culinary attractions to tourists (Kurniawan and Hanjani 2023).

One of them is Wonosobo Market. Wonosobo has several markets, two of which are the Kertek Market and the Wonosobo Main Market. Wonosobo Market is one of the large markets in Wonosobo District, Central Java Province. Kertek Market is one of the traditional markets in Wonosobo District. Located in Kertek District, this market is famous for its various agricultural products. However, the drawback is that circulation in this market does not appear to be well planned, resulting in conditions in the market being less well organized (Hermawan 2022). Kertek Market has become a shopping center for local residents, which offers various basic necessities, such as rice from Wonosobo District, flour, sugar, salt, vegetables, onions, chilies, fish, chicken, and others. At the Kertek Market, sellers and buyers can negotiate to reach a mutually beneficial price agreement. Merchants also often provide discounts, promotions, or discounts to their customers. On the other hand, Wonosobo Main Market is the largest market in Wonosobo District (Miftah et al. 2023).

Understanding changes in community mindsets and perspectives is essential for developing appropriate steps (Afif et al. 2023). Observations and theoretical hypotheses should guide this process. Interviews provide insight into people's or groups experiences, opinions, and motives around specific topics (Islam 2022). These interviews aid in forecasting potential solutions and offer profound insights into social processes (Edwards and Holland 2020). This study aims to (i) understand the perspectives of Wonosobo District residents on traditional foods; (ii) determine the frequency of traditional food consumption; and (iii) clarify public preferences between traditional and modern foods. The research focuses on patterns, processes, and mechanisms, with age, education, social environment, and rural development policies shaping food preferences (Turner et al. 2023).

MATERIALS AND METHODS

Study area

The entire area of Wonosobo District, Central Java Province, Indonesia, is a plateau with an altitude of 744 m above sea level. Wonosobo District is located between 7° 21.793'S 109° 54.011'E (Muafani 2017). This research was conducted in two traditional markets, Kertek Market and Wonosobo Main Market (Figure 1). The selection of this research area is based on recommendations from several speakers regarding the community's views on traditional foods. This research will be carried out in October 2024. Kertek Market is located in Kertek District. This market is a market located in a mountainous area, precisely on the slopes of Mount Sindoro and flanked by Mount Sindoro and Mount Sumbing. The Wonosobo Main Market is located in the Wonosobo Sub-district. This market is the center of the local economy in Wonosobo District. This market is located in the center of Wonosobo City, so it is very easy to find and reach the public.

Procedures

This study employs a qualitative research method based on a post-positive approach, where the researcher acts as the instrument. This approach acknowledges that local perception cannot be fully explained objectively, requiring the researcher to interpret data with an awareness of social context and potential subjectivity. We collected interview data in a semi-structured manner, asking respondents with previously formulated questions to gauge their reactions to certain issues. This method allows respondents to answer freely based on their understanding while maintaining an open and flexible approach. Our study is highly adaptive, capturing quick responses to the issues being explored. We used interview points referenced from the research of Peulic et al. (2023).

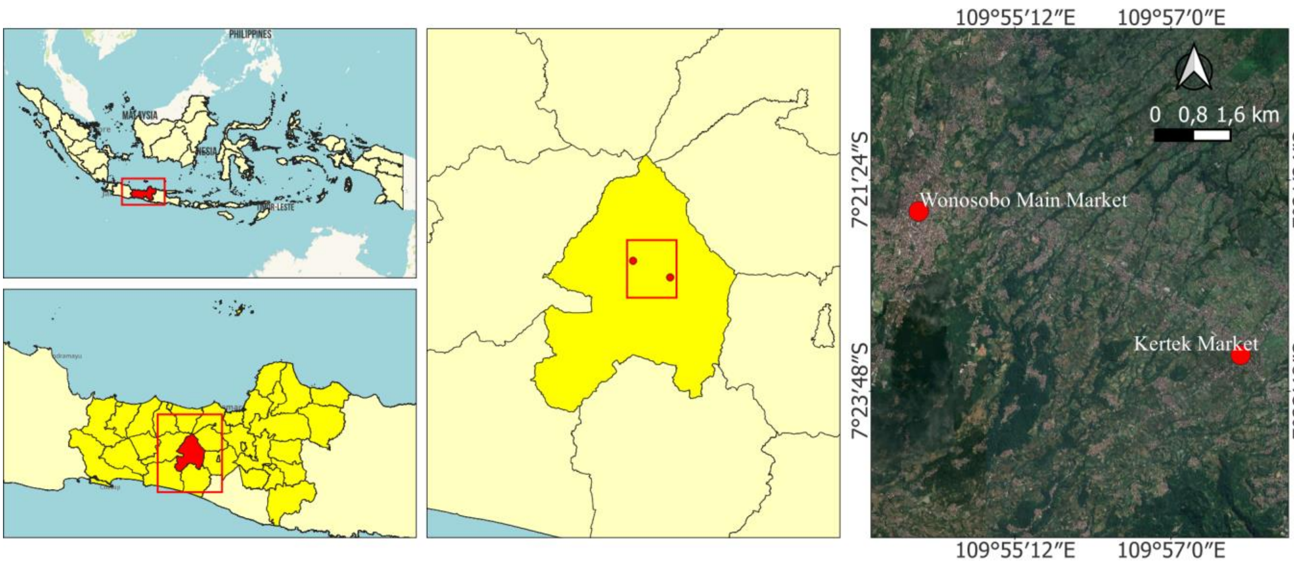


Figure 1. Map of the study area in Kertek Market and Wonosobo Main Market in Wonosobo District, Central Java, Indonesia

In our study, we obtained responses from 90 people of Javanese ethnicity across two markets in Wonosobo: Kertek Market and Wonosobo Main Market. Overall, there were 46 women and 44 men. At Wonosobo Main Market, 53 respondents participated, with a significantly higher number of men (33 respondents) compared to women (20 respondents). In contrast, Kertek Market had 37 respondents, showing a more balanced proportion of 26 women and 11 men respondents.

Data analysis

Data processing was conducted using a qualitative descriptive analysis method, where data obtained from the interviews were classified based on the categories of questions and answers. Microsoft Excel was employed as a supporting tool to organize and quantify the categorized data. These results were then converted into numerical form and visualized through graphs to facilitate the identification of patterns. Although Excel was used for quantification and visualization, the analysis remained descriptive and interpretative in nature. Descriptive analysis was used to provide comprehensive interpretation using scientific article references as an additional form of interpretation.

RESULTS AND DISCUSSIONS

Demographic characteristics in Kertek Market and Wonosobo Main Market

The majority of participants in this survey were female, accounting for 51.1% of the total respondents, while males comprised only 48.9% (Figure 2). This indicates a predominance of female respondents. Nearly all respondents were native residents of Wonosobo, with only about 2% from outside the area, indicating strong local community involvement.

The age range of respondents reveals significant variation. People with an age range of 46-55 years have the largest percentage, which is 27.8%. People with an age range of 26-35 years have a smaller percentage, which is 15.6%. These demographics provide a comprehensive perspective, revealing that the survey encompasses various life stages and community segments, which is crucial for understanding local perceptions of traditional food in Wonosobo.

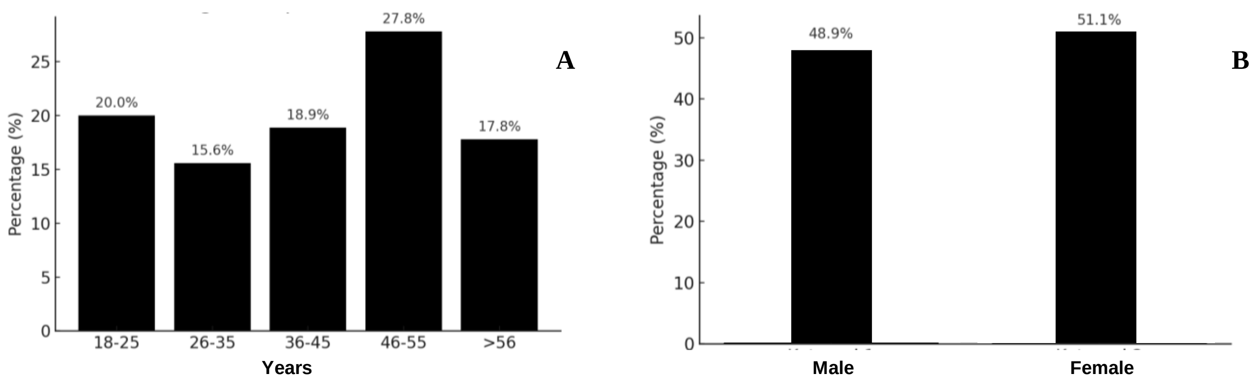


Figure 2. Demographic characteristics: A. Age; B. Gender

Frequency of traditional food consumption in Kertek Market and Wonosobo Main Market

Figure 3 shows that the majority of respondents, 60%, consume traditional food daily. This shows that traditional food consumption is still very high in the daily lives of the Wonosobo people. Apart from that, 18.9% of respondents consume traditional food weekly. Although not as often as the group who consumes it every day, they still consume traditional foods quite regularly.

On the other hand, 4.4% of people only consume traditional food once a month. This rare frequency can be caused by busyness or other priorities in daily life. This weekly and monthly consumption is due to demands for a more hygienic lifestyle, where people prefer to cook for themselves at home rather than buy it at traditional markets. Despite this, they still maintain traditions by consuming traditional foods regularly, although not as often as other groups. There are also people with a percentage of 16.7% who only eat traditional food very rarely. This is caused by preferences that tend towards modern food or lifestyle demands that do not support the consumption of traditional food. Nevertheless, they still have the awareness to maintain traditions, even in a small portion. Overall, the graph shows that consumption of traditional food is still quite high among respondents, which is a promising sign for the future of traditional food culture. However, there are significant differences in frequency between groups who consume it daily, weekly, monthly, and rarely.

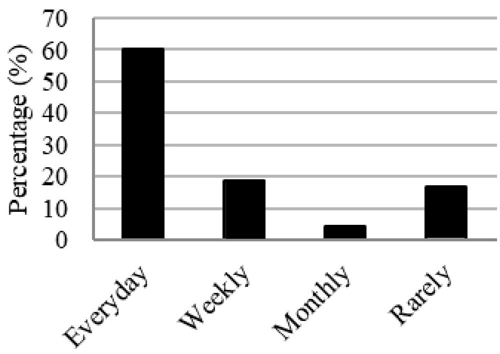


Figure 3. Frequency of traditional food consumption

Local views of the significance of traditional food in Kertek Market and Wonosobo Main Market

Figure 4 revealed that 62% of respondents identify traditional food as food that is specific or unique to a certain area. Then, 23% of respondents believe that traditional production methods influence the definition of traditional food. A percentage of 11% of the community also states that traditional food does not use any additives or is free from chemicals. Only a small portion of the community (3%) defines traditional food as produce from the agricultural sector.

The availability of traditional food at the Wonosobo Main Market and Kertek Market based on the results of interviews, it was found that a lot of traditional food is sold in both markets for various reasons. Firstly, traditional food has a special place in the hearts of the local people, where traditional markets are often visited by people looking for authentic flavors that are difficult to find elsewhere, so the demand remains high. In addition, the availability of local raw materials around traditional markets, such as vegetables, fruits, spices, and other products, makes it easier for traders to get raw materials at more affordable prices and good quality. Cultural factors and customs also come into play, as traditional foods are often associated with local traditions, and traditional markets are a great place to sell food rooted in local customs and traditions. Affordable prices in traditional markets are also the reason, as lower operational costs make the products sold, including traditional foods, more accessible to different walks of life. Local wisdom also supports this, where traders are often direct producers or have close relationships with producers, and they may follow family recipes or traditional processing methods that have been passed down from generation to generation so that the food sold is more authentic. The social environment in traditional markets that supports interaction between sellers and buyers is crucial. It allows for direct communication about consumer preferences, helping merchants understand local tastes and tailor the products sold. This emphasis on social interactions makes consumers feel understood and catered to, enhancing their experience in traditional markets.

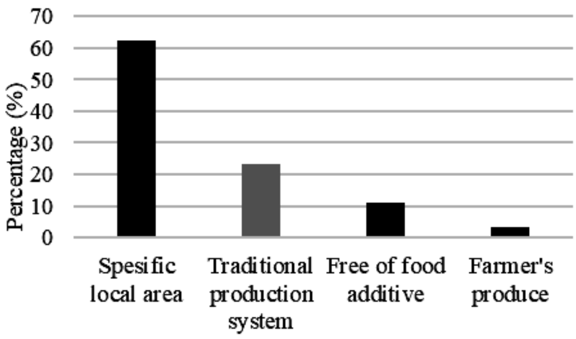


Figure 4. Definition of traditional food based on the community at Kertek Market and Wonosobo Main Market, Wonosobo District, Central Java Province, Indonesia

Local perceptions regarding characteristics of traditional food in Kertek Market and Wonosobo Main Market

As many as 66% of respondents strongly agreed with the existence of traditional food in both markets, namely Kertek Market and Wonosobo Main Market (Figure 5). This reflects the high enthusiasm of the community towards traditional food. The quality of traditional food also received a good response, with a percentage of 60% of respondents strongly agreed that the quality of traditional food in both markets is satisfactory and 36% of respondents agreed that the quality of traditional food in both markets is satisfactory. This suggests that the majority of the community perceives the quality of traditional food in both markets as quite good. The qualities in question are food hygiene and environmental friendliness. People pay attention to specific characteristics of traditional foods, with the aspect "GMO-free" being the most important at 50%. Responses also highlighted the importance of foods that are "free of chemical additives" and "organic products." The organic products referred to are food ingredients that are not mixed with pesticides and other ingredients, while being free from chemicals, the criteria for these foods is that they are not mixed with preservatives and other additives like modernized foods.

The percentage of respondents who disagree with the response that traditional food is healthier than modern food is small, 5-10% disagree. However, the assumption that modernized food will affect traditional food in the Traditional Market showed the largest value, which was 31%. Local people think that even with the presence of modernized food, they will prefer traditional food because it has become an everyday food and still has a strong appeal to the community. The majority of respondents who disagree with traditional food are minors or teenagers. This shows that although traditional food has high cultural and health value, the increasing influence of modern food also changes people's perceptions in choosing types of food.

Preference local towards traditional food with modernized food in Kertek Market and Wonosobo Main Market

Figure 6 reveals how people in Kertek Market and Wonosobo Main Market prefer traditional food to modern food. People with a percentage of 72% strongly agree that they prefer traditional food to modern food. 70% of people strongly agree that traditional food is healthier than modern food and the availability of modern food can affect the existence of traditional food in Traditional Markets with a percentage of 49% strongly agreeing regarding this. Meanwhile, 20-21% agree that people prefer traditional food to modern food, consider traditional food to be healthier than modern food, and the existence of modern food can affect the availability of traditional food.

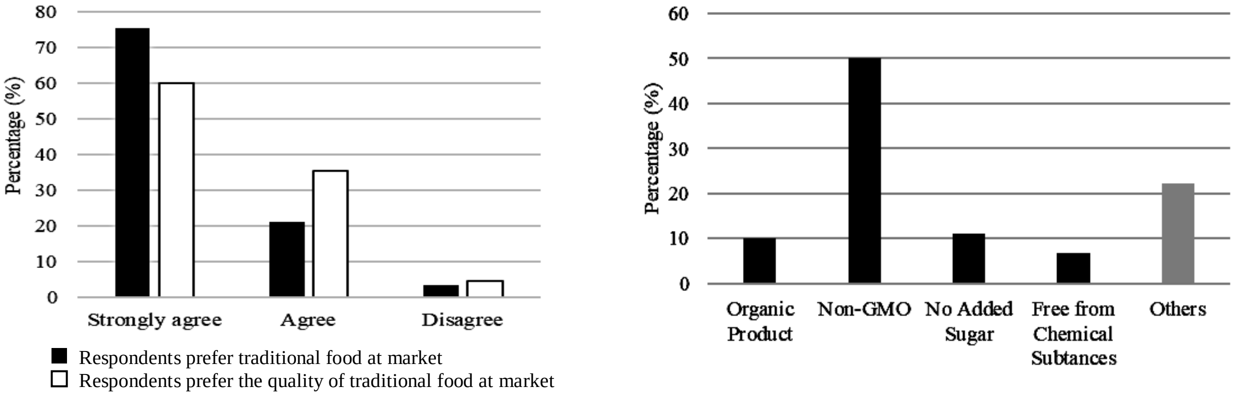


Figure 5. Perceptions of the community regarding traditional food at Wonosobo Traditional Markets, Wonosobo District, Central Java Province, Indonesia

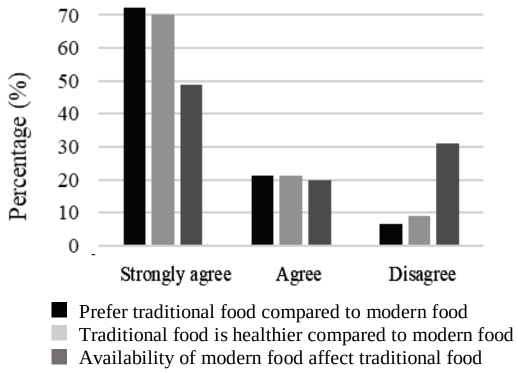


Figure 6. Community preference towards traditional food with modernized food

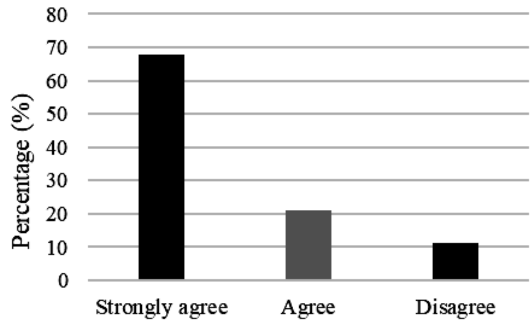


Figure 7. Community preferences on the importance of preserving traditional foods

Local perceptions towards how important traditional food in Kertek Market and Wonosobo Main Market

Based on the findings regarding public perceptions of traditional foods in both Kertek Market and Wonosobo Main Market, the availability of these foods is considered important to preserve (Figure 7). The public recommends a number of actions to increase the visibility of traditional foods, such as increasing online sales and using social media to promote them. The rise of food media and internet platforms has greatly impacted consumer preferences and the dissemination of traditional food. Similar to the research of Rajan (2023), technology's role in traditional food is continually reshaping our perceptions and experiences of the cuisine of traditional food. Additionally, innovations in flavor and packaging that align with current trends are viewed as effective ways to increase young people's interest in consuming traditional foods. In Indonesia, for instance, some innovative packaging for traditional foods has been successfully conducted, and the products are successfully marketed, such as 'hygienic tempe' as the innovative product of traditional tempe, 'canned gudeg' as the innovative product of 'gudeg besek', 'sambal in a jar' as the innovative product of 'homemade sambal', and 'powdered coconut milk' as the innovative product of fresh coconut milk (Fibri and Frost 2019). In developed countries, traditional food products have been developed. In Western countries, traditional food products are standardized by Geographical Indication (GI). Many of these products are registered as Protected Designation of Origin, Protected Geographical Indication, or Traditional Speciality Guaranteed, and they can be produced on a small to large industrial scale (Fibri et al. 2022).

Discussion

Demographically, this research is dominated by women respondents of various ages. The availability of information regarding demographic data can show each individual's views regarding traditional food at The Wonosobo Traditional Market. Things that can influence local consumption patterns are eating patterns and the availability of food ingredients as external factors, as well as internal factors such as age, academics, work, lifestyle, and personality (Khairullah et al. 2020). The results show that the frequency of locals consuming traditional food is every day, followed by the smallest frequency of consuming traditional food every month. The reason why the consumption of traditional food is still high among respondents can be caused by several factors, including the fact that traditional food is part of the cultural heritage that has become part of the lifestyle of the Wonosobo people. Consuming traditional food can be an identity and a way to preserve traditions. People tend to like the taste and texture of traditional food that is familiar and suits their tastes. The ingredients used in traditional food are generally readily available in the local environment, making it convenient for people to consume them. People may think that traditional food, with its rich flavors and superior nutritional content, is of higher quality compared to modern food. The research of Moscatelli et al. (2017) stated that high interest in food is not only assessed based on health but also on cultural and economic factors.

The Wonosobo community sees that the related traditional food is the specific food in the local area or special area. The research of Zrnic et al. (2021) shows that traditional food is best defined as dishes or foods that are passed down from one generation to the next. In almost all countries, this practice preserves the traditional food heritage, an inseparable part of each nation's unique culture. Traditional food often reflects the cultural heritage and identity of a region. For example, traditional foods characteristic of the Wonosobo area includes *tempe kemul*, *mie ongklok*, *gethuk*, *sagon*, *cenil*, *nasi megono*, *geblek*, carica, *dendeng gepuk*, and others. *Tempe kemul* is one of the most frequently served foods because it is an everyday food for the local people of Wonosobo. Many people associate traditional food with being healthier due to its natural ingredients and preparation methods. This belief is supported by the view that traditional foods are less processed and contain fewer additives.

The study showed that most of the local people of Wonosobo tend to pay more attention to the existence of traditional food and the quality of traditional food. Local people consider traditional food to be better because it contains non-GMO. In addition, people also highlighted that the food has no added sugar, including organic products, and is free from chemicals. The products are of high quality due to the use of traditional food and often environmentally friendly raw materials (Feldmann and Hamm 2015). Similar to the research of Kalenjuk Pivarski et al. (2022), the criteria for good quality traditional food can be seen from the freshness of the product, hygiene, and health benefits. In the study by Peulic et al. (2023), the population of Vojvodina tended to have the perception that traditional food is free from added sugar. This is related to public health policies that recommend providing sugar intake due to associated risks such as obesity, diabetes, and heart disease (Balletti et al. 2017). Meanwhile, in the research of Hartmann et al. (2019), it is explained that Serbian consumers consider the presence of GMOs in products as one of the most important factors in their purchasing decisions, according to their report on European consumers perceptions and assessments of the European Union food quality scheme. Local perceptions of GMO-free traditional foods are also related to health. It is claimed that Genetically Modified (GM) crops can lead to antibiotic resistance, the presence of harmful toxins, fungi, toxic metals, and increased cancer risks in humans. Additionally, these crops are said to reduce the nutritional value of food and introduce new allergens and other potential hazards (Ekici and Sancak 2020). This shows that respondents are looking for traditional foods that are free from additives, preservatives, and synthetic ingredients.

Globalization significantly influences food preferences among youth, driven by factors such as fashion, social imitation, and technological advances. It standardizes consumption patterns, fostering a global consumer culture with shared values and attitudes toward brands and products (Hanus 2018). In line with this, interview data from the present study indicated that teenage respondents showed a stronger inclination toward modern food options compared to older age groups. However, globalization can also help local products become internationally recognized. Social media can play an important role, although on the one hand it can encourage the younger generation to tend to choose modern food, but on the other hand traditional food can be recognized by the international community. Social media helps food marketers reach young consumers, especially teenagers, who are easily influenced and not as skeptical about advertising as adults. This makes it easier for them to be swayed by social media marketing (Qutteina et al. 2019). Globalization can open up opportunities for local products to international markets, such as local products made to suit geographical and seasonal conditions so that they can provide a unique impression for tourists. In addition, local culinary festivals introduced to the global market can also strengthen the local identity of the product (Mak et al. 2012). Furthermore, globalization of consumption leads to consumer ethnocentrism, where buyers show a preference for locally made products (Angowski and Lipowski 2014). Therefore, many activities are needed to preserve traditional foods, and maintaining a balance between traditional food sustainability and modern culinary innovation can be an important strategy to meet the preferences of diverse consumers. However, it is important to understand that the modernization of traditional foods and the increase in their production pose serious risks to the preservation of the rich and diverse cultural heritage that accompanies them. The local community also believes that government support is essential for preservation initiatives, such as organizing events that can attract interest or providing special stalls. Furthermore, improving hygiene in the production process is deemed important to ensure that people feel safe and comfortable consuming traditional foods.

In conclusion, local community in Wonosobo have a strong preference for traditional food, which remains a part of their daily consumption and cultural identity. Traditional foods are perceived as healthier, more natural, and free from additives compared to modern alternatives. These findings highlight the urgent need for strategic efforts, especially from local governments and communities to preserve and promote traditional foods in ways that appeal to evolving consumer preferences, particularly among youth.

ACKNOWLEDGEMENTS

The researcher would like to thank all traders in Kertek Market and Wonosobo Main Market who have contributed to the research. The researcher also thanks the Department of Environmental Sciences, Faculty of Mathematics and

Sciences, Sebelas Maret University, and other participants whom we can't mention one by one for their support.

REFERENCES

Afif Z, Azhari DS, Kustati M, Sepriyanti N. 2023. Scientific research (quantitative) along with paradigms, approaches, basic assumptions, characteristics, data analysis methods and outputs. INNOVATE: J Soc Sci Res 3 (3): 682-693. [Indonesian]

Angowski M, Lipowski M. 2014. Choice of food products and their place of purchase. Marketing iRynek 2014 (6): 4.

Belletti G, Marescotti A, Touzard JM. 2015. Geographical indications, public goods, and sustainable development: The roles of actors' strategies and public policies. World Dev 98: 45-57. DOI: 10.1016/j.worlddev.2015.05.004.

Dominique-Ferreira S, Braga RJ, Rodrigues BQ. Rodrigues. 2021. Role and effect of traditional markets: The internationally awarded case of Barcelos. J Glob Scholars Mark 32 (3): 470-492. DOI: 10.1080/21639159.2020.1808852.

Edwards R, Holland J. 2020. Reviewing challenges and the future for qualitative interviewing. Intl J Soc Res Methodol 23 (5): 581-592. DOI: 10.1080/13645579.2020.1766767.

Ekici K, Sancak YC. 2020. A perspective on genetically modified food crops. Intl J Manures Fertilizers 5 (2): 1-4.

Feldmann C, Hamm U. 2015. Consumers' perceptions and preferences for local food: A review. Food Qual Prefer 40: 152-164. DOI: 10.1016/j.foodqual.2014.09.014.

Fibri DLN, Ayouaz S, Utami RF, Muhammad DRA. 2022. Current situation and future direction of traditional foods: A perspective review. Camera J: Food Technol Nutr Culinary 5 (1): 112-126. DOI: 10.20956/canrea.v5i1.633.

Fibri DLN, Frøst MB. 2019. Consumer perception of original and modernised traditional foods of Indonesia. Appetite 133: 61-69. DOI: 10.1016/j.appet.2018.10.026.

Florek M, Gazda J. 2021. Traditional food products—Between place marketing, economic importance and sustainable development. Sustainability 13 (3): 1277. DOI: 10.3390/su13031277.

Hanus G. 2018. Traditional or modern? Preferences of young consumers in the food market-literature and researches review. Intl J Econ Business Manag Res 2 (1): 90-99.

Harsana M, Rinawati W, Fauziah A. 2023. Inventory of traditional food to support the development of culinary tourism. JPPI (Jurnal Penelitian Pendidikan Indonesia) 9 (1): 81-86. DOI: 10.29210/020221974. [Indonesian]

Hartmann M, Yeh CH, Amilien V, Čeliković Z, Csillag P, Filipovic J, Giraud G, Gorton M, Menozzi D, Quarrie S, Roos G. 2018. Report on Quantitative Research Findings on European Consumers' Perception and Valuation of EU Food Quality Schemes as well as their Confidence in Such Measures. [Doctoral Dissertation]. Newcastle University, United Kingdom.

Hermawan H. 2022. Thermal investigation at Wonosobo Market, Indonesia. J Architectural Res Educ 4 (2): 95-102. DOI: 10.17509/jare.v4i2.50724.

Irianto AM. 2016. Commodification of culture in the era of global economy on local wisdom: A case study of the existence of the tourism industry and traditional arts in Central Java. Jurnal Theologia 27 (1): 212-236. DOI: 10.21580/teo.2016.27.1.935. [Indonesian]

Iskandar BS, Iskandar J, Mulyanto D, Aliifah F. 2023. Local knowledge of the Sundanese community on traditional foods to enhance the family food security. ETNOSIA: Jurnal Etnografi Indonesia 8 (1): 76-89. DOI: 10.31947/etnosia.v8i1.24461.

Islam MA, Aldaihani FM. 2022. Justification for adopting qualitative research method, research approaches, sampling strategy, sample size, interview method, saturation, and data analysis. J Intl Business Manag 5 (1): 1-11. DOI: 10.37227/JIBM-2021-09-1494.

Kalenjuk Pivarski B, Šmugović S, Tekić D, Ivanović V, Novaković A, Tešanović D, Banjac M, Đerčan B, Peulić T, Mutavdžić B, Lazarević J. 2022. Characteristics of traditional food products as a segment of sustainable consumption in Vojvodina's hospitality industry. Sustainability 14 (20): 13553. DOI: 10.3390/su142013553.

Khairullah M. 2020. Analysis of the influence of demographic variables on buying interest in traditional snacks in Kraton District Yogyakarta. IJIEB: Indones J Islamic Econ Business 5 (1): 15-31. [Indonesian]

Klara MS. 2023. The role of stakeholders in the strategy of developing local culinary as a tourist attraction in the Dieng Highlands of Wonosobo, Central Java. Edunity 2 (12): 1394-1409. DOI: 10.57096/edunity.v2i11.180.

Kurniawan N, Hanjani VP. 2023. the fading existence and shifting value of traditional snacks: A case study of es gempol pleret in Semarang. Sabda: Jurnal Kajian Kebudayaan 18 (2): 14-28. DOI: 10.14710/sabda.18.2.14-28. [Indonesian]

Lestari NS, Christina C. 2018. Doclang, a traditional food that's starting to fall by the wayside. Khasanah Ilmu-Jurnal Pariwisata dan Budaya 9 (2): 21-27. DOI: 10.31294/khi.v9i2.5224. [Indonesian]

Mak AHN, Lumbers M, Eves A. 2012. Globalisation and food consumption in tourism. Ann Tour Res 39 (1): 171-196. DOI: 10.1016/j.annals.2011.05.010.

Miftah H, Marfuah E, Mubarokah S, Yoesdiarti A, Pramartaa IQ. 2023. Market conduct analysis of salak pondoh commodities (*Salacca edulis reinwardt*) sold in traditional market. Jurnal Sosial Humaniora 14 (2): 177-186. DOI: 10.30997/jsh.v14i2.10112. [Indonesian]

Moscatelli S, Gamboni M, Dernini S, Capone R, El Bilali H, Bottalico F, Debs P, Cardone G. 2017. Exploring the socio-cultural sustainability of traditional and typical agro-food products: Case study of Apulia Region, South-eastern Italy. J Food Nutr Res 5 (1): 6-14. DOI: 10.12691/jfnr-5-1-2.

Muafani, Hidayah A. 2017. Identification of Wonosobo Heritage Buildings. E-Proceeding of the 2nd International Nusantara Cultural Heritage Symposium 2017, Faculty of Civil Engineering and Planning, Universitas Bung Hatta. [Indonesian]

Mulyani PA, Sudiartini NWA, Sariani NLP. 2020. Behavior of people in Denpasar City in consuming fast food. JUIMA: Jurnal Ilmu Manajemen 10 (2): 90-103. DOI: 10.36733/juima.v10i2.1398. [Indonesian]

Nurhayati E, Ekowati VI, Meilawati A. 2014. Inventory of Javanese traditional foods with sesaji elements in traditional markets of Bantul District. Jurnal Penelitian Humaniora 19 (2): 124-140. DOI: 10.21831/hum.v19i2.8039. [Indonesian]

Peulic T, Maric A, Maravic N, Novakovic A, Pivarski BK, Cabarkapa I, Lazarevic J, Smugovic S, and Ikonic P. 2017. Consumer attitudes and preferences towards traditional food products in Vojvodina. Sustainability 2023 (15): 1-17. DOI: 10.3390/su151612420.

Purba EC, Silalahi M, Nisyawati. 2018. gastronomic ethnobiology of "terites" a traditional Batak Karo medicinal food: A ruminant's stomach content as a human food resource. J Ethn Foods 5 (2): 114-120. DOI: 10.1016/j.jef.2018.06.002.

Romulo A, Surya R. 2021. Tempe: A traditional fermented food of Indonesia and its health benefits. Intl J Gastronomy Food Sci 26 (2021): 1-9. DOI: 10.1016/j.ijgfs.2021.100413.

Qutteina Y, Hallez L, Mennes N, De Backer C, Smits T. 2019. What do adolescents see on social media? A diary study of food marketing images on social media. Front Psychol 10: 2637. DOI: 10.3389/fpsyg.2019.02637.

Rajan A. 2023. Gastronomic evolution: A review of traditional and contemporary food. Intl J Multidimens Res Perspect 1 (2): 62-76.

Rocillo-Aquino Z, Cervantes-Escoto F, Leos-Rodríguez JA, Cruz-Delgado D, Espinoza-Ortega A. 2021. What is a traditional food? Conceptual evolution from four dimensions. J Ethn Foods 8: 38. DOI: 10.1186/s42779-021-00113-4.

Turner KL. 2023. Biocultural diversity, Campesino kitchens, and globalization: Ethnobiological perspective on dietary change in Southern Bolivia. J Ethnobiol 39 (1): 110-130. DOI: 10.2993/0278-0771-39.1.110.

Zrnić M, Brdar I, Kilibarda N. 2021. The importance of traditional food quality-the viewpoint of the tourism. Meat Technol 62 (1): 69-76. DOI: 10.18485/2021.62.1.7.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025 E-ISSN: 2580-4510
Pages: 57-78 DOI: 10.13057/asianjethnobiol/y080106

Ethnozoological documentation of traditional vertebrate-based practices in the mountainous regions of Eastern Anatolia from Erzurum, Ardahan, Iğdır, and Kars (Turkey)

SONGÜL KARAKAYA[1,♥], ZEHRA KIMIŞOĞLU[2], ÜMİT İNCEKARA[3], AHMET POLAT[3], YUSUF ZİYA SÜMBÜLLÜ[4], ÖZKAN AKSAKAL[3]
[1]Department of Pharmaceutical Botany, Faculty of Pharmacy, Atatürk University. Erzurum 25240, Turkey.
Tel.: +90-244-223-15-250, ♥email: songul.karakaya@atauni.edu.tr
[2]Department of Turkish Language and Literature, Faculty of Arts and Sciences, Kafkas University. Kars 36100, Turkey
[3]Department of Biology, Faculty of Science, Atatürk University. Erzurum 25240, Turkey
[4]Department of Turkish Language and Literature, Faculty of Arts and Sciences, Erzurum Technical University. Erzurum 25240, Turkey

Manuscript received: 21 February 2025. Revision accepted: 3 May 2025.

Abstract. *Karakaya S, Kimişoğlu Z, İncekara Ü, Polat A, Sümbüllü YZ, Aksakal Ö. 2025. Ethnozoological documentation of traditional vertebrate-based practices in the mountainous regions of Eastern Anatolia from Erzurum, Ardahan, Iğdır, and Kars (Turkey). Asian J Ethnobiol 8: 57-78.* The mountainous and moorland regions of Eastern Anatolia, particularly Erzurum, Ardahan, Iğdır, and Kars, harbor a wealth of traditional knowledge regarding the medicinal and cultural use of vertebrate species. This study aims to document and analyze local ethnozoological practices, emphasizing the cultural significance of vertebrates in traditional healthcare systems shaped by Turkey's diverse ecological and socio-cultural landscape. Between 2017 and 2021, an ethnobiological field survey was conducted across 180 villages (Erzurum: 60, Ardahan: 40, Iğdır: 30, Kars: 50), involving 600 participants, including traditional healers and knowledgeable community members. Data were collected through semi-structured questionnaires, informal interviews, and participant observations and analyzed using the Fidelity Level (FL) index. A total of 28 vertebrate species from 26 genera and 23 families were recorded, yielding 249 distinct applications. These uses were categorized into culturally embedded domains: human medicine (135 uses), utilitarian practices (81), veterinary treatments (24), and plant-based remedies for animal health (9), reflecting the interwoven nature of cultural and medicinal knowledge systems. Notably, nine species exhibited high consensus in use, with FL values ranging from 94 to 98%. These results underscore the enduring relevance of animal-based remedies and the integration of zoological knowledge into local health traditions. By situating the findings within a broader ethnobiological framework, this study contributes to global discussions on biocultural heritage preservation. It supports the call for biodiversity conservation strategies informed by indigenous knowledge systems.

Keywords: Eastern Turkey, ethnozoology, traditional knowledge, vertebrate ethnomedicine zootherapy

INTRODUCTION

The historical relationship between humans and animals dates back to the origins of humanity, with animals providing essential resources such as food, medicine, and textiles. Biodiversity has been a key source of healing practices across cultures, with communities developing expertise in utilizing natural ecosystems for various needs. Approximately 60% of pharmaceutical drugs are derived from bioactive compounds found in nature, many of which stem from traditional remedies explored by different cultures (Lohani et al. 2008; Jaroli et al. 2010). Ethnozoology studies the complex interactions between humans and animals, with "zootherapy" focusing on using animals and their byproducts to treat illnesses, forming an integral part of many traditional healing systems (Jaroli et al. 2010; Yirga et al. 2011).

Currently, the examination of animal utilization within indigenous communities is conducted across diverse regions worldwide. In the contemporary era, the utilization of animals possessing medicinal attributes has become a widespread phenomenon across the globe. The utilization of animal-derived products for treating human or animal ailments seems to be widespread in specific regions globally, particularly in areas where traditional medicine holds greater significance compared to allopathic medicine. Examples of such regions are Brazil, various parts of the Middle East, Turkey, India, China, and Korea (Jaroli et al. 2010; Kim and Song 2013).

Ethnozoology, as a foundational branch of ethnobiology, explores the multifaceted perceptual, cognitive, and practical relationships between human communities and animal species (Gutiérrez-Santillán et al. 2019). While traditional ethnozoological studies have often centered on the utilitarian value of fauna, recent perspectives call for a paradigmatic shift—one that moves beyond anthropocentric frameworks and acknowledges animals not solely as resources but as co-inhabitants within shared ecosystems. This includes embracing intercultural dialogues between academic zoologies and local ontologies, thus fostering alternative epistemologies for coexistence and multispecies justice (Descola 2013; Kohn 2013). This perspective also promotes the consideration of species traditionally viewed as culturally 'insignificant,' encouraging a more inclusive ethical framework and greater acknowledgment within ethnozoological studies (van Dooren 2014). Traditional medicine has significantly contributed to modern drug discovery, leading to the development of key pharmaceuticals like digitoxin, reserpine, tubocurarine, and ephedrine. Notably, of the 252 essential compounds recognized by the World Health Organization, approximately 8.7% are derived from animal sources (Kendie et al. 2018).

Anatolia boasts an exceptional abundance of flora and fauna, ranking among the world's top regions for biodiversity. Despite this distinction, there is a notable scarcity of comprehensive global cross-cultural studies. Over its extensive history, Anatolia has served as a melting pot for diverse civilizations, each leaving an indelible mark on its cultural landscape. The diverse knowledge systems of its inhabitants across different eras can be readily explored through the wealth of resources found within Anatolia's museums and archaeological sites (Yenmiş et al. 2018). In Turkish folk culture, research and analysis studies have been carried out on many animals, especially horses, wolves, sheep, goats, camels, snakes, and deer, and their places in folk culture have been determined (Çiçek et al. 2020).

Turkey's rich wildlife history, dating back to the Pleistocene era, includes a variety of mammals, reptiles, and birds. As a global biodiversity hotspot, Turkey has a strong connection with animals, reflected in both urban and rural life. The regions of Central and Southeastern Anatolia served as some of the earliest hubs for the domestication of livestock, including pigs, sheep, goats, and cattle. Animals also play therapeutic and symbolic roles, with species like birds of prey, wolves, bulls, horses, and scorpions symbolizing life, death, or fortune. Studying these relationships through ethnozoology and sociology enhances our understanding of Turkey's cultural heritage and human-nature dynamics (Emre 2023).

Hence, to address this gap, the present study explicitly asks: What vertebrate species are traditionally used for medicinal purposes in the provinces of Erzurum, Ardahan, Iğdır, and Kars, and what cultural meanings and therapeutic functions are attributed to these uses by local communities? This research aims to (i) document vertebrate species used in traditional medicine in these provinces; (ii) categorize their medicinal, veterinary, and symbolic roles; and (iii) analyze the cultural and ecological knowledge that shapes these uses. By articulating this research question, we aim to provide a structured contribution to the field of ethnozoology in Turkey while also situating the study within global discourses on the preservation of indigenous knowledge systems. This work not only enriches our understanding of traditional healing practices but also contributes to biodiversity conservation and the recognition of cultural heritage.

MATERIALS AND METHODS

Study area

Situated at the crossroads of Asia, Europe, and Africa, Turkey is a transcontinental nation extending between 36-42° N latitude and 26-45° E longitude. Encompassing a total area of 783,562 km², the majority of its territory (97%) lies within the Asian continent (Anatolia), while the remaining 3% is situated in Europe. Geographically, the country is categorized into seven distinct regions, each defined by unique climatic conditions, vegetation types, and agricultural practices. Among these, the Eastern Anatolia Region (EAR) stands as the largest, covering nearly 163,000 km². Iraq, Iran, Nakhichevan, Armenia, and Georgia border it. It is characterized by its high altitude, averaging 2,000 meters, and its rugged terrain, which includes extensive mountain ranges, high plateaus, and broad plains (Bakirci and Kirtiloglu 2022).

Eastern Anatolia, Turkey's largest geographical region, exhibits distinctive climatic features shaped by its topography. Encircled by coastal mountain ranges, the region is largely insulated from the tempering effects of maritime air masses. As a result, winters tend to be long and harsh, with snowfall dominating the precipitation and remaining on the ground for extended periods. The short spring season is marked by rainfall, which is soon followed by a dry and intensely hot summer (Özgökçe and Özçelik 2004). The exact location of the study area is illustrated in Figure 1.

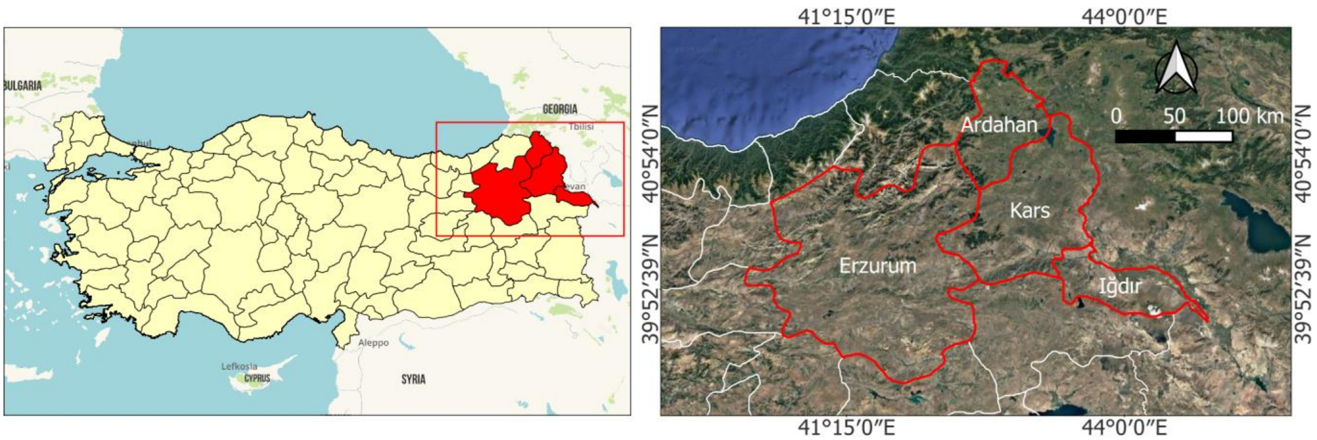


Figure 1. Study area location. The approximate coordinates of the main cities in the study region are as follows: Erzurum (39.9334° N, 41.2674° E), Ardahan (41.1100° N, 42.7028° E), Iğdır (40.3667° N, 44.0400° E), and Kars (40.6167° N, 43.1000° E) Provinces in Turkey. These coordinates indicate the general geographical positions of the cities within the Eastern Anatolia Region

Eastern Anatolia hosts 444 wild plant taxa belonging to 62 families that are traditionally utilized for medicinal purposes. Among these, the most frequently represented families are Asteraceae (93 taxa), Lamiaceae (52), Rosaceae (30), Fabaceae (27), and Boraginaceae (20). The most commonly used genera include *Achillea* and *Centaurea* (11 taxa each), followed by *Scorzonera* (9 taxa), as well as *Euphorbia*, *Salvia*, and *Alcea* (8 taxa each). Despite the region having the highest plant endemism rate in Turkey (25%), only around 8% of the medicinal taxa are endemic to this area (Altundag and Ozturk 2011). From 1927 to 2012, Turkey experienced a major shift in population dynamics, with urbanization increasing rapidly. The urban population grew from 3.3 million (24.2%) to 56.4 million (74.6%), driven by internal migration and developments in transportation and communication. A key turning point was the 1950s, after which urban growth accelerated sharply. Meanwhile, the rural population declined from 75.8% to 25.4%. This transformation reflects a broader national trend, showing that urbanization in Eastern Anatolia aligns with Turkey's overall demographic evolution (Coşkun 2013).

Data collection

The study involved a comprehensive survey across provincial centers, districts, and rural settlements in Ardahan, Iğdır, Kars, and Erzurum. An irregular survey design was adopted to allow for flexibility across diverse field conditions. Both male and female residents of the region were presented with structured questions aimed at eliciting their local zoological knowledge. The responses collected were subsequently compiled to generate a detailed ethnozoological profile of the region. An ethnozoological inventory was systematically constructed using the insights shared by participants from designated pilot regions. Prior to data collection, all participants received a detailed briefing outlining the study's objectives and procedures. Interviews were then conducted with voluntary participants, during which their traditional zoological knowledge was carefully documented. In addition to ethnozoological data, demographic information was also collected to explore potential correlations between socio-cultural factors and the transmission of local zoological knowledge. These demographic parameters, such as age, gender, education, occupation, and residency, are summarized in Table 1, providing a basis for examining socio-economic influences on ethnozoological knowledge. A sample size of 600 participants was determined based on regional population densities and the need for representative data across the 180 surveyed villages. This number was deemed adequate to ensure both demographic and cultural diversity, thereby enhancing the robustness of the findings. The fieldwork for this study was conducted within the framework of the nationally coordinated project “Recording Traditional Knowledge Based on Biodiversity”, overseen by the Ministry of Agriculture and Forestry of the Republic of Turkey. This project spans all provinces of the country, and all data collected are systematically archived in the national database known as the Traditional Knowledge Management System. The results presented in this article originate specifically from field activities carried out in the designated provinces under the responsibility of our research team. These activities were conducted in collaboration with local village headmen (muhtars) and formally communicated to the relevant provincial governorships. In accordance with the standardized national protocol applied uniformly across Turkey’s 81 provinces, no additional ethical approval was required. Numerous academic publications have emerged from this initiative, none of which necessitated separate ethical committee reviews, given that the overarching project has been officially sanctioned at the national level. To ensure both cultural sensitivity and methodological clarity, the interview forms and related instruments were pilot-tested prior to full implementation and adjusted as necessary based on feedback. After the fieldwork and face-to-face interviews were completed, participants' responses were transcribed into digital form. This allowed for the generation of individualized reports and the categorization of data based on demographic characteristics, thereby facilitating structured comparative analysis across different participant groups. In order to preserve data integrity, all interviews were recorded using digital voice recorders, following the participants' explicit verbal consent. This practice helped minimize the risk of information loss or misinterpretation during subsequent analysis. Any inconsistencies or unclear segments in the audio recordings were reviewed and resolved promptly, thus enhancing the overall accuracy and reliability of the research outcomes.

Quantitative analysis

To determine the most culturally significant animal species used in treating specific health conditions, the Fidelity Level (FL) was employed. This quantitative index helps reveal the relative therapeutic importance of each species by measuring the level of consensus among informants regarding its use. The FL reflects the percentage of participants who cited the same species for a particular ailment, thus offering insight into the specificity and reliability of its ethnomedical application. The FL was calculated using the formula:

$$FL = (Np / N) \times 100$$

Where: Np = Denotes the number of participants who mentioned the use of a species for a particular disease; N = Represents the total number of individuals who referred to that species for any medicinal purpose.

FL values range from 1 to 100%, with higher percentages indicating a strong agreement among respondents regarding the species’ use for a particular ailment. Conversely, lower FL values point to less agreement, suggesting a broader or more variable range of uses. This method has been widely adopted in ethnobiological research to assess the cultural salience of species in traditional healing practices (Friedman et al. 1986; Alexiades 1996; Jaroli et al. 2010; Kim and Song 2013).

RESULTS AND DISCUSSION

Demographic characteristics of study participants

Demographic data of the participants were obtained through in-person interviews, ensuring broad representation of the local communities throughout the study region. In total, 600 individuals participated in the study from 180 villages located in the provinces of Erzurum, Kars, Ardahan, and Iğdır. The distribution of participants by province was as follows: 202 individuals from Erzurum (111 women, 91 men), 149 from Kars (68 women, 81 men), 129 from Ardahan (52 women, 77 men), and 120 from Iğdır (46 women, 74 men). Special attention was given to selecting participants recognized by their communities for their traditional knowledge and practical experience. These included elderly women over the age of 60, midwives, shepherds, and individuals known locally as "healers" or "traditional practitioners." Their contributions enriched the dataset with deeply rooted cultural insights and traditional zoological knowledge. This broad demographic base ensured that the data reflected a wide array of cultural and ecological knowledge systems. The sample regional and gender diversity allowed for comparative analyses between different provinces and social groups, which strengthened the study's findings on the cultural transmission and preservation of ethnozoological knowledge. A detailed demographic summary, including participants' age, gender, educational level, occupation, and residency, is provided in Table 1.

Medicinal animals for humans

An extensive ethnomedicinal investigation recorded the utilization of 30 different animal species used in traditional medicine, spanning 25 genera and 22 families, and yielding a total of 135 unique therapeutic applications (Table 2). The most frequently cited therapeutic use was for hemorrhoids (6.67%), followed by rheumatism and wound treatment (each 5.93%), and eczema (5.19%). These findings emphasize the significance of animal-based remedies in addressing a broad spectrum of human health conditions within traditional medical systems. In terms of material usage, 25 different animal parts were reported. Meat emerged as the most commonly used component (40%), followed by fat (36%) and feces (32%), suggesting a strong reliance on accessible and multifunctional animal products. Key species with the highest number of citations included *Gallus gallus* f. *domesticus* (14 uses), *Capra aegagrus hircus* (12), *Erinaceus europaeus* Linnaeus, 1758 (12), *Salmo trutta* Linnaeus, 1758 (10), *Ovis aries* subsp. *aries* (9), *Bos taurus* Linnaeus, 1758 (9), and *Ursus arctos* Linnaeus, 1758 (8). These frequent mentions indicate the central role these species play in the cultural pharmacopeia of the region. The implications of these results reflect both ecological availability and deep-rooted ethnomedical traditions, which highlight the necessity of preserving local knowledge systems.

Medicinal animals for animal

A total of 19 animal species with medicinal value, belonging to 15 genera and 12 families, were documented as being used in 24 distinct ethnoveterinary treatment practices (Table 3). The most commonly reported ailments treated with these remedies were wounds and eczema, each accounting for 12.2% of all therapeutic applications. These findings underscore the continued importance of animal-based remedies in supporting livestock health and demonstrate a strong dependence on traditional veterinary knowledge in rural communities.

The survey also identified 11 different types of animal-derived materials employed in treatments. Among these, fat emerged as the most frequently used component (44.46%), followed by feces (27.27%), indicating a preference for materials that are both accessible and functionally adaptable. *Capra aegagrus hircus* (reported 5 times) and *Ovis aries* subsp. *aries* (reported 3 times) were the most frequently cited species, highlighting their prominent roles in local healing practices. Overall, the results reflect a well-established body of ethnoveterinary knowledge, illustrating how animal-based biological resources remain deeply embedded in traditional livestock care systems.

Table 1. Demographic characteristics of the participants

Localities	Erzurum	Ardahan	Iğdır	Kars
Demographic characteristics				
Age				
31-40	12	7	5	10
41-50	49	40	20	26
51-60	53	33	41	47
61-70	55	29	35	42
70 above	33	20	19	24
Gender				
Female	111	52	46	68
Male	91	77	74	81
Educational level				
Illiterate	95	45	41	61
Primary school	85	51	45	52
Secondary school	14	25	25	23
High school	6	5	7	9
University	2	3	2	4
Employment status				
Housewife	111	52	46	68
Farmer	44	46	42	47
Pensioned	33	23	23	24
Shepherd	9	6	6	8
Other jobs	5	2	3	2
Total	202	129	120	149

Medicinal plants for animals

In the context of animal healthcare, eight medicinal plant species representing eight genera and six families were documented, resulting in nine distinct ethnoveterinary treatment practices (Table 4). These plants were predominantly used in traditional practices aimed at treating animal ailments, with the most common application being for snakebite treatment and snake repellent purposes, comprising 33.3% of all reported uses. This finding underscores the perceived importance of plant-based interventions in managing venomous threats within local pastoral systems. Five different plant parts were cited in the preparations. Aerial parts were the most frequently used (44.44%), followed by leaves (22.22%), while stems, seeds, and roots were employed less often but still held medicinal relevance. Among the recorded species, *Juglans regia* L. emerged as the most frequently referenced, indicating its prominent role in ethnoveterinary knowledge. Overall, the findings emphasize the integration of botanical resources in traditional animal health strategies and reflect a nuanced understanding of local flora for veterinary purposes.

Animal species for different purposes

A comprehensive survey identified a total of 16 families, 19 genera, and 21 species of medicinal animals, yielding 81 distinct usage applications for various traditional purposes (Table 5). These animals were most commonly involved in practices embedded in relational ontologies and situated knowledge systems, with amulet-related applications representing the most frequently reported category (18.52% of all uses). Rather than reducing these uses to matters of "belief," which risks reinforcing a binary between academic knowledge and local epistemologies, this study approaches them as expressions of alternative ontological frameworks. As emphasized by Haraway (2008), Despret (2004), and Descola (2013), these practices reflect different ways of thinking with and through animals, grounded in lived experiences, affective relations, and non-anthropocentric modes of engagement. Recognizing these acts as relational and epistemic rather than symbolic or irrational allows for a more inclusive and respectful account of local knowledge systems within ethnobiology. This was followed by remedies or protections against the evil eye (11.11%), applications involving rennet (4.94%), and usage in traditional games or recreational activities (3.70%). Our analysis indicated that 24 different animal parts were utilized across these diverse purposes. Among these, leather and feces emerged as the most frequently used materials, each representing 29.17% of the total recorded applications. Bones were the second most commonly utilized part, contributing 25%, followed by fat and horns, each accounting for 16.67%. These findings underline the extensive and multifaceted use of animal-derived materials in traditional practices. The most frequently mentioned species included *B. taurus* (16 references), *C. aegagrus hircus* (10 references), and *O. aries* subsp. *aries* (12 references), highlighting their cultural and functional significance within the local community. These results reflect the deep-rooted ethnobiological knowledge and practices that incorporate animal resources for both utilitarian and symbolic purposes.

Data analysis

Fidelity Level (FL). The fidelity level is a valuable indicator for determining which species are most consistently favored by local residents in the treatment of specific ailments. In this study, FL values ranged between 12.0 and 98%. A species with an FL of 100% indicates complete consensus among informants, meaning that all use reports referred to the same therapeutic application of that particular animal (Jacobo-Salcedo et al. 2011).

Then, to ensure better accuracy, the analysis excluded animal species mentioned only once, focusing instead on those with higher Fidelity Levels (FL). The study identified a total of 13 animal species with notably high FL values: 2 species were recorded with an FL of 98%, 4 species with 96%, 3 species with 94%, and 4 species with 92% (Tables 2-5). These findings highlight the consistent reliance of the local community on a select group of species for traditional medicinal purposes, reflecting their perceived efficacy and cultural importance in addressing specific health conditions. The cream derived from the milk of *B. taurus* holds the highest fidelity level (FL) at 96%. It is traditionally applied to burns using a soft material, such as a chicken wing, for effective relief and healing. Similarly, *S. trutta* also demonstrates an FL of 96%, with its entire body being utilized in a unique traditional practice. In this method, individuals suffering from stomach ulcers swallow live specimens measuring 5-7 cm in length, reflecting the deeply rooted cultural practices and a high degree of trust placed in these animal-based remedies for specific ailments.

Among the categories, mammals were the most frequently used, accounting for 6.43% of all recorded applications. This highlights the predominant role of mammals in traditional practices, underscoring their significance in the ethnobiological knowledge of the region. Figures 2 and 3 provide photographic documentation of various traditional applications recorded in the study. These images visually illustrate the diverse uses of vertebrate species in local healthcare and cultural practices. The photographs capture key aspects of treatment methods, preparation techniques, and the specific animal-derived materials utilized by traditional healers and community members. Additionally, they highlight the socio-cultural context in which these remedies are applied, offering valuable insights into the integration of ethnozoological knowledge within daily life.

Table 2. Animal species used for medical purposes in human diseases

Category	Scientific name	Family	Turkish name	Used part	Usage	Locality	FL
Mammals	*Ovis aries* subsp. *aries*	Ovidae	Koyun	Feces	The person with hemorrhoids is made to sit directly on sheep feces.	A,E,K	28%
					A woman who cannot have children is laid lengthwise in warm sheep manure up to her neck. Her body is covered with this manure up to her neck.	E,K	52%
				Fat	Animal fat is applied to the affected area with hemorrhoids.	A	16%
					A mixture of tail fat, meteorite, clove, and cinnamon is crushed in a mortar. It is made into tablets. It is placed in the vagina of women who cannot have children.	A,E	72%
					Tail fat is wrapped directly around the finger affected by whitlow.	E	12%
					It is applied directly to cracked hands.	I	88%
				Leather	To alleviate pain in postpartum women, a freshly sheared sheep pelt is wrapped around the abdomen.	E	60%
				Lung	A piece is placed directly over the aching eye.	E	52%
				Wool	Dirty wool is wrapped around the aching lower back for one night.	A,E,I,K	88%
Reptiles	*Anguis fragilis* Linnaeus, 1758	Anguidae	Ankara, Kör kertenkele	Meat	It is cut into cubes. It is strung on a string and dried. It is turned into powder. It is fed to mothers who cannot have children or to children with developmental delays	A	20%
					It is cut into cubes and dried and fed against unreasonable weight loss (called Mattausur).	A	16%
Birds	*Gallus gallus* f. *domesticus*	Gallidae	Tavuk	Feces	It is given to children in small amounts to help with stomach aches.	A	60%
					It is diluted slightly with water and given to a child or baby experiencing cramps.	A,E	92%
					It is directly applied to the area with swelling.	A,E	52%
					It is wrapped in a cloth around the swollen ear or throat.	E	10%
				Egg	The peel is burned, then crushed into a powder. It is mixed with the egg yolk and applied to burns.	A	29%
					The peel is ground into a powder and used as a hemostatic.	E,K	52%
					The peel is ground into a powder and consumed with chicken to prevent bone loss.	I	72%
					The peel is ground into a powder. If this powder is inhaled through the nose during a nosebleed, the bleeding will stop.	I	60%
					In case of dental inflammation and pain, the yolk of an egg is boiled and placed on the affected area. This procedure is repeated 1-2 times.	I,E	88%
					The yolk is dripped 1-2 drops into the aching ear.	I	80%
					When the yolk is thoroughly roasted in a pan without oil, the resulting egg oil is applied to the burnt area until it heals.	K	
				Fat	The whole chicken is boiled, the resulting oil is applied to the burns with chicken feathers.	E,K	80%
				Gizzard	It is boiled in half a liter of water, and the water is consumed twice a day to relieve kidney pain.	A	28%
				Whole animal	The whole crushed black chicken is wrapped around the aching waist. The bandage that remains overnight is removed in the morning.	A,E,I	88%
Mammals	*Capra aegagrus hircus*	Bovidae	Keçi	Hair	In the treatment of fractures such as those in the foot or arm, if the mixture obtained by mixing egg white with goat hair is applied to the broken foot by placing it between a cloth, it is good for the fracture and accelerates healing.	E	12%
					It is mixed with egg and applied to the forehead as a fever reducer.	A	60%
					For the wounds on children's heads, whole egg white and goat hair are applied by wrapping them around the wound.	A	64%
					In the treatment of scabies, wool is soaked in salt water and applied to the body. After this process is done for a day, a bath is taken.	E	72%

				Fat	Goat fat and sheep fat are mixed and applied to the area with boils.	A	28%
					Beeswax, *Cannabis sativa* aerial part and goat body fat are mixed and brought to a paste consistency, then this mixture is kept in cold. After waiting, it is applied to women in small pieces (like suppositories) for the treatment of infertility.	E	
					Goat fat is mixed with Beeswax to make an ointment and is applied to foot wounds and cracks.	E	31%
				Milk	If you drink a glass of red hairy goat's milk every morning for 9 days, it will relieve shortness of breath.	E	88%
				Leather	A piece of freshly peeled leather is cut and tied to the area with heel spurs. It is left for 2-3 days.	E	52%
					To reduce the pain of women giving birth, freshly cut goatskin is wrapped around the abdomen.	E	16%
				Animal hide	When there are multiple bruised areas on the body, a freshly skinned animal hide is wrapped around the person’s bare body. The same method can also be applied using a sheep hide.	A,E,I,K	88%
				Horn	Its horn is burned. Its ash is applied to the skin for itching and allergies.	E	60%
Mammals	*Bubalus bubalis* (Linnaeus, 1758)	Bovidae	Camış, Manda	Horn	It is ground into powder. After it is mixed with butter and brought to a creamy consistency, it is applied to the body for eczema.	E	50%
				Feces	The foot that is frozen and gangrenous from the cold is wrapped in buffalo feces. It is opened after 1-2 hours and washed. The newly made curd is wrapped in cloth (3 times). Each time the curd remains for 1 day.	E	12%
					Buffalo feces, warmed to body temperature or fresh, is applied to the aching chest.	E	72%
					Fresh buffalo feces is applied directly to fire and water burns.	A,E,I,K	92%
				Earwax	The earwax of a water buffalo is inserted into a person's ear to relieve earache.	I	52%
Mammals	*Meles meles* (Linnaeus, 1758)	Mustelidae	Porsuk	Fat	It is applied directly to the affected area to treat eczema.	A	50%
				Meat	It is eaten boiled against leprosy.	A	16%
					It is eaten boiled against hemorrhoids.	A,K	92%
					It is eaten boiled against rheumatism.	E	80%
Birds	*Anser anser* (Linnaeus, 1758)	Anseridae	Kaz	Fat	The tallow is lightly melted and drunk against bronchitis.	A	20%
					The tallow is applied directly to the area with rheumatism.	E	88%
Reptiles	*Squamata* sp.	Dibamidae	Yılan	Meat	For the treatment of a person who has erysipelas, a snake of any kind is caught. The part of it that is 1 hand span from its head is cut off and thrown away. If the remaining part is boiled and fed to the person, he will be cured of his illness.	K	96%
				Leather	The snake's shirt is ground into powder, mixed into flour and made into buns. It is fed to a person with hemorrhoids.	E	16%
					The snake skin (shirt) is placed in enough olive oil to cover it. It is left for a week. It is mixed until it reaches a paste consistency. It is applied to the hair loss area. It helps new hair to grow.	E,I,K	80%
					If snake skin (shirt) is eaten with bread, the warts will dry up and fall off.	I,K	52%
				Bone	An ointment is obtained by mixing barley flour and cow's milk with snake bones that have been reduced to ashes in a fire. This ointment is applied to the snakebite area.	E,A,K	96%
Mammals	*Erinaceus europaeus* Linnaeus, 1758	Erinaceidae	Kirpi	Meat	It is boiled and eaten against hemorrhoids.	A,E,I,K	92%
					It is boiled and eaten against rheumatism.	E	44%
					It is boiled and its meat is fed to a person to stop coughing.	I	12%
					It is boiled and eaten against leprosy.	A	88%
					It is boiled and eaten against eczema.	A,E,I,K	75%
					It is boiled and eaten against cirrhosis.	I	52%
					It is boiled and eaten against erysipelas as a wound healer.	I	72%
					It is boiled and fed to people who have nocturnal wetting and the boiled water is given to drink.	A,E,I,K	85%
					It is boiled and eaten against syphilis.	E	16%

				Leather	It is wrapped directly for headaches.	A	88%
					It is wrapped directly on the area that has eczema.	A	32%
				Urine	1-2 drops of urine are given to a person with earache. To obtain the urine, the hedgehog is kept in a basin.	I	85%
Mammals	*Lepus europaeus* Pallas, 1778	Leporidae	Tavşan	Feces	Feces are swallowed by people who have nighttime urination.	E,I	16%
				Fat	It is applied to the thorn-bitten part to ensure easy removal and the oil is wrapped to heal that area.	A,E	17%
					It is applied directly to the rheumaticm area.	E	12%
					It is dropped in a warm melted form into the aching ear.	A,E,I	44%
					It is applied directly to the burnt area.	A,E	60%
Mammals	*Sus scrofa* Linnaeus, 1758	Suidae	Domuz	Fat	It is wrapped on the hemorrhoidal nodes for 4-5 hours a day for 5 days in a row.	A,E,K	75%
Mammals	*Equus asinus* Linnaeus, 1758	Equidae	Eşek	Blood	It is applied directly to the burned area.	A	16%
					Donkey's blood is applied to the itchy areas of a person with scabies.	E	80%
					Donkey's blood is added to water and given to the patient without their knowledge for jaundice.	E	88%
				Milk	It is drunk cold and raw as a cough suppressant.	A,E,I	85%
					It is given to tuberculosis patients.	I	72%
					A person with jaundice is given 1 glass a day on an empty stomach. It is continued for 2-3 days.	I	56%
				Urine	In case of centipede bite, donkey urine is applied to the bitten area to remove the centipede from the body.	K	16%
Reptiles	*Testudo* sp.	Testudinidae	Kaplumbağa	Shell	The shell is ground. Fresh barley grains are boiled and filtered. The pulp obtained is mixed with shell powder. This mixture is good if applied to wounds.	I	12%
					Lemon juice is mixed with tortoise shell powder. This mixture is rubbed on fishskin disease like a scraper.	I	16%
				Meat	Turtle meat is applied raw against lumps in the breast.	I	60%
Mammals	*Canis familiaris* Linnaeus, 1758	Canidae	Köpek	Bone	For mouth sores; a piece of the dog's (regardless of color or gender) hind leg bone and pomegranate peel are roasted and turned into powder and applied to the mouth sores once a day.	A,E,I,K	42%
					It is dried, turned into powder and applied to the area with ringworm.	A	16%
				Saliva	To treat a dog's elbow (sty), dip your finger into the bowl the dog ate food from and apply a few drops to the stye.	A,E,I,K	80%
Mammals	*Canis lupus* Linnaeus, 1758	Canidae	Kurt	Bone	10-15 grams of bone pieces torn from the skull are ground into powder and mixed with 100 grams of filtered flower honey and fed to lung cancer patients on an empty stomach in the morning. This process is done 3-5 times.	A	88%
					Its bone is burned and the resulting ash powder is sifted and mixed with butter to form a paste used in rheumatism.	E	31%
Mammals	*Bos taurus* Linnaeus, 1758	Bovidae	İnek, Sığır	Meat	Fresh meat is wrapped around a leg that has swollen due to a sprain.	I	20%
				Leather	If there are bruises in many areas of the body, warm cowhide (freshly peeled) is wrapped around the naked body of the person. It is left for 12 hours.	A,E,I,K	28%
				Feces	A child with a diaper rash is made to sit on cold feces ashes or this ash is passed through cheesecloth and applied to the area where the diaper rash occurs.	A,E,I,K	60%
				Spleen	In folk belief (treatment of warts), it is used as a ritual object: The spleen is cut, the blessed barley grains are placed inside and the spleen is buried somewhere. When the spleen dries, the warts also dry up.	A,E,I,K	88%
					It is boiled or roasted and fed to children who wet their bed.	E	72%
				Mucus	The wrapped finger is inserted into the cow's nose and waited for (1-2 minutes). After 5 minutes, the same process is repeated a second time.	E	18%

				Milk	The cream of the milk is applied to the burns with something soft, such as a chicken wing.	A,E,I,K	98%
				Lung	Fresh bovine lungs are wrapped to cover the sprained area. It relieves swelling and pain.	I	16%
				Urine	It is used in the treatment of scabies. A person with scabies takes a bath with cow urine that has been rested for a day.	K	52%
Mammals	*Equus caballus* Linnaeus, 1758	Equidae	At	Cleansings	To relieve pain in children, the thin membrane from the placenta of a horse that has just given birth is wrapped around the baby's belly.	A	16%
					Hug the person with diarrhea directly.	A	12%
				Feces	Fresh feces of a horse that has eaten barley is squeezed and 1 drop of the juice is added for earache.	A,K	80%
					It is applied directly to cut wounds as a hemostatic.	A,E,I,K	88%
Reptiles	*Lacerta* sp.	Lacertidae	Kertenkele	Whole animal	To get rid of the inflammation, the exact cause of which is unknown, a small live lizard is thrown into the animal's mouth.	E	16%
Mammals	*Vulpes vulpes* (Linnaeus, 1758)	Canidae	Tilki	Meat	It is fed to patients suffering from rheumatism in boiled or fried form. This process is applied 1-2 times.	E	14%
				Fat	It is used directly as a pain reliever in humans.	I	16%
Fish	*Salmo trutta* Linnaeus, 1758	Salmonidae	Alabalık	Whole animal	It is used in the softening process of broken and reconnected bones that have healed incorrectly.	A,E,I,K	88%
					People with stomach ulcers swallow live ones that are 5-7 cm in size.	A,E,I,K	98%
					In the treatment of erysipelas disease in the arms and legs, 2-3 trouts are tied directly alive.	E	60%
					In the treatment of swelling seen on the arms and legs, called "yerdeki", 2-3 live trout are wrapped directly on the relevant area.	E,K,A	96%
					The cloth is wrapped directly on the area that has back pain.	A,E,I,K	94%
					It is directly wrapped for swelling in the arms and legs due to sprains. It relieves pain and swelling.	E,K,A	72%
					In women who cannot bear children, it is placed in the uterus in raw form and left until it melts.	E,K,A,I	94%
					It is boiled with milk. One spoonful is eaten twice a day on an empty stomach against tuberculosis.	K	16%
					A few trouts, 5-10 cm in size, are placed in a bottle filled with olive oil, lemon juice is added. After waiting for a month, it is fed to people with stomach problems.	E	16%
				Egg	Its eggs are dried and turned into powder. It is blown into the eyes of people with eye pain. This process is done once.	E	12%
Birds	*Passer domesticus* (Linnaeus, 1758)	Passeridae	Serçe	Feces	The feces is mixed with breast milk and fed to babies who are in pain.	A	16%
				Meat	Sparrows are caught and their feathers are sorted out. Their meat is boiled and eaten against hemorrhoids.	E	52%
Frogs	*Rana ridibunda* Pallas, 1771	Ranidae	Kurbağa	Whole animal	*Plantago* sp. leaf is tied to anthrax wounds in humans. A frog is tied to it. As the frog dies, it renews itself. The treatment is completed when 2-3 frogs die.	A	28%
					To relieve knee pain, a live frog is placed on the knee from morning until evening.	I	80%
				Blood	Frog blood is applied directly to warts on the hands and face.	I	16%
Birds	*Columba livia* J.F.Gmelin, 1789	Columbidae	Güvercin	Lung	Cooked pigeon liver is fed to patients with chronic asthma and shortness of breath.	E	18%
				Heart	Adults and children who are afflicted with the disease of fear are made to swallow a pigeon's heart.	E,K	52%
				Bone	As a wound healer, pigeon bone and onion are crushed and mixed. It is applied directly to the affected area.	E	46%
Reptiles	*Eryx jaculus* (Linnaeus, 1758)	Boidae	Mahmuzlu yılan	Spur	The left spur is ground and mixed with milk. A cup of the mixture is given to those with stomachaches. The pain goes away immediately, or the person vomits.	E	16%
Mammals	*Ursus arctos* Linnaeus, 1758	Ursidae	Ayı	Fat	It is applied to the rheumatic area by warming it slightly.	E	36%
					It is applied to the hemorrhoid area by heating it.	A,E,I,K	94%
					It is drunk hot against asthma and bronchitis.	E,K	12%
					It is eaten slightly heated in the treatment of syphilis.	E	44%
					It is applied directly to the body against scabies.	E,A	52%

			Meat	Bear meat is eaten for hemorrhoids.	A,E,K	76%
				It is boiled and fed to rheumatism patients.	E	60%
			Feces	Dry feces are applied to the area where hair loss is seen. The feces should be softened with hot water. This application is not necessary for fresh feces. This procedure should be applied to the relevant part of the head 2-3 times, staying for 2-3 hours. With this application, it is seen that the hair becomes thicker and hair grows in places where hair did not grow.	E	88%
Mammals	*Mus musculus* Linnaeus, 1758	Muridae	Fare	Whole animal	Newborn baby mice are placed in a bowl. Pure olive oil is added to it. It is left in front of a sunny window for 5-10 days. Then it is mixed. It is applied to cuts and wounds.	E,K	16%
Mammals	*Spalax* sp.	Spalacidae	Köstü, Kös, köstebek	Home soil	A mixture of raw mole soil and yoghurt is applied to the sprained area. It is tied and waited for 3-5 hours.	E,I	52%
					The nest soil is spread on a piece of cheesecloth and wrapped around the entire body of the person with scabies.	I	80%
					The nest soil and yogurt mixture is applied to the area where the bee sting is.	E	72%
					The nest soil is applied to the area with the wart twice, one day apart.	K	60%
				Meat	It is boiled and eaten in the treatment of syphilis.	E,K	28%

Note: E: Erzurum; A: Ardahan; I: Iğdır; K: Kars

Table 3. Animal species used for medical purposes in animal diseases

Category	Scientific name	Family	Turkish name	Used part	Usage	Locality	FL
Mammals	*Ovis aries* subsp. *aries*	Ovidae	Koyun	Feces	The incense is burned and given to the hive as a bee killer.	A,E,K	72%
					Fresh sheep feces are applied to the worm-infested area. The worms pass into this feces.	I	24%
				Bone	The ankle bone is burned and crushed into powder. One spoonful is fed to cattle with diarrhea.	A	36%
Birds	*Gallus gallus* f. *domesticus*	Gallidae	Tavuk	Egg	Powdered eggs are poured onto large or small cattle with swollen ears or throats.	E,A	50%
				Fat	The whole chicken is boiled, the resulting oil is applied to the animal's burns with chicken feathers.	A	32%
Mammals	*Capra aegagrus hircus*	Bovidae	Keçi	Hair	In the treatment of animals with broken legs or arms, if the mixture obtained by mixing egg white with goat hair is applied to the broken leg by placing it between a cloth, it is good for the fracture and accelerates the healing.	E	12%
					In the treatment of large head scabies, wool is soaked in salt water and applied to the body. After this process is done for a day, a bath is taken.	E,K	64%
				Fat	It is mixed with beeswax to form an ointment and applied to animal foot wounds and cracks.	E	48%
				Leather	A piece is cut from freshly peeled skin and tied to the eczema-affected area of the animal (cattle). It is left for 2-3 days.	E	28%
				Horn	Its horn is burned. Its ashes are applied to the skin of goats, shelducks, etc. for eczema.	E,K	52%
Mammals	*Bubalus bubalis*	Bovidae	Camış, Manda	Horn	It is ground into powder, mixed with butter and applied to injured animals.	E	30%
Reptiles	*Squamata* sp.	Dibamidae	Yılan	Bone	An ointment is obtained by mixing barley flour and cow's milk with snake bones that have been reduced to ashes in a fire. This ointment is applied to animals that have been bitten by snakes.	K	24%
Mammals	*Erinaceus europaeus*	Erinaceidae	Kirpi	Leather	It is applied directly to the skin of the animal with eczema.	A	18%
Mammals	*Lepus europaeus*	Leporidae	Tavşan	Feces	Rabbit feces is fed to chickens and turkeys to make them lay eggs.	K	18%
				Fat	It is applied to the burned area of the animal.	A,E,I	80%
Mammals	*Sus scrofa*	Suidae	Domuz	Fat	Pig fat is used to wrap animal cuts.	A,E,I,K	90%
Reptiles	*Testudo* sp.	Testudinidae	Kaplumbağa	Shell	The shell is ground. Fresh barley grains are boiled and filtered. The pulp obtained is mixed with shell powder. This mixture is good if applied to animal wounds.	A	12%
Mammals	*Canis familiaris*	Canidae	Köpek	Saliva	Against wolf bites, tail fat and felt are mixed and beaten, turned into a paste, and dog saliva is added. It is wrapped around the wounded area.	A,E,K	76%
Mammals	*Bos taurus*	Bovidae	İnek, Sığır	Meat	Fresh meat is wrapped around an animal whose leg has swollen due to a sprain.	I	8%
Mammals	*Equus caballus*	Equidae	At	Feces	Fresh feces is wrapped around an animal whose leg is swollen due to a sprain.	A,E,I,K	96%
Reptiles	*Lacerta* sp.	Lacertidae	Kertenkele	Whole animal	To get rid of the inflammation, the exact cause of which is unknown, a small live lizard is thrown into the animal's mouth.	E	6%
Mammals	*Vulpes vulpes*	Canidae	Tilki	Meat	It is fed to patients suffering from rheumatism in boiled or fried form. This process is applied 1-2 times.	E	56%
				Fat	It is used directly as a pain reliever in animals.	I	10%
Fish	*Salmo trutta*	Salmonidae	Alabalık	Whole animal	Horses that are running so hard they are about to burst and have difficulty breathing are fed two or three small trout.	A	46%

Note: E: Erzurum; A: Ardahan; I: Iğdır; K: Kars

Table 4. Plant species used for animal diseases or animal bites and other uses

Category	Scientific name	Family	Turkish name	Used part	Usage	Locality	FL
Spermatophyte	*Cichorium intybus* L.	Asteraceae	Çatlankuş	Aerial part	The aerial part is boiled in a pot. The cooled water is given to cattle suffering from foot and mouth disease.	E	64%
Spermatophyte	*Artemisia arborescens* L.	Asteraceae	Yavşanotu	Aerial part	The aerial part is hung in the house and used as a snake repellent.	I	12%
Spermatophyte	*Achillea millefolium* L.	Asteraceae	Sarıçiçek	Flower	The flowers of the plant are chewed while they are fresh, placed on the snakebitten area and this process is repeated several times.	A,E	32%
Spermatophyte	*Juglans regia* L.	Juglandaceae	Ceviz	Leaf	The leaves are put in a cauldron and boiled. Flour is added to the water and dough is made. The resulting dough is prepared in the shape of marbles and used as rat poison.	E	76%
				Peel	Fresh peel is ground into powder. They are thrown into water containing fish. This powder stuns the fish and causes them to float to the surface.	A,E,K	80%
Spermatophyte	*Corylus avellana* L.	Betulaceae	Yabani fındık	Fruit	It is mixed with yogurt and applied to the snakebite area.	A	8%
Spermatophyte	*Plantago major* L.	Plantaginaceae	Bağa yaprağı	Leaf	After the leaves are crushed, they are tied to the snakebite site.	I	48%
Spermatophyte	*Hyoscyamus niger* L.	Solanaceae	Deli batbat	Aerial part	The aerial part is hung around the neck of animals to protect them from evil eyes. This is called "Dardağan"	A,E,K	24%
Spermatophyte	*Verbascum* sp.	Scrophulariaceae	Sığırkuyruğu	Aerial part	The aerial part is crushed with stones and mixed into water. Fish that come to the surface of the water due to the stunning effect of the plant sap are caught.	K	24%

Note: E: Erzurum; A: Ardahan; I: Iğdır; K: Kars

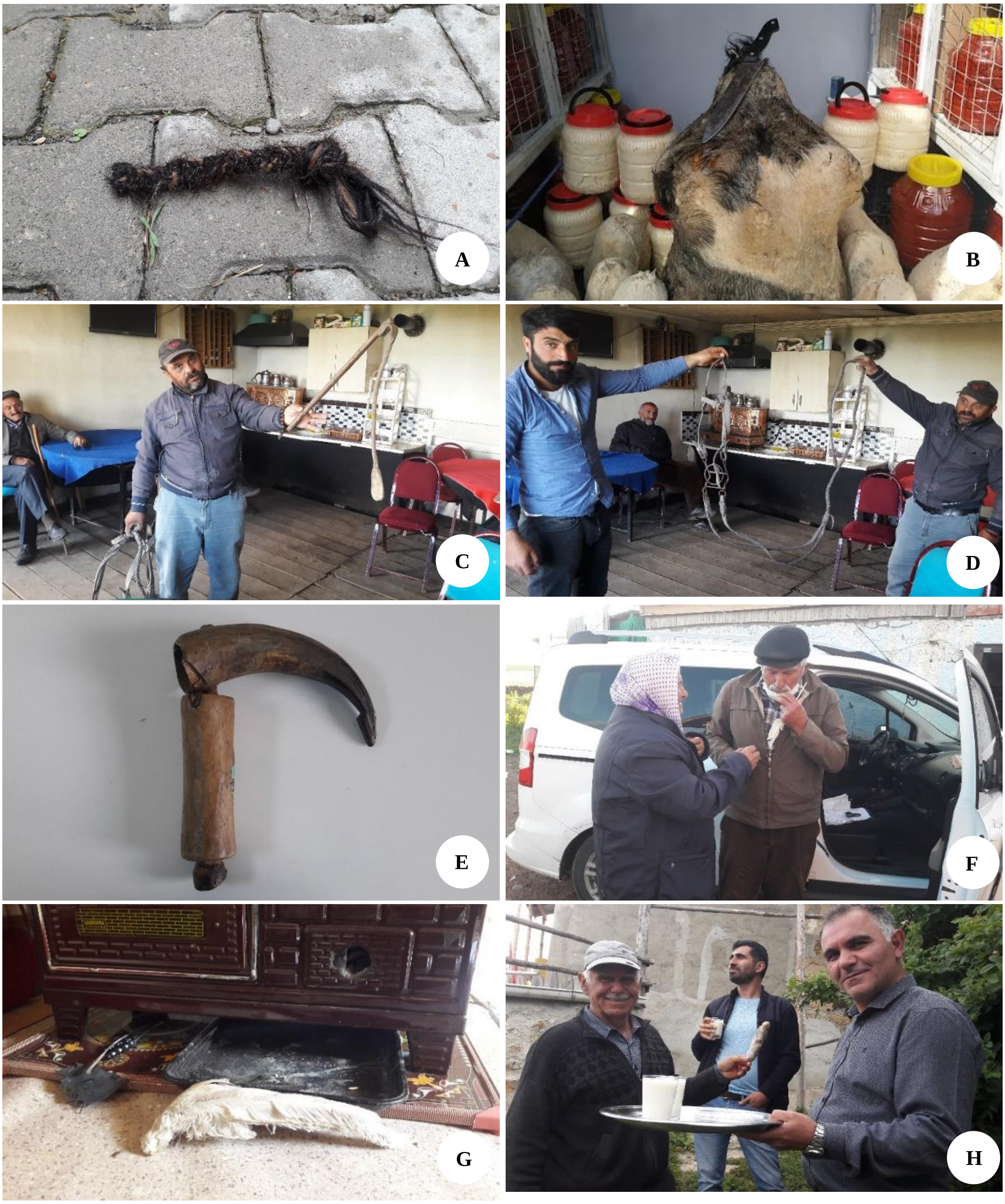
Table 5. Animal species used for different purposes in Erzurum (E), Ardahan (A), Iğdır (I), and Kars (K) in Turkey

Category	Scientific name	Family	Turkish name	Used part	Usage	Locality	FL
Mammals	*Ovis aries* subsp. *aries*	Ovidae	Koyun	Intestine	Arrow bows are made. Wool is beaten (whipped) with it.	A	64%
					It is cleaned. The first milk of the animal that gave birth and salt are added to it. It is dried in the sun and used as rennet (the same process can be done using the intestines of all large and small cattle.	A,E,I,K	48%
				Fat	It is used to lubricate snow shovels so that the snow does not stick to the shovel.	A,E	80%
					It is used as candle oil.	A,E,I,K	8%
					The fat extracted from the chest area of the sheep is used to easily ignite the fire.	I	48%
					Soap is made by adding melted oil from the above-ground parts of the *Erodium* sp. plant.	K	24%
				Leather	After the leather is made into a small bag, flour and water are put into it and after waiting for 1 week, it is used as dough yeast.	K	42%
					The musical instrument called "Def" is made.	A,E,I,K	12%
					Its leather is peeled, salted and dried. It is used as a prayer rug.	A,E,I,K	96%
					A bag-shaped toolbox is made. Tools used in construction are carried in this bag	A,E,I,K	90%
					It is used in the production of bags called tulum for the ripening and long-term storage of cheeses	A,E,I,K	12%
				Bone	Dice are made from ankle bones to play the game of "Aşık"	A,E,I,K	76%
				Tongue	The tongues, ears or eyes of animals slaughtered as offerings are dried and strung together with evil eye beads and hung in houses.	E	8%
				Horn	Hanged at the entrances of houses, garden walls, and barns as an amulet. The same applies to bear, horse, dog, and cattle skulls (F-4a,b,c).	A,E,I,K	96%
					Used in making knife handles	A,E,I,K	6%
Birds	*Gallus gallus* f. *domesticus*	Gallidae	Tavuk	Feces	It is dried, wrapped in cloth, and hung around the neck as an amulet.	A,E,I,K	56%
				Egg	To paint worn-out blackboards in schools, egg yolk, stovepipe soot and butter are mixed. Chicken feathers or rabbit legs are used as brushes to paint the board.	E,A	10%
				Feather	It is used as a brush to spread egg on pastries and cakes.	A,E,K	46%
				Bone	A piece of bone taken from the chest of a chicken or a rooster and resembling a moon is hung on the forehead and chest of large cattle or horses to protect against the evil eye and for ornamental and jewelry purposes.	E	28%
Mammals	*Capra aegagrus hircus*	Bovidae	Keçi	Hair	Incense is used around houses as a repellent against mice and snakes.	A,E,I,K	52%
					A human saddlebag made of hair is a material made in the form of a bag and used to carry items. It has a handle to hang on the shoulder or on the back of animals. Shepherds usually put their necessary items, especially food, inside when they go far away.	A,E,I,K	60%
					The hair is combed and turned into thread, and a rug called "çul" is woven. It is thrown over the animals to prevent them from getting wet. Again, since it is carrying a load, it is placed on the sweating animal after the load is lowered and it is placed on the sweaty animal.	A,E,I,K	52%
					It is made into a rope by bending, especially used to pull and drop baskets onto the tree during fruit picking.	A,E,I,K	18%
				Fat	It is melted in a pan, a "wick" is made from old cloths and used for lighting.	A,E,I,K	28%
					The soil called "Bora" is collected by sweeping. It is mixed with goat fat and boiled. It is put into molds while warm to make soap.	A,E,I,K	80%
				Leather	It is used in the production of bags called tulum for the ripening and long-term storage of cheeses.	A,E,I,K	64%
					Its leather is peeled, salted and dried. It is used as a prayer rug.	A,E,I,K	32%

				Crop	The animal's crop is washed, dried and mixed with grapes (dried) and lemon. The mouth is closed and left at room temperature for 1 month. The resulting mixture is used in cheese rennet.	A,E,I,K	6%
				Horn	It is used in making knife handles.	A,E,I,K	30%
Mammals	*Bubalus bubalis* (Linnaeus, 1758)	Bovidae	Camış, Manda	Leather	A horse whip is made by knitting	A,E,I,K	24%
					Horse halters are made by knitting	A,E,I,K	96%
				Horn	It is used in making combs. This comb is mostly used to clean nits and lice from the hair.	A,E,I,K	10%
					The grass bender called clamp (Leyden, Badok) is made from traditional agricultural tools.	A,E,I,K	12%
					The knife handle is made.	A,E,I,K	88%
					It is ground into powder, mixed with butter, and applied to the body as a cream as an emollient.	E	64%
Mammals	*Meles meles* (Linnaeus, 1758)	Mustelidae	Porsuk	Intestine	Arrow bows are made. Wool is beaten (whipped) with it.	A	48%
				Leather	It is cut into 4 cm wide pieces and hung around the necks of lambs as an amulet.	A	24%
Birds	*Anser anser* (Linnaeus, 1758)	Anseridae	Kaz	Hair	A musical instrument (whistle) is made.	A,K	48%
					It is used in pillow making.	A,E,I,K	
				Wing	Used as a household item (broom).	A,E,I,K	80%
Reptiles	*Squamata* sp.	Dibamidae	Yılan	Leather	Snake leather (shirt) is carried in a pocket or hung in the house to protect against the evil eye.	A,E,I,K	90%
				-	In order to catch a snake that has caused harm to humans or animals but has not been caught yet, yoghurt or milk is placed as a trap at the place where the snake was last seen.	A,E,I,K	12%
				Bone	It is carried as an amulet against the evil eye.	A,E,I,K	76%
					A rosary is made from the spine and hung around the neck of children to protect them from the evil eye.	I	8%
Mammals	*Erinaceus europaeus* Linnaeus, 1758	Erinaceidae	Kirpi	Leather	A muzzle is made for suckling calves to prevent them from suckling milk from their mothers.	A,E,I,K	96%
Mammals	*Lepus europaeus* Pallas, 1778	Leporidae	Tavşan	Foot	Used instead of a brush to spread egg on pastries.	A,E,I,K	6%
					Used to sweep dust from under the stove.	A	56%
					Used as a blackboard eraser in schools.	E	10%
					Hanged in the house or car as an ornament.	A	22%
				Tail	To prevent dust from entering the cleaned candlestick glass, the rabbit's tail is closed over the glass like a cork stopper.	E,K	10%
				Feces	It is applied to the eyebrow area to make eyebrows appear.	K	6%
				Fat	It is used to lubricate weapons.	A,E	28%
Birds	*Aquila chrysaetos* (Linnaeus, 1758)	Accipitridae	Kartal	Nail	Used as a necklace.	A,E,I,K	52%
					As an amulet, it is hung around the neck, car, house, or the neck or horn of an ox.	A,E,I,K	30%
Reptiles	*Testudo* sp.	Testudinidae	Kaplumbağa	Shell	It is used to make prayer beads.	A	24%
Mammals	*Canis familiaris* Linnaeus, 1758	Canidae	Köpek	Feces	It is dried and used as an amulet. It is carried in a pocket or hung in the house against the evil eye.	A,E,I,K	18%
					It is dried, wrapped in a cloth and worn on the right shoulder as an amulet.	A,E,I,K	18%
				Bone	Bone pieces found in dog feces are wrapped in cloth and hung from the neck or horns of animals such as horses and cattle towards the forehead to be used as an amulet.	A,E	28%
					It is thrown into a bowl of water and given to the person who has been hit by the evil eye to drink.	A,E,K	48%
Mammals	*Canis lupus* Linnaeus, 1758	Canidae	Kurt	Bone	The ankle bone is rubbed into the mouth of a calf that is not latching on to the udder.	A,E,I,K	60%
					The ankle bone is used as an amulet.	K	24%
				Tooth	It is hung around the neck as an amulet.	A,E,I,K	80%
				Feces	It is hung around the neck, in the house or in the barn as an amulet.	A,E,I,K	64%
				Genital organ	The female wolf's genital organ is hung around the neck or carried in a pocket as an amulet. It is also called a wolf's pucker.	A,E,I,K	86%

				Tail	It is hung on vehicles as an ornamental object.	A,E,I,K	16%
Mammals	*Bos taurus* Linnaeus, 1758	Bovidae	İnek, Sığır	Eye	The eyes of the sacrificed people are dried and carried in a pocket or hung in a house or barn to protect against the evil eye	A,E,I,K	52%
				Mamma	A sticky liquid comes out of the udders of a raw heifer that is 2-3 months away from giving birth for the first time. This liquid, called bulama, is used as an adhesive.	E,K	40%
				Hair	The hairs on the back are collected by rubbing with the hand, wetted and formed into a ball and a local game called “CİZİ TOPİ” = “Çizgi Topu” is played. Top is also called by the same name. It is a game played as a team by drawing a large circle in the middle.	E	18%
					The "Oynek" game is played with a toy made into a ball by heating the hairs taken from the back of a horse or a cow. The game is played by two teams of 4 people. A circle called a "threshing" is drawn in the middle. Everyone pretends to hide the ball in their bosom. One person tries to find the ball. It is a game similar to baseball.	E	6%
				Leather	The leather is cut to an equal width (10-20 cm), twisted and made into rope. It is used as a tow rope for animals to carry wood. This is called "Odun kayışı"	A,E,I,K	72%
					A large porous screening tool called a sieve is made to sift wheat and corn.	A,E,I,K	44%
					A wide strap called “horse trousers” or “horse trousers” is made. This strap prevents the saddle from slipping forward.	A,E,I,K	18%
					Used in the production of tinsmith bellows	A,E,I,K	16%
					It was used in the past for making sandals.	A,E,I,K	44%
				Bone	The scapula of the slaughtered animal is either buried or destroyed so that others cannot use it to perform magic or spells.	A,E,I,K	24%
				Crop	The crop of the animal is washed. White alum, powdered sugar and lemon juice are added to it. It is placed in a canister. This mixture is left to stand for 15-20 days. It is used as rennet. The same rennet can be made with a different recipe: şırdan (şirden, kırkbayır) is cleaned and placed in a casserole. Dried cranberries, gendime, salt are added to it and left in a warm place for 10-15 days.	A,E,I,K	28%
				Feces	It is dried in molds and called dung. It is used as fuel.	A,E,I,K	30%
					Incense is used as a mosquito repellent.	E	6%
					Incense is used as a bear repellent.	E	12%
				Gallbladder	The gallbladder water is drained. The remaining part is mixed with lemon salt, grapes and whey and left at room temperature for a week. It is used as rennet.	E	8%
				Horn	A chess set is made	K	42%
Mammals	*Equus caballus* Linnaeus, 1758	Equidae	At	Skull	Hanged inside barns to prevent the evil eye from hitting animals in particular. The same applies to skulls of bears, dogs, rams and cattle.	A,E,I,K	44%
				Feces	Dried ones are rolled and smoked instead of cigarettes.	A,E,I,K	56%
Mammals	*Vulpes vulpes* (Linnaeus, 1758)	Canidae	Tilki	Tail	It is hung in homes and vehicles as an ornamental object and to bring luck.	A,E,I,K	80%
					It is hung in barns as an amulet.	K	4%
				Pelt	It is hung in homes and vehicles as an ornamental object and to bring good luck.	A,E,I,K	50%
Frogs	*Rana ridibunda* Pallas, 1771	Ranidae	Kurbağa	Whole animal	A live frog is hung in a corner of the house or barn as an amulet.	A	32%
Birds	*Columba livia* J.F.Gmelin, 1789	Columbidae	Güvercin	Feces	Its fertilizer is applied as a supplement to plants, especially cabbage..	E	24%
Mammals	*Ursus arctos* Linnaeus, 1758	Ursidae	Ayı	Nail	It is hung around the necks of animals such as horses and oxen as an amulet.	E	44%
				Fat	The belt of the ox cart is greased with bear fat to make it soft. *The shovel used to clear snow is lubricated with bear fat to prevent snow from sticking.	A,E, *G	28%
Mammals	*Mus musculus* Linnaeus, 1758	Muridae	Fare	Whole animal	If mice gather together in the barn and make a piercing sound with their ears raised, this is a sign of an earthquake.	E	20%

Note: E: Erzurum; A: Ardahan; I: Iğdır; K: Kars



Figures 2. A. Rope made of goat hair; B. "Tulum" is made of goat skin for storing cheese; C. Horse whip made of buffalo leather; D. Horse halter made of buffalo leather; E. Traditional agricultural tools made from buffalo horn; F. Musical instrument (whistle) made from a goose feather; G. Goosewing used as a broom; H. A rabbit's foot is used as a brush to put eggs on pastries, a broom to sweep dust under the stove, or a blackboard eraser in schools

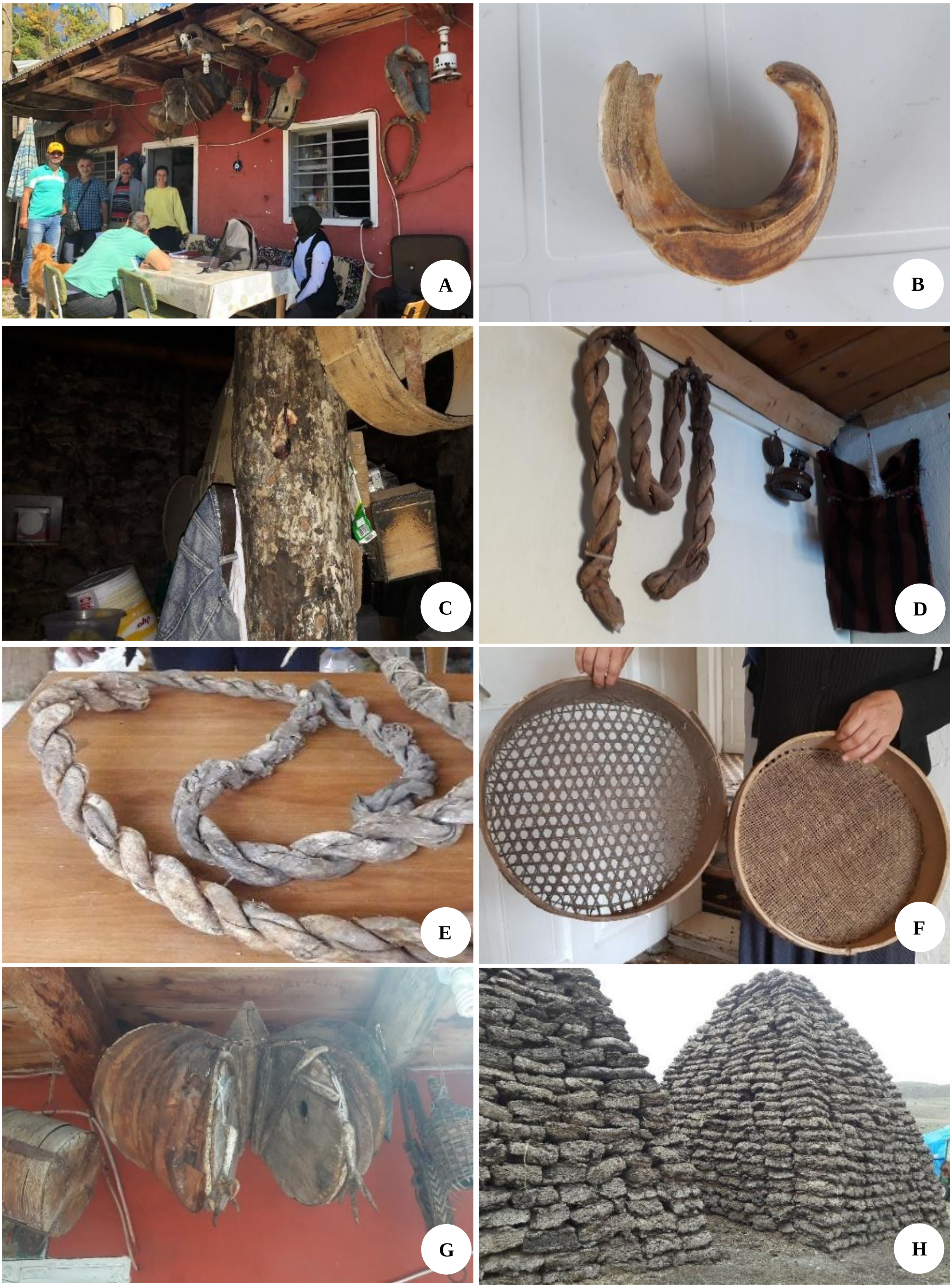


Figure 3. A. Eagle nail used as an amulet; B. Pig tooth used in the treatment of "Pig Nose" disease in cattle; C. The eye of the sacrificed cows hung in the barn to ward off the evil eye; D. "Wood belt" made from cow skin and used as a pulling rope for animals to carry wood; E. "Sifter" made of cow skin to sift wheat and corn; F. "Horse's breeches" or "Horse's trousers," which are made of cowhide and prevent the saddle from slipping forward; G. Tinsmith's Bellows are made of cowhide; H. "Dung," molded and dried cow dung for use as fuel

Discussion

Local ethnobiological knowledge is fundamental in empowering communities to sustainably manage, protect, and improve the stewardship of mangrove ecosystems (Nijamdeen et al. 2023). Ethnozoological studies in Türkiye remain limited. Notable works include research on trout (*S. trutta*) (Türker and Ergül 2022) and reviews emphasizing the need for further studies (Siddiq 2019). Yenmiş et al. (2019) highlight Anatolia's rich biodiversity and historical ethnozoological knowledge but note a scarcity of research on human-fauna interactions. Surprisingly, despite Anatolia's vast zoological diversity, its ethnozoological heritage remains underrepresented in the literature. Interestingly, the review by Yenmiş et al. (2019) does not cite a single ethnozoological study from Türkiye, whereas Siddiq (2019) presents numerous examples. This discrepancy raises concerns about the misalignment between the article's title and content and the scattered nature of ethnozoological research across various disciplines rather than dedicated ethnozoological journals. For instance, Ertürk and Şanlı (2017) provide a comprehensive ethnozoological study, but its publication in a different field limits visibility among ethnozoologists. Such fragmentation hinders recognition and accessibility, underscoring the need for more focused dissemination of ethnozoological research.

Mammals were the most frequently utilized group in the study area, a trend that can be attributed to the region's predominantly mountainous and moorland geography. These habitats provide an ideal environment for a wide range of mammalian species, making them more accessible to local communities. Mammals are not only valued for their availability but also for the multifunctionality of their parts, which are used across diverse domains of cultural expression, including healing practices. Rather than drawing a strict line between medicinal and cultural uses, this study recognizes traditional medicine as an integral component of local cultural systems. The frequent reliance on mammalian species underscores the central role of biodiversity in shaping and sustaining culturally embedded medical knowledge and practice. The use of fish in traditional medicine aligns with regional ethnobiological practices that reflect the specific therapeutic roles of local fauna. For instance, in various cultural contexts, species such as *G. gallus* f. *domesticus* on Jeju Island, Korea, have been employed to relieve earaches, demonstrating how diverse animals, including fish and birds, contribute to traditional healthcare systems.

In various regions across Asia and Africa, traditional medicinal practices have incorporated a diverse range of animal species for the treatment of both external and internal ailments. For instance, in the Mount Abu Wildlife Sanctuary in India, *B. taurus* has been traditionally used for wound healing, emphasizing its role in addressing external injuries. Amphibians, such as species from the *Rana* genus, have been employed in the Silent Valley Region of Kerala for managing skin conditions, illustrating their significance in local healing traditions. In Ethiopia, members of the *Equus* genus have been reported in the treatment of respiratory ailments in both the Kafta-Humera District (Northern Ethiopia) and Metema Woreda (Northwestern Ethiopia), highlighting their importance in treating internal disorders. Likewise, *C. aegagrus* has been utilized in Metema Woreda for wound care, reflecting its continued ethnoveterinary relevance in rural Ethiopian communities (Jaroli et al. 2010; Yirga et al. 2011; Kim and Song 2013; Vijayakumar et al. 2015; Kendie et al. 2018). A study conducted in western Granada (Andalusia, Spain) documents the traditional medicinal use of animals and animal products, examining species used, administration methods, treated ailments, and cultural significance, including magico-religious practices. Data were collected through semi-structured interviews with 42 participants across 16 municipalities, and a use-value index was applied to identify key species. The findings reveal 26 animal species used for treating 26 ailments across 10 pathological groups, contributing to 7% of the total medicinal resources, including both plants and animals. While some practices are referenced in classical and anthropological literature, most remain unpublished (Benítez 2011).

An ethnozoological study conducted in the Attappady Hills of the Western Ghats, located in the Palakkad District of India, investigated the traditional zoological knowledge of the Irula, Kurumba, and Muduga tribal communities. Data were gathered through direct interviews with local healers, and species identification was performed using indigenous names alongside references from previous ethnozoological literature and biodiversity databases, including those of the Silent Valley National Park. Limited biodiversity documentation in the area posed challenges to accurate species classification. Among the findings, ailments related to the musculoskeletal system exhibited the highest Informant Consensus Factor (ICF), while *Varanus bengalensis* (Daudin, 1802) and *Rusa unicolor* (Kerr, 1792) recorded the highest Fidelity Level (FL). The Index of Agreement on Remedies (IAR) was notably high for seven species (Rajmohan et al. 2017).

Similarly, in Southeast Anatolia, a region with a deep-rooted history of pastoralism dating back to the Neolithic period, knowledge of contemporary human-animal relationships remains limited. A recent ethnographic investigation conducted in the Ömerli District explored the intricate interactions between pastoral communities and domestic or wild animal species. The study uncovered deep emotional attachments between shepherds and specific animals, often resembling the human-animal bonds seen in urban pet ownership. Shepherds frequently assigned personal names to these animals, occasionally naming them after friends or family members. The emotional significance of these animals was further underscored by the grief experienced upon their loss or sale. Additionally, the research documented the multifunctional use of certain species, such as tortoises and hares, not only as food sources but also as providers of medicinal materials, including bone, blood, skin, and shell, all of which were incorporated into traditional healing practices (Siddiq and Şanlı 2020).

The black-boned sheep, selectively bred by the Pumi community in Northwest Yunnan, China, represent a significant genetic resource with both cultural heritage value and economic relevance. This study documents traditional knowledge related to their breeding, forage use, and conservation strategies. Field surveys conducted between 2019 and 2021 in seven villages identified 91 forage plant species, with *Prinsepia utilis* Royle, *Rubus* L., *Berberis* L., and Yushania being the most utilized. Seasonal shortages are managed with cultivated crops. The findings highlight the deep cultural connection between the Pumi people and black-boned sheep. Conservation efforts should incorporate local knowledge, as traditional practices are crucial for their sustainable management (Fan et al. 2022).

A recent study documents 16 ingredients used in preparing hare and their health benefits. The dish combines plant materials with animal products like buffalo milk, honey, and chicken eggs. Traditionally, a young pregnant woman leads the preparation, sharing it with neighbors as a symbol of joy. However, the tradition is declining due to modernization. To preserve its cultural significance, the local government promotes hare as a traditional Batak dish, symbolizing the cosmological worldview of the Parmalim community. Future studies may focus on analyzing its nutritional profile in greater detail (Adinugraha 2024). Recently, an ethnomedical investigation reported the use of both plant and animal species in the treatment of rheumatic conditions across the provinces of Ardahan, Iğdır, and Kars. Interviews with 329 individuals revealed 15 plant species and 9 animals commonly used for treatment. *Urtica dioica* L. was the most frequently cited plant, with others from the Asteraceae and Rosaceae families also noted. Species such as *Ursus arctos* Linnaeus, 1758, *Anser anser* f. *domesticus*, and *E. europaeus* were among the animals reported to have medicinal uses. These findings emphasize the critical role of safeguarding traditional knowledge systems in the studied regions (Karakaya et al. 2024). Similarly, an ethnobotanical study conducted among the Naxi people of Southwest China examined the traditional medicinal plants and fungi documented in the Dongba Sutras, a historical source of cultural and medical wisdom. The study identified 85 species belonging to 51 botanical families, 25 of which are endemic to China.

These plants are mainly wild-collected, with some also used as food. The most common method of preparation is oral decoction, and they are primarily used for treating digestive, respiratory, musculoskeletal, and general conditions. The study highlights the localized therapeutic knowledge of the Naxi people regarding medicinal plants and fungi specific to Southwest China, emphasizing the importance of preserving this regionally rooted traditional knowledge within its ecological and cultural context (Li et al. 2021). Although not directly related to medicinal or therapeutic animal use, studies such as the one exploring the ecological and cultural dimensions of the kemençe in Turkey's Eastern Black Sea Region offer a complementary perspective. They illustrate how traditional knowledge systems, including material selection and environmental awareness, shape biocultural relationships-insights that are also reflected in local ethnozoological practices across Eastern Anatolia (Aslan and Karahasanoğlu 2021). In Swat, Pakistan, an ethnomycological investigation revealed the extensive traditional knowledge of local communities regarding wild mushrooms. Interviews with 62 participants documented the use of 34 mushroom species, primarily from the Basidiomycetes class, for both nutritional and medicinal purposes. Key species included *Morchella angusticeps* Peck, *Pleurotus* spp., and *Ganoderma lucidum* (Curtis) P.Karst., underscoring the region's potential for socio-economic growth through the domestication and commercialization of wild fungi (Hussain et al. 2023). Similarly, in Surakarta City, Central Java, an ethnobotanical study explored the Javanese ritual of *tumpeng*, highlighting the symbolic use of 19 plant and 3 animal species, such as coconut, spinach, chicken, and milkfish. Based on interviews with 60 residents, the study revealed that each ingredient conveys specific cultural meanings-chicken symbolizes gratitude, while the cone-shaped rice mound represents aspirations for prosperity and progress (Septhia et al. 2024).

In India’s Northwestern Ghats, a pilot ethnzoological study captured the traditional knowledge of local healers, identifying 37 animal species used to treat 59 ailments, with mammals comprising the largest proportion (33%). Notably, the oral application of the Maharashtra zipper loach (*Paracanthocobitis mooreh*) for treating excessive salivation was reported as a novel ethnomedical use in the region (Zope et al. 2025). In another pilot study from Ethiopia, the medicinal use of animals among the Awi, Gamo, and Konta communities was examined. Data from 90 informants and 37 focus groups documented 20 animal species employed to treat 23 different human ailments. Mammals were the most commonly utilized group, and body parts such as meat, skin, and blood were frequently used. The findings not only highlight the depth of ethnozoological knowledge within these communities but also stress the need for further investigation into traditional practices and the development of conservation measures for medicinal fauna (Biru et al. 2022).

In traditional practices documented in the Assosa District of Benishangul-Gumuz, Western Ethiopia, various animals were employed to treat livestock ailments. For instance, *Hippopotamus amphibius* Linnaeus, 1758 and *Lepus fagani* Thomas, 1903 were used in remedies for donkey illnesses, while *G. gallus* was utilized to address diseases affecting both cows and donkeys. Additionally, *Iguana iguana* (Linnaeus, 1758) played a role in treating cattle wounds, highlighting the diverse application of animal resources in veterinary care (Kumera et al. 2022). Similarly, our study found that *G. gallus* was used for comparable purposes, particularly in treating diseases in cows, underscoring the widespread reliance on traditional knowledge for managing livestock health across different regions.

This study highlights the most commonly utilized plant families, parts, and preparation techniques in ethnoveterinary practices across Eastern Turkey. The frequent citation of species from the Fabaceae and Asteraceae families is particularly noteworthy, as it mirrors findings from comparable ethnoveterinary research conducted in Ethiopia and Mongolia, where these taxa were also extensively employed in animal healthcare (Makkar et al. 2009; Offiah et al. 2011). The predominance of leaf-based remedies is indicative of both the high pharmacological potential of foliage and its sustainability, as harvesting leaves generally does not harm the plant. Although Turkey lacks a unified, nationwide ethnoveterinary inventory, earlier localized investigations (Tabata et al. 1994; Yeşilada et al. 1995; Sezik et al. 2001) affirm the persistent use of native plants in traditional animal treatments, pointing to a strong continuity of cultural knowledge and practical utility.

In addition to medicinal plant use, the region also retains important agricultural traditions, such as the use of the handmade farming implement known as "Elçek." Commonly employed in Ardahan, Erzurum, Bingöl, Bayburt, and Gümüşhane, this tool is constructed using three basic components readily available in livestock-rearing communities: an animal horn, a wooden handle, and a shaft. It plays a vital role in crafting "Kem" ropes by twisting grasses such as *Cil* into durable and flexible cords. Despite the labor-intensive nature of this practice, it remains an effective and respected method. However, the increasing availability of synthetic alternatives poses a threat to its continued use, emphasizing the importance of safeguarding such traditional techniques for the sake of agricultural sustainability and cultural preservation (İncekara et al. 2024).

Consistent with ethnobiological research conducted among the Nyishi and Galo communities of northeastern India, the present study confirms that mammals constitute the most frequently used vertebrate group in traditional medicinal practices. However, a notable distinction lies in the conservation implications: while the Indian studies report frequent use of endangered and wild fauna, the species employed in Eastern Anatolia are predominantly domestic and locally accessible, thereby presenting a lower risk to biodiversity (Chakravorty et al. 2011). Similar patterns have been observed among the Tangsa and Wancho communities, where both mammals and birds are commonly used in zootherapeutic remedies. However, unlike those studies, which encompass a broader spectrum of animal taxa including invertebrates such as insects and mollusks, this research focuses exclusively on vertebrate species (Jugli et al. 2020a).

Beyond therapeutic uses, Jugli et al. (2020b) also reported that animals in Eastern Arunachal Pradesh hold symbolic and ritual significance, featuring prominently in cultural festivals, adornments, and oral traditions. These findings underscore the importance of cultural narratives in shaping species selection and highlight the need to balance tradition with conservation efforts. Supporting this view, a study in Arba Minch Zuriya, Ethiopia, identified 20 medicinal animal species—including birds, reptiles, fish, and insects-used in 30 different remedies, with skin-related ailments being the most frequently addressed. Among these, members of the Bovidae family were the most commonly used, and bile was reported as the most frequently applied animal-derived material (Kebebew et al. 2021). Similarly, research from Southern Ethiopia documented 24 medicinal species, primarily wild mammals used in traditional healing, with cattle being the most frequently cited. Products such as honey, milk, and raw meat were commonly used in treatments (Mengistu et al. 2024). Collectively, these findings emphasize the regional specificity and cultural dimensions of zootherapeutic knowledge systems, while also reinforcing the need for integrative approaches to biodiversity protection and traditional medicine documentation.

Although Turkey possesses a rich tradition of ethnoveterinary knowledge, much of the documented literature emphasizes plant-based remedies. By comparison, our research is distinctly centered on vertebrate use in ethnoveterinary applications. While works such as Erarslan and Kültür (2019) provide valuable insight into herbal treatments, comprehensive studies centered exclusively on animal-based remedies remain limited. Our findings help address this gap by documenting culturally significant vertebrate species and their therapeutic roles, contributing to a more holistic understanding of traditional veterinary practices in Turkey. This study underscores the richness of ethnobiological knowledge embedded within the traditional practices of communities in Eastern Anatolia, particularly in their use of vertebrate species for medicinal, cultural, and spiritual purposes. The research aimed to document and interpret how animal-derived materials contribute to healthcare and socio-cultural continuity, and the findings strongly affirm this objective.

A total of 30 medicinal animal species and 8 medicinal plant species were recorded, with 135 human-related applications and 24 veterinary uses, reflecting a well-integrated system of knowledge where biodiversity and healthcare are deeply intertwined. Notably, species such as *B. taurus* and *S. trutta* demonstrated high fidelity levels (96%), indicating consistent use across respondents and strong cultural consensus on their efficacy in treating burns and stomach ulcers, respectively. These results support the hypothesis that a limited group of species is relied upon for specific therapeutic outcomes, reinforcing their perceived effectiveness and cultural embeddedness. In addition to healthcare, animal-derived materials were employed in spiritual practices, protective amulets, and artisanal expressions. The use of *Equus* genus tail hair for crafting musical instruments, observed both in this study and among the Garasiya people of Rajasthan (Jaroli et al. 2010), exemplifies the innovative and multifunctional application of biological resources, extending traditional medicine into broader realms of cultural practice. While the findings offer valuable insights, certain limitations must be acknowledged. Furthermore, due to the informal transmission of traditional knowledge, some practices may be underreported or at risk of being lost, particularly among younger generations. The lack of pharmacological validation of the claimed therapeutic effects also presents a limitation, which could be addressed in future interdisciplinary studies.

Therefore, future research should focus on (i) the pharmacological screening of high-fidelity species to verify therapeutic claims; (ii) exploring the ecological impact of harvesting animal-based remedies; and (iii) integrating ethnobiological knowledge into biodiversity conservation policies. Additionally, studies should further investigate the transmission dynamics of traditional knowledge, especially in rapidly modernizing communities, to support cultural preservation initiatives. In conclusion, this study not only documents valuable traditional practices but also reveals the intricate relationship between cultural heritage, biodiversity, and health. It advocates for the inclusion of indigenous knowledge in sustainable development and health research frameworks, positioning ethnobiology as a crucial bridge between local wisdom and global challenges.

This study sheds light on the deeply rooted ethnozoological knowledge in the mountainous and moorland regions of Eastern Turkey, particularly within the provinces of Erzurum, Ardahan, Iğdır, and Kars. The findings reveal that vertebrate-based remedies continue to hold a significant place in local healthcare traditions, closely intertwined with cultural and utilitarian practices. Notably, the inclusion of plant-based treatments for animal ailments emphasizes the holistic nature of traditional medicine, where the boundaries between the animal and plant kingdoms are fluid and interconnected. This inseparability highlights a worldview in which healing is not limited to a single kingdom but rather arises from a dynamic interplay of biocultural relationships. Future research and conservation strategies should, therefore, consider this integrated perspective, supporting both biodiversity and the rich tapestry of traditional knowledge that sustains it.

ACKNOWLEDGEMENTS

We would like to express our heartfelt appreciation to the Republic of Turkey Ministry of Agriculture and Forestry, General Directorate of Nature Conservation and National Parks, 13th Regional Directorate Erzurum Branch Office for their invaluable support of the project titled "Determination of Traditional Knowledge Based on Biological Diversity in Erzurum Province." We also extend our sincere thanks to the 13th Regional Directorates of Ardahan, Iğdır, and Kars Branch Offices for their continued collaboration and contributions. Their support has been crucial to the successful execution of the project entitled "Recording of Traditional Knowledge Based on Biological Diversity in Kars, Ardahan, and Iğdır Provinces."

REFERENCES

Adinugraha F. 2024. Ethnobiological study of *Wiwitan* in the Somongari Javanese Community as biodiversity learning through educational video. Jurnal Penelitian Pendidikan IPA 10 (12): 10065-10075. DOI: 10.29303/jppipa.v10i12.8720.

Alexiades MN, Sheldon JW. 1996. Selected Guidelines for Ethnobotanical Research: A Field Manual. Advances in Economic Botany Bronx: The New York Botanical Garden, USA.

Altundag E, Ozturk M. 2011. Ethnomedicinal studies on the plant resources of east Anatolia, Turkey. Procedia-Social Behav Sci 19: 756-777. DOI: 10.1016/j.sbspro.2011.05.195.

Aslan U, Karahasanoğlu S. 2021. Sound ethnobiology of musical instruments: A sound view of nature in manufacturing kemençe. Musicologist 5 (2): 240-263. DOI: 10.33906/musicologist.988011.

Bakirci K, Kirtiloglu Y. 2022. Effect of climate change to solar energy potential: A case study in the Eastern Anatolia Region of Turkey. Environ Sci Pollut Res Intl 29 (2): 2839-2852. DOI: 10.1007/s11356-021-14681-0.

Benítez G. 2011. Animals used for medicinal and magico-religious purposes in western Granada Province, Andalusia (Spain). J Ethnopharmacol 137 (3): 1113-1123. DOI: 10.1016/j.jep.2011.07.036.

Biru Y, Gibru A, Temesgen Z, Hunde K, Fekensa T. 2022. Zootherapeutic animals used by Awi, Gamo, and Konta communities in Amhara and Southern Regions of Ethiopia. Asian J Ethnobiol 5 (2): 84-91. DOI: 10.13057/asianjethnobiol/y050202.

Chakravorty J, Meyer-Rochow VB, Ghosh S. 2011. Vertebrates used for medicinal purposes by members of the Nyishi and Galo tribes in Arunachal Pradesh (North-East India). J Ethnobiol Ethnomed 7: 13. DOI: 10.1186/1746-4269-7-13.

Çiçek E, Sungur S, Seçer B, Öztürk S. 2020. Fish in ethnozoology belief and health tourism. Acta Biologica Turcica 33 (3): 172-179. [Türkçe]

Coşkun O. 2013. Urbanization and urban development in Eastern Anatolia Region. Doğu Coğrafya Dergisi 18 (30): 229-256. [Türkçe]

Descola P. 2013. Beyond Nature and Culture. University of Chicago Press, IL.

Despret V. 2004. The body we care for: Figures of anthropo-zoo-genesis. Body Soc 10 (2-3): 111-134. DOI: 10.1177/1357034X04042938.

Emre Y. 2023. Faunal influences on dailylife in thrace region (Edirne-Kirklareli) and recording of oral ethnozoological information from past to today. [Master's Thesis]. Trakya University, Edirne. [Türkçe]

Erarslan ZB, Kültür Ş. 2019. Ethnoveterinary medicine in Turkey: A comprehensive review. Turk J Vet Anim Sci 43 (5): 55-582. DOI: 10.3906/vet-1904-8.

Ertürk D, Şanlı S (eds). 2017. Türkiye'de Devecilik Kültürü ve Deve Güreşleri, Gece Kitaplığı, Ankara. [Turkije]

Fan Y, Cheng Z, Liu B, Hu X, Ali M, Long C. 2022. An ethnobiological study on traditional knowledge associated with black-boned sheep (*Ovis aries*) in Northwest Yunnan, China. J Ethnobiol Ethnomed 18 (1): 39. DOI: 10.1186/s13002-022-00537-5.

Friedman J, Yaniv Z, Dafni A, Palewitch D. 1986. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev desert, Israel. J Ethnopharmacol 16 (2-3): 275-287. DOI: 1016/0378-8741(86)90094-2.

Gutiérrez-Santillán TV, Albuquerque UP, Valenzuela-Galván D, Reyes-Zepeda F, Vázquez LB, Mora-Olivo A, Arellano-Méndez LU 2019. Trends on mexican ethnozoological research, vertebrates case: A systematic review. Ethnobiol Conserv 8 (1): 1-39. DOI: 10.15451/ec2019-01-8.01-1-39.

Haraway DJ. 2008. When Species Meet. University of Minnesota Press, Minneapolis.

Hussain S, Sher H, Ullah Z, Elshikh MS, Al Farraj DA, Ali A, Abbasi AM. 2023. Traditional uses of wild edible mushrooms among the local communities of Swat, Pakistan. Foods 12 (8): 1705. DOI: 10.3390/foods12081705.

İncekara Ü, Polat A, Aksakal Ö, Karakaya S, Kimişoğlu Z, Sümbüllü Y, Koçak UÇ. 2024. First record and ethnozoological description of two traditional agricultural tools from Türkiye: Elcek and Elçek. Eurasian J Zool 1 (2): 1-15.

Jacobo-Salcedo Mdel R, Alonso-Castro AJ, Zarate-Martinez A. 2011. Folk medicinal use of fauna in Mapimi, Durango, Me'xico. J Ethnopharmacol 133 (2): 902-906. DOI: 10.1016/j.jep.2010.10.005.

Jaroli DP, Mahawar MM, Vyas N. 2010. An ethnozoological study in the adjoining areas of Mount Abu wildlife sanctuary, India. J Ethnobiol Ethnomed 6: 6. DOI: 10.1186/1746-4269-6-6.

Jugli S, Chakravorty J, Meyer-Rochow VB. 2020a. Zootherapeutic uses of animals and their parts: An important element of the traditional knowledge of the Tangsa and Wancho of eastern Arunachal Pradesh, North-East India. Environ Dev Sustain 22: 4699-4734. DOI: 10.1007/s10668-019-00404-6.

Jugli S, Chakravorty J, Meyer-Rochow VB. 2020b. Tangsa and Wancho of North-East India use animals not only as food and medicine but also as additional cultural attributes. Foods 9 (4): 528. DOI: 10.3390/foods9040528.

Karakaya S, Kimişoğlu Z, Sümbüllü YZ, Aksakal Ö, İncekara Ü, Polat A. 2024. Halk Arasında Romatizmal Hastalıklar için Kullanılan Bitkiler ve Hayvanlar: Ardahan, Iğdır ve Kars İlleri Üzerine Yapılan Kesitsel Araştırma. J Tradit Med Complement Therapies 7 (3): 241-252. DOI: 10.5336/jtracom.2024-103078. [Türkçe]

Kebebew M, Mohamed E, Rochow VBM. 2021. Knowledge and use of traditional medicinal animals in the Arba Minch Zuriya District, Gamo Zone, Southern Ethiopia. Eur J Ther 27 (2): 158-167. DOI: 10.5152/eurjther.2021.20064.

Kendie FA, Mekuriaw SA, Dagnew MA. 2018. Ethnozoological study of traditional medicinal appreciation of animals and their products among the indigenous people of Metema Woreda, North-Western Ethiopia. J Ethnobiol Ethnomed 14 (1): 37. DOI: 10.1186/s13002-018-0234-7.
Kim H, Song MJ. 2013. Ethnozoological study of medicinal animals on Jeju Island, Korea. J Ethnopharmacol 146 (1): 75-82. DOI: 10.1016/j.jep.2012.11.011.
Kohn E. 2013. How Forests Think: Toward an Anthropology Beyond the Human. University of California Press, Berkeley.
Kumera G, Tamire G, Degefe G, Ibrahim H, Yazezew D. 2022. Ethnozoological study of traditional medicinal animal parts and products used among indigenous people of Assosa District, Benishangul-Gumuz, Western Ethiopia. Intl J Ecol 2022 (1): 8430489. DOI: 10.1155/2022/8430489.
Li H, Li Z, Zhang X, Yang S, Chen C, Yang Q, He C, Liu J, Song J. 2021. Ethnobiological study on traditional medicinal plants and fungi recorded in the Naxi Dongba sutras. J Ethnobiol Ethnomed 17 (1): 32. DOI: 10.1186/s13002-021-00459-8.
Lohani U, Rajbhandari K, Shakuntala K. 2008. Need for systematic ethnozoological studies in the conservation of ancient knowledge systems of Nepal–a review. Indian J Tradit Knowledge 7 (4): 634-637.
Makkar HPS, Norvsambuu T, Lkhagvatseren S, Becker K. 2009. Plant secondary metabolites in some medicinal plants of Mongolia used for enhancing animal health and production. Tropicultura 27 (3): 159-167.
Mengistu M, Kebebew M, Meyer-Rochow VB. 2024. Ethnozoological study of medicinal animals used by the inhabitants of the Kucha District, Gamo Zone, Southern Ethiopia. J Ethnobiol Ethnomed 20 (1): 72. DOI: 10.1186/s13002-024-00714-8.
Nijamdeen TM, Ephrem N, Hugé J, Kodikara KAS, Dahdouh-Guebas F. 2023. Understanding the ethnobiological importance of mangroves to coastal communities: A case study from Southern and North-western Sri Lanka. Mar Pol 147: 105391. DOI: 10.1016/j.marpol.2022.105391.
Offiah NV, Makama S, Elisha IL, Makoshi MS, Gotep JG, Dawurung CJ, Oladipo OO, Lohlum AS, Shamaki D. 2011. Ethnobotanical survey of medicinal plants used in the treatment of animal diarrhoea in Plateau State, Nigeria. BMC Vet Res 7: 36. DOI: 10.1186/1746-6148-7-36.
Özgökçe F, Özçelik H. 2004. Ethnobotanical aspects of some taxa in East Anatolia, Turkey. Econ Bot 58: 697-704. DOI: 10.1663/0013-0001(2004)058[0697:EAOSTI]2.0.CO;2.
Rajmohan D, Niranjana KM, Yamuna R, Logankumar K. 2017. An ethnozoological assessment of traditionally used animal-based therapies in attappady of Palakkad District, Kerala, India. Kong R J 4 (3): 86-89. DOI: 10.26524/krj237.
Septhia ND, Izdihar NS, Destiani NFL, Rindiani N, Izdihar RS, Setyawan AD. 2024. Ethnobiological study of Tumpeng, traditional food in Surakarta City, Central Java, Indonesia. Asian J Ethnobiol 7 (1): 61-67. DOI: 10.13057/asianjethnobiol/y070107.
Sezik E, Yeşilada E, Honda G, Takaishi Y, Takeda Y, Tanaka T. 2001. Traditional medicine in Turkey X. Folk medicine in central Anatolia. J Ethnopharmacol 75 (2-3): 95-115. DOI: 10.1016/s0378-8741(00)00399-8.
Siddiq AB, Şanlı S. 2020. Animals and pastoral groups in the mountainous Ömerli district of Southeast Anatolia. Anthrozoös 33 (2): 153-173. DOI: 10.1080/08927936.2020.1719754.
Siddiq AB. 2019. Necessity of Anthrozoology Studies in Turkey. Sosyoloji divanı 7 (14): 139-158.
Tabata M, Sezik E, Honda G, Yeşilada E, Fukui H, Goto K, Ikeshiro Y. 1994. Traditional medicine in Turkey III. Folk medicine in East Anatolia, van and Bitlis provinces. Intl J Pharmacognosy 32 (1): 3-12. DOI: 10.3109/13880209409082966.
Türker D, Ergül E. 2022. An overview of ethno-ichthyological practices in Turkey, as well as some cases from several other countries. Acta Biologica Turcica 35 (4): 1-11.
van Dooren T. 2014. Flight Ways: Life and Loss at the Edge of Extinction. Columbia University Press, New York. DOI: 10.7312/columbia/9780231166188.001.0001.
Vijayakumar S, Yabesh JE, Prabhu S, Ayyanar M, Damodaran R. 2015. Ethnozoological study of animals used by traditional healers in Silent Valley of Kerala, India. J Ethnopharmacol 162: 296-305. DOI: 10.1016/j.jep.2014.12.055.
Yenmiş M, Ayaz D, Tok CV. 2018. Ethnozoology: A review. Acta Biologica Turcica 32 (1): 33-36.
Yeşilada E, Honda G, Sezik E, Tabata M, Fujita T, Tanaka T, Takeda Y, Takaishi Y. 1995. Traditional medicine in Turkey. V. Folk medicine in the inner Taurus Mountains. J Ethnopharmacol 46 (3): 133-152. DOI: 10.1016/0378-8741(95)01241-5.
Yirga G, Teferi M, Gebreslassea Y. 2011. Ethnozoological study of traditional medicinal animals used by the people of Kafta-Humera District, Northern Ethiopia. Intl J Med Med Sci 7 (11): 1-5.
Zope A, Sonawane A, Patil S, Nirgude B, Jagdale P. 2025. Ethnozoological study of animal-based medicine used by traditional healers in Northern Western Ghats of Maharashtra, India. Asian J Ethnobiol 8 (1): 1-11. DOI: 10.13057/asianjethnobiol/y080101.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025 E-ISSN: 2580-4510
Pages: 79-91 DOI: 10.13057/asianjethnobiol/y080107

Ethnobotanical documentation of home gardens in relation to Javanese basic life needs in Kediri District, East Java, Indonesia

WHISNU FERBY AFRIANTO
Ecosystem and Biodiversity Indonesia (ECOSBIO). Jl. Merapi 02/01, Kediri 64151, East Java, Indonesia. email: whisnu.afrianto@gmail.com

Manuscript received: 12 February 2025. Revision accepted: 15 May 2025.

Abstract. *Afrianto WF. 2025. Ethnobotanical documentation of home gardens in relation to Javanese basic life needs in Kediri District, East Java, Indonesia. Asian J Ethnobiol 8: 79-91.* Home gardens, as traditional agroforestry approaches, not only promote plant diversity but also support human livelihoods. The Javanese community exhibits distinct cultural practices in the utilization of plant species in home gardens. This study examines the plant species utilized by the Javanese based on five dimensions of basic life needs. Data were collected from 55 home gardens through purposive sampling and analyzed based on Javanese philosophy: nourishment (*pangan*), clothing (*sandang*), shelter (*papan*), herbal medicine (*loro*), and traditional death-related rituals (*pati*). Information on all plants and their uses was directly obtained from respondents. The ethnobotany R package assessed the ethnobotanical importance of these plants. A total of 71 plant species from 43 families were identified, with trees being the most common life form and fruit-bearing plants dominating the community. The plants were mainly used as food (53 species), followed by medicine (17 species), construction (9 species), ritual (6 species), and clothing (1 species). Notably, *Moringa oleifera* Lam. and *Bambusa* sp. were found to serve three use categories. Ethnobotanical indices showed that *Mangifera indica* L. had the highest values. The study highlights that plant conservation in Javanese home gardens can be effectively achieved through cultural approaches. The role of sustainable home gardens in managing household and community food security and nutritional needs is significant and promising.

Keywords: Community, home garden, Javanese culture, quantitative ethnobiology, sustainable

INTRODUCTION

Home gardens, or *pekarangan* in Indonesian, are multifunctional spaces surrounding homes traditionally used to cultivate various plant species, including food crops, medicinal herbs, spices, and ornamental plants (Hakim et al. 2018). They are often categorized as traditional agroforestry systems due to their complex structure, high biodiversity, and sustainable land management practices (Park et al. 2019). Compared to other agricultural systems, home gardens offer a unique blend of ecological, economic, and social functions, with plant composition and diversity influenced by factors such as landholding size, cultural preferences, and household needs (Panyadee et al. 2018; Suwardi et al. 2023). Studies have demonstrated that more extensive home gardens exhibit higher Net Present Value (NPV), making them economically advantageous (Park et al. 2019).

Home gardens play an integral role in community life, contributing to food security by providing fresh, natural, and highly nutritious food sources (Lal 2020; Castañeda-Navarrete et al. 2021). Traditionally, home gardening employs environmentally friendly methods, avoiding synthetic pesticides and chemical fertilizers. Ecologically, these gardens enhance soil health by facilitating rainwater infiltration and nutrient cycling while also creating distinct microclimates and serving as habitats for various species (Mohri et al. 2013; Ibarra et al. 2021; Padmakumar et al. 2021). Economically, they reduce household expenses by supplying homegrown food, thereby decreasing reliance on store-bought produce. In addition to self-consumption, surplus crops can be sold or exchanged, providing families with an extra source of income and enhancing economic resilience (Linger 2014; Prihatini et al. 2018). Socially, home gardens serve as gathering spaces where family members and neighbors interact, strengthening community bonds (Iskandar et al. 2018). Given these various benefits, home gardens are integral to promoting food security, economic stability, and environmental sustainability.

Several studies have explored plant diversity in East Java, including regions such as Banyuwangi, Malang, Madura, Bondowoso, and Pasuruan (Oktavianti and Hakim 2013; Maningtyas and Gunawan 2017; Hakim et al. 2018; Faruq et al. 2021; Hariyati et al. 2022; Setiani et al. 2022; Agustina et al. 2024). In Javanese society, five fundamental human needs—*sandang*, *pangan*, *papan*, *loro*, and *pati*—are essential for survival and well-being. *Sandang* (clothing) refers to the necessity of garments that provide protection, comfort, and a means of expressing social identity. *Pangan* (food) represents the fundamental requirement for nourishment, supplying the energy and nutrients essential for health and growth. *Papan* (shelter) signifies the need for a safe and comfortable living space that offers protection from environmental elements and serves as a place for rest and family gatherings. *Loro* (health) encompasses overall well-being, including access to healthcare and the adoption of a healthy lifestyle to prevent diseases. Finally, *pati* (death) relates to cultural and spiritual aspects, ensuring proper preparation and respect for individuals after their passing. These five needs are intricately connected to the traditional Javanese calendar system, *weton*, which is used to determine auspicious days for significant life events such as weddings, house moves, and business ventures (Hidayati et al. 2023; Ma'ruf and Kusumawati 2023; Putri et al. 2024). In other Indonesian cultures, basic human needs are also categorized into five key aspects. For instance, in the Tidung Tribe of North Kalimantan, plants are recognized for their usefulness in providing food (*ngakan*), shelter (*baloy*), health and medicine (*sihat*), traditional ceremonies (*adat*), and clothing (*memana*) (Suciyati et al. 2021). Meanwhile, Suwardi et al. (2023) sought to align the roles of plants in home gardens with the Sustainable Development Goals (SDGs), which broadly reflect similar dimensions of human well-being and sustainable resource use.

Despite these benefits, several challenges persist, including declining land availability, lifestyle and dietary preferences shifts, and reduced transmission of traditional ecological knowledge to younger generations (Afrianto et al. 2021). In particular, the erosion of local knowledge systems has led to the underutilization of home gardens' multifunctionality and the loss of plant diversity in some regions. This study addresses that gap by analyzing plant diversity and traditional plant utilization in Kediri, East Java, home gardens. By concentrating on how plant species accomplish the five essential needs of Javanese families and how traditional beliefs and cultural calendars shape these traditions, this research contributes to a more comprehensive understanding of home gardens as dynamic socioecological systems. The study aims to inform sustainable development and biodiversity conservation strategies that respect and leverage local knowledge systems (Afrianto et al. 2021, 2023; Afrianto and Metananda 2023).

MATERIALS AND METHODS

Study area

The study was conducted in February 2024 in Datengan Village, Grogol Sub-district, Kediri District, East Java Province, Indonesia (Figure 1). The area is located at a latitude of -7.7458° (7°44'45" south) and longitude of 111.9928° (111°59'34" east); the village lies at an elevation of 62 meters (203 feet) above sea level. The area features sloping and lowland topography. Agriculture is the primary livelihood of the local population, with most residents engaged in farming. Rice is the leading agricultural commodity, and many villagers supplement their income by raising livestock, including chickens, goats, and cows.

Procedures

Data were collected from 55 home gardens and served as study samples. Purposive sampling was employed to define and select samples based on specific criteria (Muhlisin et al. 2021). Informants were collected from home garden owners, most of whom were between 40 and 60 years old and primarily worked as farmers. The majority of the gardeners were women, with an average of two to three people involved in maintaining each garden. Their education levels ranged from elementary school to junior high school, and their economic status varied from low to middle income. Based on Suwardi et al. (2023), the surveyed home gardens were divided into three categories: (i) small (<500 m^2); (ii) medium (501-1500 m^2); and (iii) large (>1500 m^2). The Javanese philosophy of *sandang, pangan, papan, loro,* and *pati* represents a holistic framework for human life needs that is deeply embedded in traditional home garden management. This concept offers a culturally grounded approach to understanding plant diversity and utilization patterns in Kediri's home gardens.

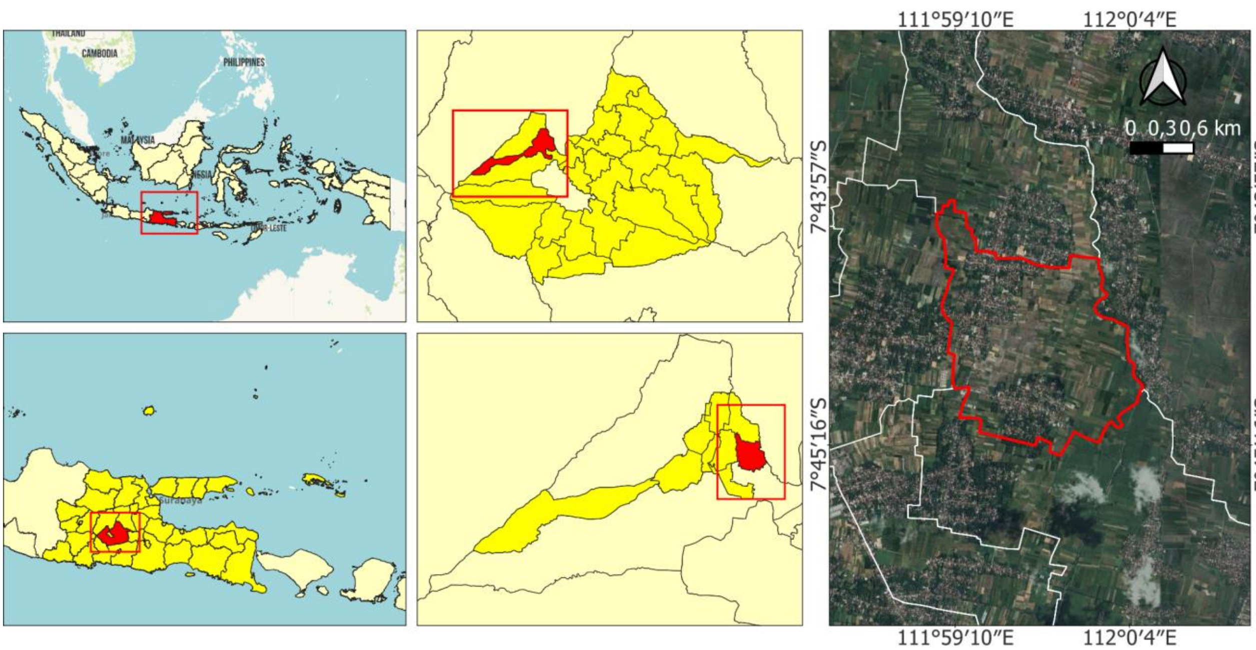


Figure 1. Map of study location in Datengan Village, Grogol Sub-district, Kediri District, East Java, Indonesia

Home gardens play a vital role in daily life. In *pangan* or food, they serve as "living supermarkets", providing a rich source of nutritious ingredients while also preserving local crop varieties. In terms of shelter or *papan*, these gardens offer essential materials for construction and housing. The health aspect, or *loro*, is reflected in the use of medicinal plants for traditional healing and disease prevention, highlighting the deep connection between herbal knowledge and Javanese wellness practices. Lastly, the concept of *pati*, or death, illustrates how plants are intertwined with human life cycles—used in funeral rituals and offerings to honor ancestors, reinforcing their cultural and spiritual significance. Direct sampling was carried out to compile a checklist of plants, and Plants of the World Online (https://powo.science.kew.org/) was utilized to verify the scientific names of the species.

Data analysis

All ethnobotanical indices are based on a fundamental data structure: "an informant i reports the use of species within use-category u." Use Report (UR) defines the combination of the three variables, informant, species, and use category (Kufer et al. 2005). In a given survey involving NS species (s_1, s_2, ..., s_n), NC use-categories (u_1, u_2,...,u_n), and N informants (i_1,i_2,..., i_n), a UR value is assigned as 1 when a particular combination is reported and 0 if it is not. These ethnobotanical records can be organized by holding one or two variables constant. The cultural importance of plants calculated the total number of UR per species:

$$\mathrm{UR_s} = \sum_{u=u_1}^{u_{\mathrm{NC}}} \sum_{i=i_1}^{i_{\mathrm{N}}} \mathrm{UR}_{ui}.$$

The process begins by totaling the use reports provided by all informants (from i_1 to i_n) for each use category associated with a given species, representing the number of informants who identified that specific use. Next, the use reports are aggregated across all use categories (from u_1 to u_{Nc}) to determine the overall frequency of use for that species.

The Relative Frequency of Citation (RFC) measures how commonly a species is mentioned by informants, regardless of how it is used. It is calculated by dividing the number of people who mention the species (frequency of citation or FC) by the total number of informants in the study (N). In this case, all mentions of the species are counted without separating them by specific use categories.

$$\mathrm{RFC_s} = \frac{\mathrm{FC_s}}{N} = \frac{\sum_{i=i_1}^{i_{\mathrm{N}}} \mathrm{UR}_i}{N}$$

The Relative Importance Index (RI) measures how important a plant species is by considering the different types of uses it has (Pardo-de-Santayana 2003). Notably, this index only includes broad categories of use and does not take more specific subcategories into account. The calculation follows a particular formula based on these general use types.

$$\mathrm{RI_s} = \frac{\mathrm{RFC_{s(max)}} + \mathrm{RNU_{s(max)}}}{2}$$

$RFC_{s(max)}$ refers to the relative frequency of citation of a species compared to the most frequently cited species in the entire study. It is calculated by dividing the frequency of citation (FC_s) for a particular species by the highest FC value among all species in the survey, $RFC_{s(max)} = FC_s$ / Max (FC). $RNU_{s(max)}$ stands for the relative number of use categories in comparison to the highest observed in the survey. It is determined by dividing the number of use categories recorded for a particular species by the maximum number in all species in the study [$RNU_{s(max)} = NU_s$ / Max (NU)].

$$NU_s = \sum_{u=u_1}^{u=u_{NC}} UR_u$$

The Cultural Value Index for ethnospecies (CVe) is calculated by multiplying three distinct components that reflect a species' cultural significance (Reyes-García et al. 2006). The first component is the ratio between the number of different uses reported for a species and the total number of use categories considered in the study, obtained by dividing the Number of Uses (NUs) by the total categories (NC). The second component is the Relative Frequency of Citation (RFC), which indicates how frequently informants mention the species. The third component is the proportion of Use Reports (UR), calculated by dividing the total number of individual reports for all uses of the species by the total number of participants (N). By multiplying these three factors, the CVe index captures not only the diversity of uses but also the frequency and cultural relevance of a species within the community.

$$\mathrm{CVe} = \left[\mathrm{NU_s}/\mathrm{NC}\right] \times \left[\mathrm{FC_s}/\mathrm{N}\right] \times \left[\sum_{u=u_1}^{u_{\mathrm{NC}}} \sum_{i=i_1}^{i_{\mathrm{N}}} \mathrm{UR}_{ui}/\mathrm{N}\right]$$

The Cultural Importance Index (CIs) measures the total proportion of informants who reported using each species.

$$\mathrm{CI_s} = \sum_{u=u_1}^{u_{\mathrm{NC}}} \sum_{i=i_1}^{i_{\mathrm{N}}} \mathrm{UR_{ui}}/\mathrm{N}$$

It is important to highlight that the total value of CI is numerically identical to that of the Use Value (UVs) index when calculated using a simplified formula, even though the two indices are conceptually distinct. UV starts with the sum of URs groupings by informants:

$$\mathrm{UV_s} = \sum_{i=i_1}^{i_{\mathrm{N}}} \sum_{u=u_1}^{u_{\mathrm{NC}}} \mathrm{UR}_{iu}/N$$

The Fidelity Level (FLs) for each species in the study by calculating the proportion of informants who report using a particular plant for a specific purpose relative to its total reported uses across all purposes. It reflects how consistently a plant is used for the same function among informants. According to Friedman et al. (1986), FCs refers to the number of informants who use a particular plant for a specific purpose, while Ns represents the total number of informants who mentioned using that plant for any purpose. Ethnobotanical indices were calculated using RStudio with the ethnobotanyR package (Whitney 2021).

$$FL_s = \frac{N_s * 100}{FC_s}$$

Indices alone might not capture the full picture of human-nature relationships, but they offer a useful entry point for examining key dynamics. By quantifying otherwise intangible aspects of how societies interact with their surroundings, these indices contribute meaningful data. While they shouldn't stand alone, they can support more in-depth and integrated evaluations. A non-parametric Bayesian bootstrap was performed utilizing the ethno-boot function. It substituted a sample of size 'n1' describing the posterior distribution of the selected statistics (e.g., 'mean'). The procedure employed the Dirichlet distribution to represent the randomness of a Probability Mass Function (PMF) across all possible outcomes for limited groups. It was conjugated before the unconditional and multinomial distributions. A Probability Mass Function (PMF), or frequency function, describes the probabilities of discrete outcomes, such as binary responses (0 = no use, 1 = use) or finite counts (e.g., plant uses reported by up to n interviewees). The Dirichlet distribution models n positive random variables (X_1 , ..., X_n) that collectively sum to 1, analogous to the multinomial distribution but as a continuous generalization. Here, we apply this framework to analyze differences in use (binary: 0/1) between two species (a and b). To compare species or informants visually, plot the posterior distribution generated by ethno-boot after reshaping the data into a ggplot2-friendly format (e.g., via melt) (Whitney 2021).

This study employed Venn diagrams to analyze and display overlaps in plant species usage across different groups or categories. Plant diversity similarities among differently-sized home gardens were analyzed and visualized through dendrogram clustering. Principal Component Analysis (PCA) was used to explore how plant diversity is related to five essential life needs. Since all variables showed non-normal distributions, we analyzed relationships between indices using Spearman's rank correlation coefficient.

RESULTS AND DISCUSSION

This study identified a total of 71 plant species in the home gardens across the study sites (Table 1), categorized according to their uses in nourishment (*pangan*), clothing (*sandang*), shelter (*papan*), herbal medicine (*loro*), and traditional death-related rituals (*pati*) (Table 1). These species belonged to 43 families (Figure 2), with Fabaceae being the most dominant (7%), followed by Zingiberaceae (6%), Annonaceae, Malvaceae, Moraceae, Myrtaceae, Poaceae, Rutaceae, and Solanaceae (5% each). Based on life forms, trees were the most prevalent (34 species), followed by herbs (21 species), shrubs (9 species), vines (6 species), and bamboo (1 species) (Figure 3.A). Fruits (30 species) were the most commonly used plant parts, followed by leaves (28 species), flowers (8 species), trunks (5 species), rhizomes (4 species), tubers (3 species), stem (3 species), and seeds (1 species) (Figure 3.B). Several species, including *Bambusa* sp., *Carica papaya* L., *Ceiba pentandra* (L.) Gaertn., *Citrus hystrix* DC., *Cocos nucifera* L., *Colocasia esculenta* (L.) Schott, *Ipomoea batatas* (L.) Lam., *Manihot esculenta* Crantz, *Morinda citrifolia* L., and *Musa ×paradisiaca* L., had multiple parts utilized for various purposes.

A total of 55 home gardens were surveyed and categorized into three size classifications: 13 large home gardens (<500 m^2), 11 medium home gardens (501-1,500 m^2), and 31 small home gardens (>1,500 m^2). The dendrogram analysis showed that medium and small home gardens exhibited greater similarity compared to large ones. Several plant species were common across all three categories, including *Amaranthus hybridus* L., *Annona squamosa* L., *Artocarpus heterophyllus* Lam., *Averrhoa carambola* L., *Capsicum annuum* L., *C. papaya*, *C. pentandra*, *Dimocarpus longan* Lour., *I. batatas*, *Jasminum sambac* (L.) Aiton, *Leucaena leucocephala* (Lam.) de Wit, *Mangifera indica* L., *M. esculenta*, *Manilkara zapota* (L.) P.Royen, *Moringa oleifera* Lam., *M. paradisiaca*, *Ocimum basilicum* L., *Plumeria* sp., *Psidium guajava* L., and *Zingiber officinale* Roscoe (Figure 4.A). The dendrogram results further indicated that medium and small home gardens tended to be more uniform in composition compared to large ones (Figure 4.B). The Venn diagram shows the absolute number of overlapping species, while the dendrogram clusters are based on relative similarity, which may explain differences in group relationships between the two.

Based on the use categories, plant species in the home gardens were primarily used for food (53 species), followed by medicine (17 species), construction (8 species), ritual (6 species), and clothing (1 species). Across all home gardens, a total of 281 Use Reports (UR) were recorded, with the majority attributed to food (UR=212), medicine (UR=24), ritual (UR=22), construction (UR=22), and clothing (UR=1) (Figure 5.A). Among the species, *Bambusa* sp. and *M. oleifera* had the highest number of uses (NU=3). The biplot analysis revealed 9 clusters of use categories based on species presence or absence, with principal components PC1 and PC2 accounting for 53.6% of the variation in the use categories (Figure 5.B).

Two species, *M. oleifera* and *Bambusa* sp. (Figure 6.A), were found to have the highest number of uses (three). A non-parametric Bayesian bootstrap analysis was conducted to calculate credible intervals for these uses. For *M. oleifera*, the credible interval for food use ranged from 1.00 (lower bound) to 1.00 (upper bound). For ritual use, the interval was 0.10 (lower bound) to 0.76 (upper bound), and for medicine, it ranged from 0.46 (lower bound) to 0.99 (upper bound). For *Bambusa* sp., the credible interval for food use was 0.05 (lower bound) to 0.95 (upper bound), while for construction use, it ranged from 1.00 (lower bound) to 1.00 (upper bound). Additionally, the interval for *Bambusa* sp. Used in construction was 0.53 (lower bound) to 0.95 (upper bound) (Figure 6.B).

Table 1. Plant species diversity in the home gardens

Code	Scientific name	Family	Form	Part	NU	UR	UV	FC	RFC	CI	RI	CVe	Use categories
A. alt	*Artocarpus altilis* (Parkinson) Fosberg	Moraceae	T	Fr	2	2	0.036	1	0.018	0.036	0.356	0	Fo, Co
A. bil	*Averrhoa bilimbi L.*	Oxalidaceae	T	L	1	1	0.018	1	0.018	0.018	0.189	0	Fo
A. car	*Averrhoa carambola* L.	Oxalidaceae	T	L	1	4	0.071	4	0.071	0.071	0.258	0.001	Fo
A. cor	*Anredera cordifolia* (Ten.) Steenis	Basellaceae	V	L	1	1	0.018	1	0.018	0.018	0.189	0	Me
A. het	*Artocarpus heterophyllus* Lam.	Moraceae	T	Fr	1	11	0.196	11	0.196	0.196	0.417	0.008	Fo
A. hyb	*Amaranthus hybridus* L.	Amaranthaceae	H	L	1	10	0.179	10	0.179	0.179	0.394	0.006	Fo
A. mur	*Annona muricata* L.	Annonaceae	T	L	1	2	0.036	2	0.036	0.036	0.212	0	Fo
A. pae	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Araceae	H	Tu	1	1	0.018	1	0.018	0.018	0.189	0	Fo
A. squ	*Annona squamosa* L.	Annonaceae	T	Fr	1	5	0.089	5	0.089	0.089	0.28	0.002	Fo
A. ver	*Aloe vera* (L.) Burm.f.	Asphodelaceae	H	L	1	2	0.036	2	0.036	0.036	0.212	0	Me
B. jun	*Brassica juncea* (L.) Czern.	Brassicaceae	H	L	1	1	0.018	1	0.018	0.018	0.189	0	Fo
B. sp	*Bambusa* sp.	Poaceae	B	Tr, St	3	4	0.071	2	0.036	0.071	0.545	0.002	Fo, Cl, Co
C. ann	*Capsicum annuum* L.	Solanaceae	H	Fr	1	7	0.125	7	0.125	0.125	0.326	0.003	Fo
C. asi	*Centella asiatica* (L.) Urb.	Apiaceae	H	L	1	1	0.018	1	0.018	0.018	0.189	0	Fo
C. cau	*Cosmos caudatus* Kunth	Asteraceae	H	L	1	1	0.018	1	0.018	0.018	0.189	0	Fo
C. esc	*Colocasia esculenta* (L.) Schott	Araceae	H	L, St	1	3	0.054	3	0.054	0.054	0.235	0.001	Fo
C. hys	*Citrus hystrix* DC.	Rutaceae	T	Fr, L	1	4	0.071	3	0.054	0.054	0.402	0.002	Fo, Me
C. jap	*Citrus japonica Thunb.*	Rutaceae	T	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
C. max	*Citrus maxima* (Burm.) Merr.	Rutaceae	T	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
C. nar	*Cymbopogon nardus* L. Rendle	Poaceae	H	St	2	6	0.107	5	0.089	0.107	0.447	0.004	Fo, Me
C. nuc	*Cocos nucifera* L.	Arecaceae	T	Tr, L, Fr	2	4	0.071	3	0.054	0.071	0.402	0.002	Fo, Co
C. odo	*Cananga odorata* (Lam.) Hook.f. & Thomson	Annonaceae	S	Fl	1	4	0.071	4	0.071	0.071	0.258	0.001	Ri
C. pap	*Carica papaya* L.	Caricaceae	T	Fr, Lv	1	11	0.196	11	0.196	0.196	0.417	0.008	Fo
C. pen	*Ceiba pentandra* (L.) Gaertn.	Malvaceae	T	L. Fr	1	6	0.107	6	0.107	0.107	0.303	0.002	Co
C. ter	*Clitoria ternatea* L.	Fabaceae	V	Fl	2	2	0.036	2	0.036	0.036	0.379	0.001	Fo, Me
C. xan	*Curcuma xanthorrhiza* D. Dietr	Zingiberaceae	H	Rh	1	1	0.018	1	0.018	0.018	0.189	0	Me
D. lon	*Dimocarpus longan* Lour.	Sapindaceae	T	Fr	1	5	0.089	5	0.089	0.089	0.28	0.002	Fo
D. zib	*Durio zibethinus* L.	Malvaceae	T	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
F. fal	*Falcataria falcata* (L.) Greuter & R.Rankin	Fabaceae	T	Tr	1	1	0.018	1	0.018	0.018	0.189	0	Co
G. man	*Garcinia mangostana* L.	Clusiaceae	T	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
H. til	*Hibiscus tiliaceus* L.	Malvaceae	T	Tr	1	1	0.018	1	0.018	0.018	0.189	0	Co
I. aqu	*Ipomoea aquatica* Forssk.	Convolvulaceae	H	L	1	1	0.018	1	0.018	0.018	0.189	0	Fo
I. bal	*Impatiens balsamina* L.	Balsaminaceae	H	Fl	1	3	0.054	3	0.054	0.054	0.235	0.001	Ri
I. bat	*Ipomoea batatas* (L.) Lam.	Convolvulaceae	H	L, Tu	1	4	0.071	4	0.071	0.071	0.258	0.001	Fo
J. mul	*Jatropha multifida* L.	Euphorbiaceae	S	L	1	1	0.018	1	0.018	0.018	0.189	0	Me
J. sam	*Jasminum sambac* (L.) Aiton	Oleaceae	S	Fl	1	5	0.089	5	0.089	0.089	0.28	0.002	Ri
K. gal	*Kaempferia galanga* L.	Zingiberaceae	H	Rh	1	1	0.018	1	0.018	0.018	0.189	0	Me
L. acu	*Luffa acutangula* (L.) Roxb.	Cucurbitaceae	V	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
L. leu	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	T	Se	2	16	0.286	13	0.232	0.286	0.629	0.027	Fo, Co
M. alb	*Morus alba* L.	Moraceae	T	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
M. cal	*Muntingia calabura* L.	Muntingiaceae	T	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
M. cit	*Morinda citrifolia* L.	Rubiaceae	T	L, Fr	1	1	0.018	1	0.018	0.018	0.189	0	Me

M. esc	*Manihot esculenta* Crantz	Euphorbiaceae	S	L, Tu	1	10	0.179	10	0.179	0.179	0.394	0.006	Fo
M. ind	*Mangifera indica* L.	Anacardiaceae	T	Fr	1	23	0.411	22	0.393	0.411	0.883	0.065	Fo
M. ole	*Moringa oleifera* Lam.	Moringaceae	T	L	3	11	0.196	5	0.089	0.196	0.614	0.011	Fo, Me, Ri
M. par	*Musa ×paradisiaca* L.	Musaceae	H	Fr, Fl, L	1	18	0.321	18	0.321	0.321	0.576	0.021	Fo
M. zap	*Manilkara zapota* (L.) P.Royen	Sapotaceae	T	Fr	1	8	0.143	8	0.143	0.143	0.348	0.004	Fo
N. lap	*Nephelium lappaceum* L.	Sapindaceae	T	Fr	1	4	0.071	4	0.071	0.071	0.258	0.001	Fo
O. bas	*Ocimum basilicum* L.	Lamiaceae	H	L	1	4	0.071	4	0.071	0.071	0.258	0.001	Fo
P. ama	*Pandanus amaryllifolius* Roxb. ex Lindl.	Pandanaceae	H	L	1	2	0.036	2	0.036	0.036	0.212	0	Fo
P. ame	*Persea americana* Mill.	Lauraceae	T	Fr	1	2	0.036	2	0.036	0.036	0.212	0	Fo
P. ang	*Physalis angulata* L.	Solanaceae	S	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
P. bet	*Piper betle* L.	Piperaceae	V	L	1	1	0.018	1	0.018	0.018	0.189	0	Me
P. gra	*Punica granatum* L.	Lythraceae	S	Fr	1	2	0.036	2	0.036	0.036	0.212	0	Fo
P. gua	*Psidium guajava* L.	Myrtaceae	T	Fr	1	15	0.268	15	0.268	0.268	0.508	0.014	Fo
P. ind	*Pluchea indica* (L.) Less.	Asteraceae	S	L	2	2	0.036	1	0.018	0.036	0.356	0	Fo, Me
P. sp.	*Plumeria* sp.	Apocynaceae	T	Fl	1	6	0.107	6	0.107	0.107	0.303	0.002	Ri
R. hyb	*Rosa x hybrida* Schleich. Ex W.D.J.Koch & Ziz	Rosaceae	S	Fl	2	3	0.054	3	0.054	0.054	0.402	0.001	Me, Ri
S. aqu	*Syzygium aqueum* (Burm.F.) Alston	Myrtaceae	T	Fr	1	2	0.036	2	0.036	0.036	0.212	0	Fo
S. gra	*Sesbania grandiflora* (L.) Poir.	Fabaceae	T	Fl	1	1	0.018	1	0.018	0.018	0.189	0	Fo
S. mel	*Solanum melongena* L.	Solanaceae	H	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
S. mon	*Selenicereus monacanthus* (Lem.) D.R.Hunt	Cactaceae	V	Fr	1	4	0.071	4	0.071	0.071	0.258	0.001	Fo
S. off	*Saccharum officinarum* L.	Poaceae	H	St	1	1	0.018	1	0.018	0.018	0.189	0	Fo
S. poly	*Syzygium polyanthum* (Wight) Walp.	Myrtaceae	S	L	1	1	0.018	1	0.018	0.018	0.189	0	Fo
T. cat	*Terminalia catappa* L.	Combretaceae	T	L	2	1	0.018	1	0.018	0.018	0.189	0	Me
T. gra	*Tectona grandis* Linn. f.	Lamiaceae	T	Tr	1	6	0.107	6	0.107	0.107	0.303	0.002	Co
T. ind	*Tamarindus indica* L.	Fabaceae	T	Fr	2	2	0.036	1	0.018	0.036	0.356	0	Fo, Me
V. vin	*Vitis vinifera* L.	Vitaceae	V	Fr	1	2	0.036	2	0.036	0.036	0.212	0	Fo
Z. mau	*Ziziphus mauritiana* Lam.	Rhamnaceae	T	Fr	1	1	0.018	1	0.018	0.018	0.189	0	Fo
Z. off	*Zingiber officinale* Roscoe	Zingiberaceae	H	Rh	2	6	0.107	5	0.089	0.107	0.447	0.004	Fo, Me
Z. zer	*Zingiber zerumbet* (L.) Roscoe ex Sm.	Zingiberaceae	H	Rh	1	1	0.018	1	0.018	0.018	0.189	0	Me

Note: T: Trees, H: Herbs, V: Vines, B: Bamboos, Fr: Fruits, L: Leaves, Rh: Rhizomes, Fl: Flowers, Tu: Tubers, Tr: Trunk, Fo: Food, Me: Medicine, Cl: Clothing, Co: Construction, Ri: Ritual, CI: Cultural Importance, RFC: Relative Frequency of Citation, RI: Relative Importance, CV: Cultural Value, FC: Frequency of Citation, UR: Number of Use-Reports, NU: Number of Uses

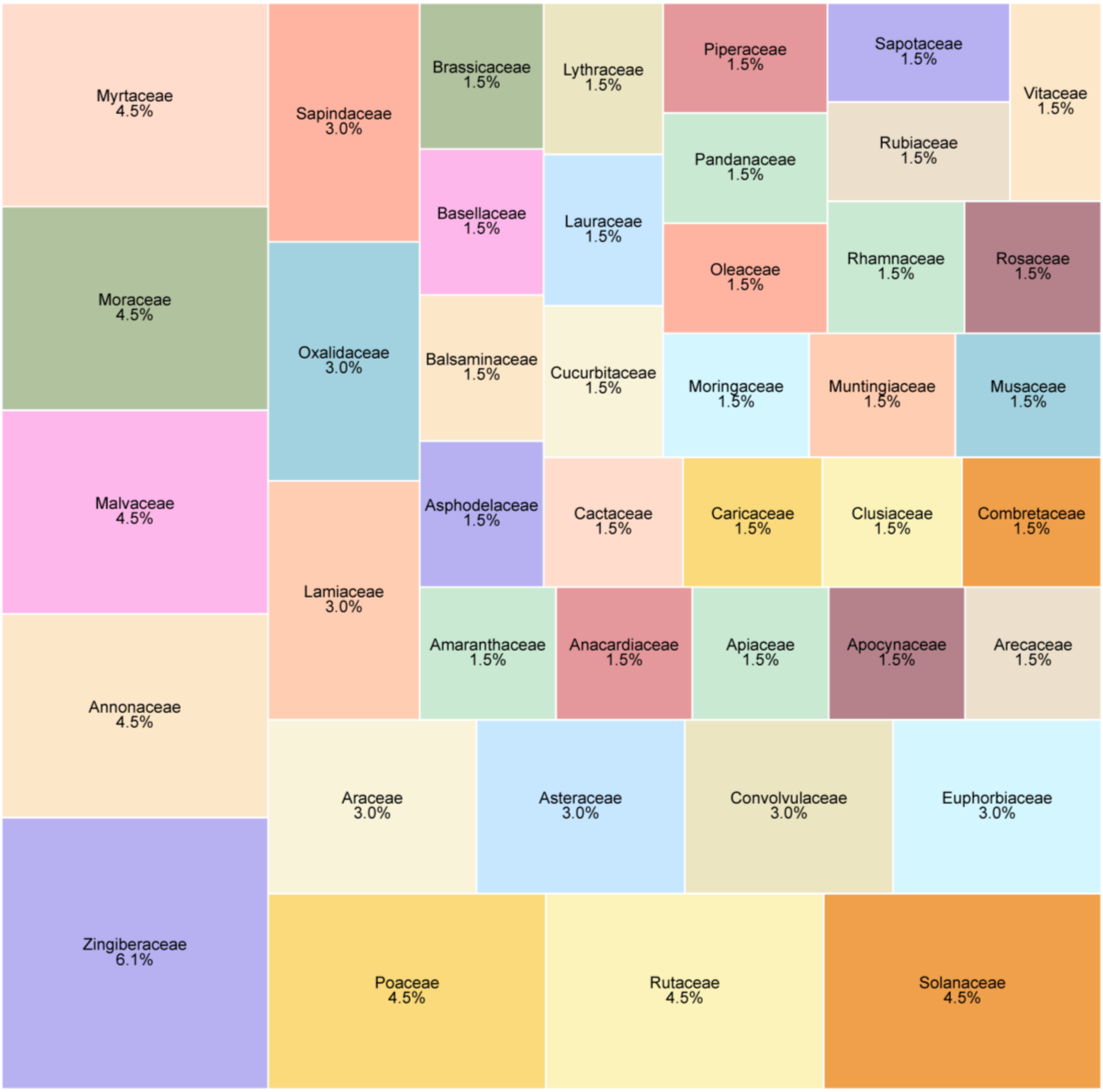


Figure 2. Classification of plant species of percentage family. T: Trees; H: Herbs; V: Vines; B: Bamboos; Fr: Fruits; L: Leaves; Rh: Rhizomes; Fl: Flowers; Tu: Tubers; Tr: Trunk; Fo: Food; Me: Medicine; Cl: Clothing; Co: Construction; Ri: Ritual

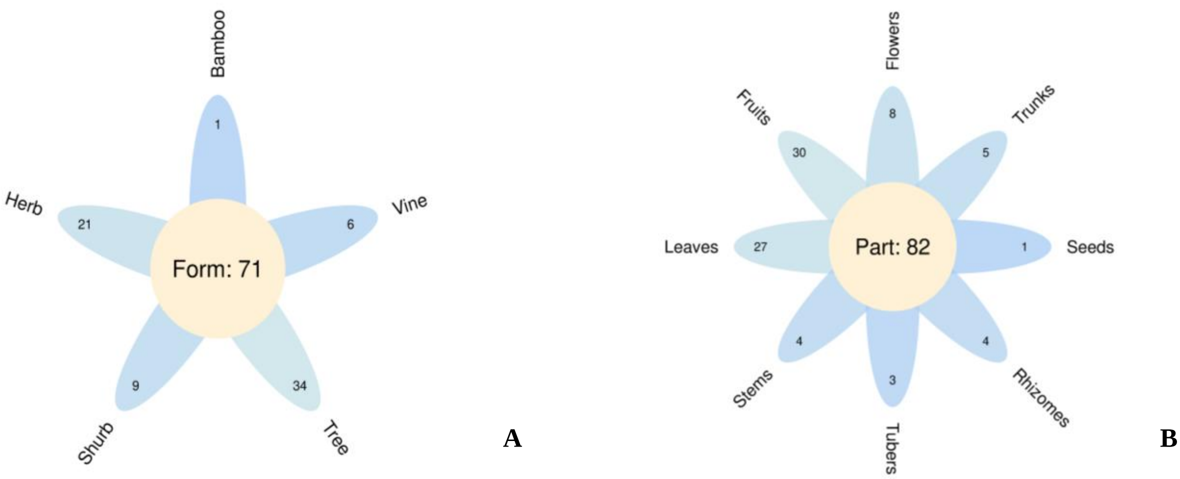


Figure 3. Classification of plant species by life form and part use

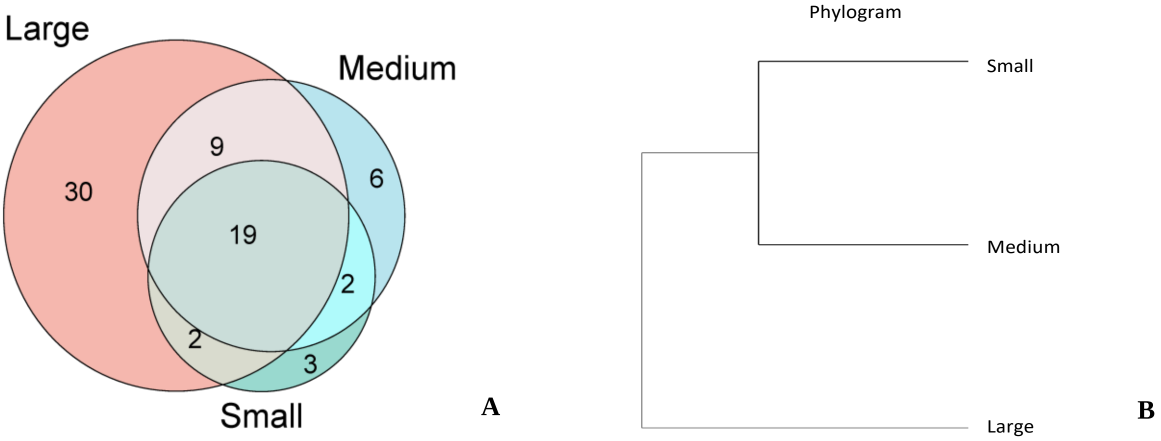


Figure 4. Home garden characteristics based on size: A. Venn diagram showing shared and unique species across small, medium, and large gardens; B. phylogram derived from unweighted pair group method with arithmetic mean (UPGMA) clustering, showing similarity patterns based on species composition. While the Venn diagram shows absolute overlap, the phylogram reflects hierarchical similarity using relative proportions

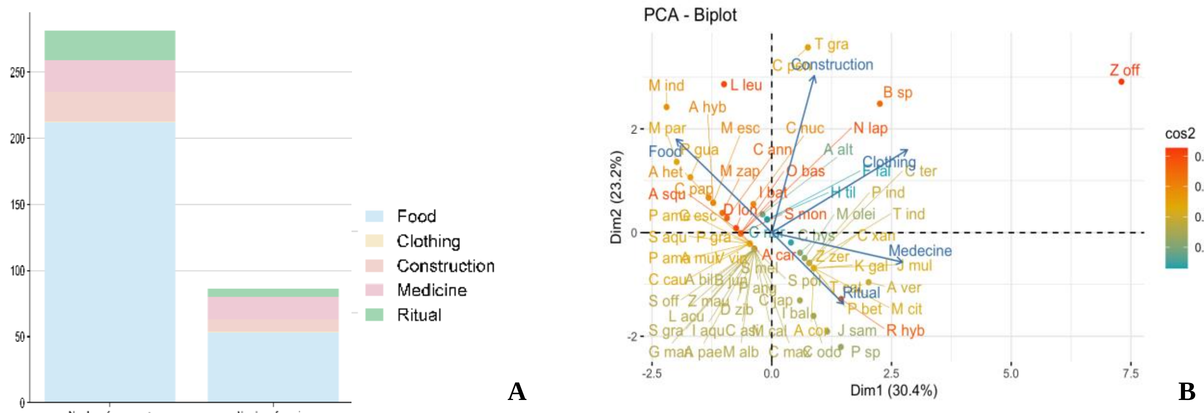


Figure 5. A. Categories of uses categories; B. Principal Component Analysis (PCA) biplot of uses categories in the study area

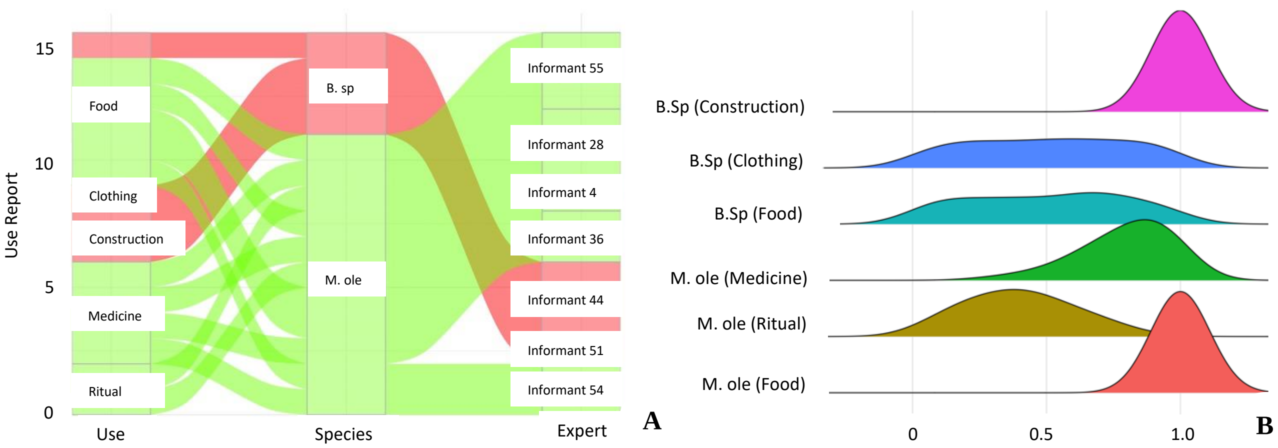


Figure 6. Species with three use categories: A. Frequency distributions across uses, experts, and use categories; B. Bayesian bootstrap

Among all the recorded indices, *M. indica* demonstrated notable cultural and practical importance in Datengan Village. It achieved a UV of 0.411, indicating that it is used for multiple purposes by various respondents. The species was cited by 22 informants, resulting in an FC of 22 and an RFC of 0.393, showing that more than half of the community members acknowledged its relevance. CI for *M. indica* was 0.411, reflecting both the frequency and diversity of its use. Furthermore, it had an RI of 0.883, suggesting its usefulness across several functional categories. CVe was 0.065, placing *M. indica* among the top species valued for both daily utility and cultural significance (Figure 7).

The correlation matrix reveals that several indices, specifically UR, UV, FC, RFC, CI, RI, and CVe, are highly correlated with one another, indicating they may be measuring similar or related constructs. These correlations were not only strong (with values close to 1.00) but also statistically significant, as shown by the low p-values in the significance matrix ($p < 0.01$) (Figure 8). In contrast, NU stands out as an outlier, showing weak correlations with most other variables and non-significant relationships with FC and RFC. This suggests that NU may represent a distinct or unrelated dimension within the dataset. RI and CVe, however, demonstrated strong and significant correlations with nearly all other indices, implying they could serve as good summary indicators for broader trends in the data.

Table 2 presents the Fidelity Level (FL) values for using home garden plants for medicinal purposes. Of 17 species, 12 species exhibit an FL value of 100%, indicating strong agreement among informants regarding their specific use. *Zingiber officinale* demonstrates the most diverse applications, being used to treat flu and cough (40%), fever (20%), boost general immunity (20%), and lower cholesterol (20%).

Discussion

The home garden farming system continues to thrive in Indonesia, particularly within the Javanese community. These gardens are recognized for their high diversity of useful plant species, often exceeding that of other agricultural systems like rice fields. Home gardens also offer greater ecological stability and long-term sustainability. In this study, 71 species were recorded, higher than the diversity reported in several previous studies, such as 60 species in the Tidung Tribe of North Kalimantan (Suciyati et al. 2021), 55 in the Menoreh Karst Area, Purworejo District (Igustita et al. 2023), 22 among the Osing Tribe in Banyuwangi (Hakim et al. 2018), and 64 among the Sundanese in Sumedang (Suwartapradja et al. 2023).

Compared to these regions, the higher species richness observed in this study suggests a more diverse pattern of plant use and management. Respondents indicated that home gardens not only contribute to household food security but also serve as supplementary income sources through the sale of surplus produce. This aligns with findings from other regions where greater species diversity is often linked to more extensive and multifunctional utilization. For example, Prihatini et al. (2018) documented 171 species in the Upstream Citarum Watershed (West Java), highlighting the inclusion of both cultivated and wild species for food, medicine, and cultural practices. Similarly, 85 species were reported among the Batak Karo people (North Sumatra) and 173 species in East Aceh (Suwardi et al. 2023), where plant diversity is closely tied to local knowledge systems and diverse household needs.

Table 2. Fidelity Level (FL) on the use of a medicinal plant for a particular therapeutic application

Scientific name	FL(%)	Instruction
Anredera cordifolia (Ten.) Steenis	100	Boiled and drunk for hypotension, diabetes, and abdominal pain
Aloe vera (L.) Burm.f.	75	Applied fresh aloe vera gel as a hair treatment
	25	Applied fresh aloe vera gel as a skin treatment
Citrus hystrix DC.	75	Squeezed and drunk for cough and sore throat
	25	Squeezed and drunk for sore throat
Cymbopogon nardus L. Rendle	100	Boiled and drunk to help relieve respiratory diseases.
Clitoria ternatea L.	100	Boiled and drunk for diabetes
Curcuma xanthorrhiza D. Dietr	100	Boiled and drunk for general immunity
Jatropha multifida L.	100	The sap as a natural remedy for cuts and wounds
Kaempferia galanga L.	50	Boiled and drunk for fever
	50	Boiled and drunk for general immunity
Morinda citrifolia L.	100	Boiled and drunk for general immunity
Moringa oleifera Lam.	100	Boiled and drunk for diabetes
Piper betle L.	40	Rolled and placed in the nose for nosebleeds
	40	Chewed to support dental and oral health
	20	Boiled and drunk for dysmenorrhea
Pluchea indica (L.) Less.	100	Boiled and drunk for dyspepsia
Rosa x hybrida Schleich. Ex W.D.J.Koch & Ziz	100	Commonly used in traditional remedies for skin care.
Terminalia catappa L.	100	Boiled and drunk for diabetes
Tamarindus indica L.	100	Boiled and drunk for dysmenorrhea
Zingiber officinale Roscoe	40	Boiled and drunk for flu and cough
	20	Boiled and drunk for fever
	20	Boiled and drunk for general immunity
	20	Boiled and drunk for cholesterol
Zingiber zerumbet (L.) Roscoe ex Sm.	100	Boiled and drunk for fever

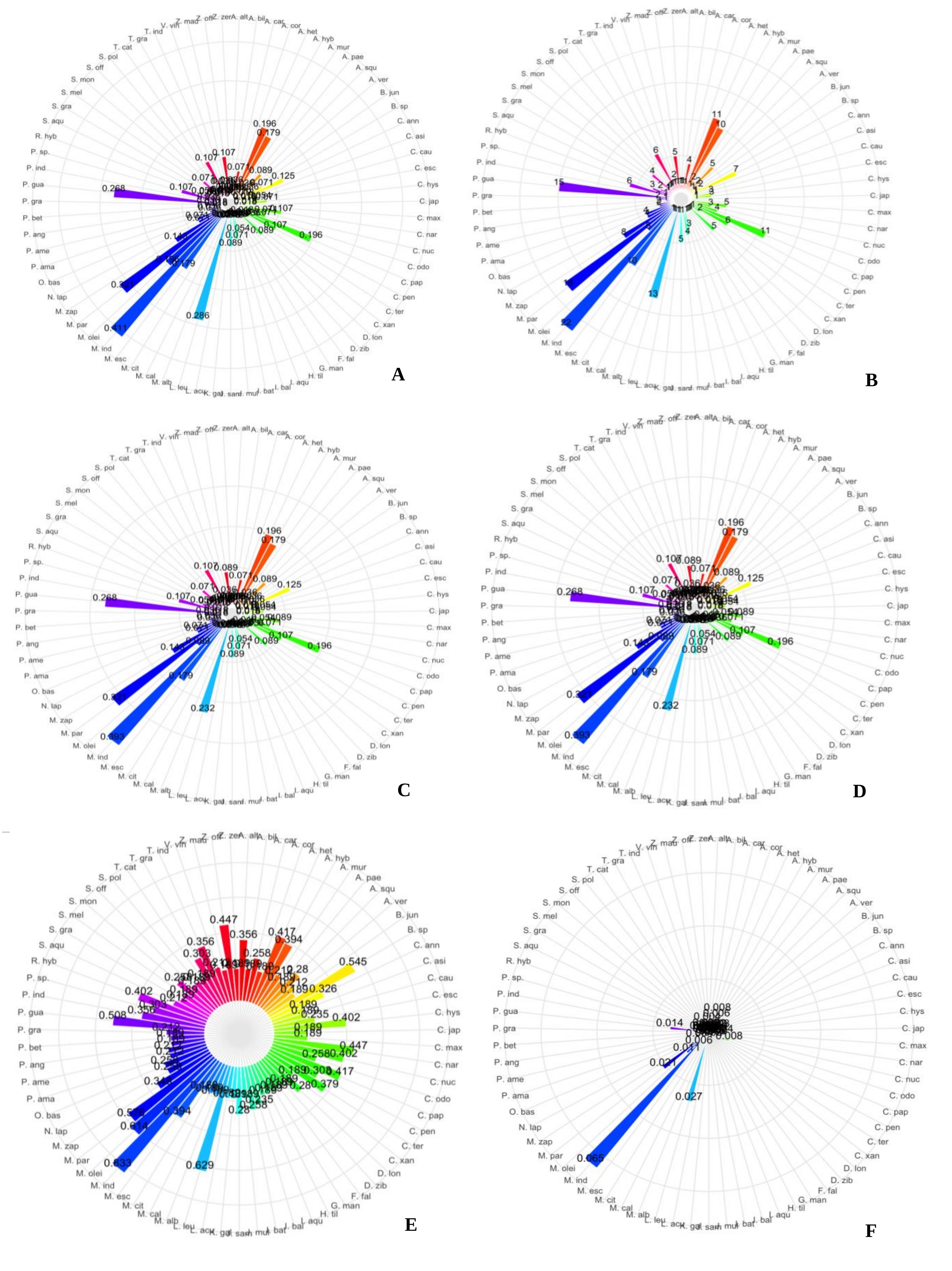


Figure 7. All indexes of quantitative ethnobotany analysis: A. Use Value (UV); B. Frequency of Citation (FC); C. Relative Frequency of Citation (RFC); D. Cultural Importance (CI); E. Relative Importance (RI); F. Cultural Value (CVe)

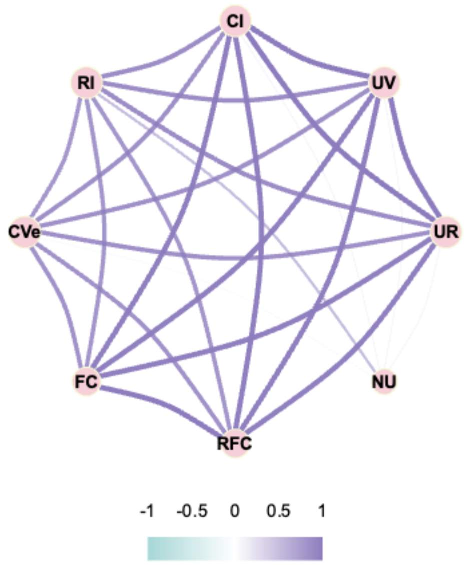


Figure 8. Spearman correlation rank (A) based on all indices, $p < 0.01$

Plant species in home gardens were predominantly cultivated for food, with 53 species identified. The Javanese employ various traditional methods of food preparation involving the selection of essential ingredients, spices, herbs, and complementary components. East Javanese cuisine is characterized by the use of shrimp paste as a flavor enhancer and a slightly spicy taste, with primary cooking methods including boiling, frying, and grilling. According to Afrianto et al. (2021), the Datengan community still utilizes forgotten foods, such as two types of fermented foods, 26 nutrient-rich plant-based foods, 6 by-product foods, and 2 types of mushrooms. This study found that the dominant edible fruit plants included *M. indica*, *A. squamosa*, *A. heterophyllus*, *P. guajava*, *C. papaya*, and *M. paradisiaca*. Plant diversity in home gardens is positively associated with increased dietary diversity, improved nutritional status, and better health outcomes for household members (Whitney et al. 2018; Thamilin et al. 2019; Depenbusch et al. 2022).

During and after the COVID-19 pandemic, home gardens have played a crucial role in strengthening food and nutritional security (Lal 2020). They serve as a practical step toward achieving household-level food resilience (Ferdous et al. 2016). According to interview findings, the food supply in the village remained stable throughout the pandemic. In addition to sourcing food externally, villagers relied heavily on produce from their home gardens. These gardens provided alternative staple foods, kitchen spices, vegetables, and fruits, as well as natural medicinal ingredients, offering a holistic support system for both nutrition and health during the crisis. This reflects their deep connection to nature and the belief that environmental imbalances were divine warnings against exploiting the environment (Afrianto and Metananda 2023).

There were 17 plant species utilized in traditional medicine (Tables 1 and 2). In Javanese tradition, herbal medicine is commonly referred to as *jamu* (Elfahmi et al. 2014). The efficacy of *jamu* is primarily based on practical knowledge passed down through generations, often conveyed orally (Surya et al. 2024). For example, *C. hystrix* leaves were boiled and used as a remedy for coughs. The young leaves of *T. indica* were processed into a traditional herbal drink known as *sinom asem*. The Javanese widely consume this drink to improve blood circulation, reduce menstrual pain, aid weight loss, and alleviate vaginal discharge and constipation (Adriani and Pritasari 2024). Similarly, *Z. officinale* (ginger) was boiled and consumed as a warming drink to treat fever and coughs. During the COVID-19 pandemic, *Z. officinale* gained widespread popularity in Indonesia as a natural immune booster (Boozari and Hosseinzadeh 2021).

The only plant species used for clothing in Datengan Village is *Bambusa* sp. In this community, *Bambusa* sp. is primarily utilized for crafting bags and traditional cone-shaped hats (*caping*). *Caping*, woven from *Bambusa* sp., offers practical advantages over conventional hats, protecting from the sun's heat during hot weather and repelling rainwater in wet conditions. While farmers commonly wear *caping* while working in the fields, it is also used by non-farmers for various outdoor activities. *Bambusa* sp. holds significant importance in Indonesian rural life, serving social, economic, cultural, and ecological functions (Partasasmita et al. 2017; Setiawati et al. 2017). *Gigantochloa apus*, a species from the genus *Gigantochloa* (locally known as *awi tali*), abundantly cultivated in the mixed gardens of Naga Hamlet, Neglasari Village, Tasikmalaya District, is the most preferred bamboo for weaving due to its long, strong, and flexible fibers (Irawan et al. 2019). In addition to household utensils, the people of Cijambu Village, Sumedang District, also utilize *G. apus* as clothesline supports, demonstrating the multifunctionality of bamboo species in daily domestic life (Ihsan et al. 2024).

Home gardens are deeply connected to the cultural identity of ethnic communities and serve as a source of plants for ritual purposes. In Datengan Village, *M. oleifera* is an important plant used in death rituals. According to local beliefs, in Javanese traditions, *M. oleifera* leaves are thought to possess magical properties capable of warding off spirits or negative energies. These leaves are commonly used in traditional rituals to cleanse homes or specific locations from supernatural disturbances. In Datengan Village, *M. oleifera* leaves are also believed to assist individuals who are sick or nearing death by helping them release supernatural influences (Afrianto and Metananda 2023). Meanwhile, flower species such as *Cananga odorata*, *Impatiens balsamina*, *J. sambac*, *Plumeria* sp., and *Rosa* × *hybrida* are commonly used for scattering on graves or during funeral ceremonies. Mukarromah et al. (2024) documented that 27 plant species from 20 families are used in various Javanese traditional rituals, such as mitoni, wedding ceremonies, and grebeg events, each selected for its symbolic meaning and cultural significance.

The Javanese community utilizes a variety of plant species for construction purposes, including *A. altilis*, *Bambusa* sp., *C. nucifera*, *L. leucocephala*, and *M. indica*. These plants serve essential functions in building structures, such as primary building materials, windows, walls, furniture, and foundations. An ethnobotanical study of the communities in Gunung Halimun Salak National Park recorded 50 plant species used for construction and household utilities (Dewi et al. 2023). *Artocarpus altilis* wood is commonly used as building poles, making it a popular choice among the Javanese (Trisulowati 2003). An ethnobotanical study of traditional building materials on the island of Bali revealed that *A. heterophyllus* is commonly used and that species richness varied significantly between villages, reflecting differing levels of traditional knowledge preservation (Sujarwo and Keim 2017). *Cocos nucifera* wood (*glugu*) is cut and split into blocks for roof frames. *Bambusa* sp. is widely used in construction, particularly for rafters, battens, and woven wall materials (*gedhek*). *G. pseudoarundinacea* (*awi surat*), *G. atter* (*awi temen*), and *B. vulgaris* (*haur hejo*) types are traditionally used by the Naga community in Tasikmalaya, West Java, as primary bamboo species for construction, including house floors (*palupuh*), walls (*bilik*), and verandas (*teras*), due to their strong, durable, and thick culms (Irawan et al. 2019). *M. indica* wood is utilized for partitions, walls, doors, windows, and light construction, while *L. leucocephala* wood is often used for light construction and furniture. The selection of wood for construction is primarily based on the durability and strength of plant species that produce hard and long-lasting wood (Ijaz et al. 2017).

In conclusion, home gardens play a crucial role in sustaining the livelihoods of residents in Datengan Village, Kediri District, with 71 plant species from 40 plant families, highlighting the significant contribution of home gardens to Javanese traditional life. Among the 5 basic life needs in Javanese culture, plants are most commonly used for food (53 species), with UR at 212, with fruit and vegetable crops being the dominant species. Further analysis revealed that medium and small home gardens exhibit greater similarity in species use compared to larger ones. *M. indica* showed notable cultural and practical value in Datengan Village, with UV of 0.411, FC of 22, RFC of 0.393, CI of 0.411, RI of 0.883, and CVe of 0.065.

The implications of this study highlight the significance of the high plant diversity recorded in Datengan Village, where 71 species from 43 families were documented. These findings provide strong evidence of the multifunctional role of home gardens in supporting household food security, primary healthcare, and the preservation of traditional ecological knowledge. The identification of key ethnobotanies such as *M. indica*, and *C. nucifera*, which scored high across multiple cultural value indices, offers a strategic reference for designing community-based conservation programs. The added value of this research lies in its ability to inform local policy and rural development initiatives by emphasizing home gardens as low-cost, crucial tools for promoting biodiversity conservation. This emphasis on the role of home gardens in biodiversity conservation should instill a sense of urgency and importance in supporting these initiatives. Moreover, by encouraging knowledge-sharing within the community and fostering intergenerational transmission of plant use practices, this study supports the long-term sustainability of both cultural heritage and agrobiodiversity in rural settings.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to all those who contributed to the completion of this study. I deeply appreciate all contributions to this research. However, any errors or omissions remain my own.

REFERENCES

Adriani A, Pritasari W. 2024. Literature review: Types and benefits of *jamu* in Indonesia. Biol Educ J 4 (1): 69-79. DOI: 10.25299/baej.2024.16976. [Indonesian]

Afrianto WF, Hasanah LN, Metananda AA. 2023. Diversity of edible plants traded in the East Jakarta traditional markets, Indonesia. Biodiversitas 24 (12): 6953-6968. DOI: 10.13057/biodiv/d241257.

Afrianto WF, Metananda AA. 2023. Revealing the biocultural importance of *Moringa oleifera* (Moringaceae) in three villages, Kediri District, Indonesia. Biodiversitas 24 (12): 6942-6952. DOI: 10.13057/biodiv/d241256.

Afrianto WF, Tamnge F, Hasanah LN. 2020. A relation between ethnobotany and bioprospecting of edible flower butterfly pea (*Clitoria ternatea*) in Indonesia. Asian J Ethnobiol 3 (2): 51-61. DOI: 10.13057/asianjethnobiol/y030202.

Afrianto WF, Tamnge F, Hidayatullah T, Hasanah LN. 2021. Local knowledge of plant-based nutrition sources from forgotten foods in Datengan Village, East Java, Indonesia. Asian J Ethnobiol 4 (1): 53-64. DOI: 10.13057/asianjethnobiol/y040106.

Agustina TP, Hasmiati, Rukmana M, Watung FA. 2024. Ethnobotany and the structure of home garden in Pujon Sub-distict Malang Regency, East Java Indonesia. Ethnobot Res Appl 27: 31.

Boozari M, Hosseinzadeh H. 2021. Natural products for COVID-19 prevention and treatment regarding to previous coronavirus infections and novel studies. Phytother Res 35 (2): 864-876. DOI: 10.1002/ptr.6873.

Castañeda-Navarrete J. 2021. Homegarden diversity and food security in southern Mexico. Food Secur 13 (3): 669-683. DOI: 10.1007/s12571-021-01148-w.

Depenbusch L, Schreinemachers P, Brown S, Roothaert R. 2022. Impact and distributional effects of a home garden and nutrition intervention in Cambodia. Food Secur 14: 865-881. DOI: 10.1007/s12571-021-01235-y.

Dewi AP, Peniwidiyanti P, Hariri MR, Hutabarat PWK, Martiansyah I, Lailaty IQ, Munawir A, Giri MS, Ambarita, E. 2023. Ethnobotany of food, medicinal, construction and household utilities producing plants in Cikaniki, Gunung Halimun Salak National Park, Indonesia. J Mt Sci 20: 163-181. DOI: 10.1007/s11629-021-7108-5.

Elfahmi, Woerdenbag HJ, Kayser O. 2014. Jamu: Indonesian traditional herbal medicine towards rational phytopharmacological use. J Herbal Med 4 (2): 51-73. DOI: 10.1016/j.hermed.2014.01.002.

Faruq MK, Muhdhar MHIA, Sari MS, Mardiyanti L. 2021. Ethnobotany home garden *Karang kitri* in the tourist area of Wurung Crater, Jampit Village, Bondowoso Regency, East Java. AIP Conf Proc 2330: 070001. DOI: 10.1063/5.0043106.

Ferdous Z, Datta A, Anal AK, Anwar M, Khan AMR. 2016. Development of home garden model for year round production and consumption for improving resource-poor household food security in Bangladesh. NJAS-Wageningen J Life Sci 78 (1): 103-110. DOI: 10.1016/j.njas.2016.05.006.

Friedman J, Yaniv Z, Dafni A, Palewitch D. 1986. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. J Ethnopharmacol 16 (2-3): 275-287. DOI: 10.1016/0378-8741(86)90094-2.

Hakim L, Pamungkas NR, Wicaksono KP, Soemarno S. 2018. The conservation of Osingnese traditional home garden agroforestry in Banyuwangi, East Java, Indonesia. AGRIVITA J Agric Sci 40 (3): 506-514. DOI: 10.17503/agrivita.v40i3.1605.

Hariyati JR, Hakim L, Batoro J. 2022. Ethnobotany of homegarden in the Island of Gili Iyang, Sumenep Regency. J Indones Tour Dev Stud 10 (2): 65-73. DOI: 10.21776/ub.jitode.2022.010.02.02.

Hidayati AN, Idris J, Marhamah U. 2023. The dynamics of family harmony in the Javanese weton perspective. SHAHIH J Islamicate Multidisciplinary 8 (1): 55-62. DOI: 10.22515/shahih.v8i1.7458.

Ibarra JT, Caviedes J, Altamirano TA, Urra R, Barreau A, Santana F. 2021. Social-ecological filters drive the functional diversity of beetles in homegardens of campesinos and migrants in the southern Andes. Sci Rep 11 (1): 12462. DOI: 10.1038/s41598-021-91185-4.

Igustita I, Fatikha LAY, Astikasari L, Kusuma D, Nugraheni RS, Muryanto BS, Anshory DA, Hidayat S, Sujarta P, Yasa A, Naim DMD, Setyawan AD. 2023. Ethnobotany of medicinal plants in homegarden of Menoreh Karst Area, Purworejo District, Indonesia. Asian J Ethnobiol 6 (2): 171-181. DOI: 10.13057/asianjethnobiol/y060208.

Ihsan M, Irawan B, Iskandar J. 2024. The traditional ecological knowledge of the local people of Cijambu Village, Sumedang, Indonesia, on the diversity, utilization, management, and conservation of bamboo. Biodiversitas 25 (4): 1754-1770. DOI: 10.13057/biodiv/d250446.

Ijaz F, Iqbal Z, Rahman IU, Ali N, Afzal M. 2017. People-plants interaction and its uses: A science of four words "ethnobotany". Altern Intgr Med 6 (1): 1-2. DOI: 10.4172/2327-5162.1000235.

Irawan B, Partasasmita R, Rahayu N, Setiawati T, Iskandar J. 2019. Indigenous knowledge of bamboos by Naga community, Tasikmalaya District, West Java, Indonesia. Biodiversitas 20 (5): 1423-1434. DOI: 10.13057/biodiv/d200535.

Iskandar J, Iskandar BS, Partasasmita R. 2018. Review: The impact of social and economic change on domesticated plant diversity with special reference to wet rice field and home-garden farming of West Java, Indonesia. Biodiversitas 19 (2): 515-527. DOI: 10.13057/biodiv/d190227.

Kufer J, Förther H, Pöll E, Heinrich M. 2005. Historical and modern medicinal plant uses—the example of the Ch'orti 'Maya and Ladinos in eastern Guatemala. J Pharm Pharmacol 57 (9): 1127-1152. DOI: 10.1211/jpp.57.9.0008.

Lal R. 2020. Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. Food Secur 12 (4): 871-876. DOI: 10.1007/s12571-020-01058-3.

Linger E. 2014. Agro-ecosystem and socio-economic role of homegarden agroforestry in Jabithenan District, North-Western Ethiopia: Implication for climate change adaptation. SpringerPlus 3: 154. DOI: 10.1186/2193-1801-3-154.

Maningtyas RT, Gunawan A. 2017. Taneyan lanjhang, study of home garden design based local culture of Madura. IOP Conf Ser Earth Environ Sci 91: 012022. DOI: 10.1088/1755-1315/91/1/012022.

Ma'ruf M, Kusumawati IR. 2023. The law and tradition of weton calculation in the Javanese Community of Jombang East Java (Study in Balong Besuk Village, Diwek Jombang). Jurnal Mahkamah: Kajian Ilmu Hukum dan Hukum Islam 8 (2): 237-250. DOI: 10.25217/jm.v8i2.4136.

Mohri H, Lahoti S, Saito O, Mahalingam A, Gunatilleke N, Hitinayake G, Takeuchi K, Herath S. 2013. Assessment of ecosystem services in homegarden systems in Indonesia, Sri Lanka, and Vietnam. Ecosyst Serv 5: 124-136. DOI: 10.1016/j.ecoser.2013.07.006.

Muhlisin M, Iskandar J, Gunawan B, Cahyandito MF. 2021. Vegetation diversity and structure of urban parks in Cilegon City, Indonesia, and local residents' perception of its function. Biodiversitas 22 (7): 2589-2603. DOI: 10.13057/biodiv/d220706.

Mukarromah AN, Dzihni A, Azzam AK, Adiningsih AR, Utami AS, Nazar IA, Sunarto, Iskandar J, Saensouk S, Setyawan AD. 2024. Ethnobotany of traditional rituals of Javanese in the city of Surakarta, Central Java, Indonesia. Asian J Ethnobiol 7 (1): 22-31. DOI: 10.13057/asianjethnobiol/y070103.

Oktavianti E, Hakim L. 2013. Ethnobotany of homestay yards in Tambaksari Tourism Village, Purwodadi, Pasuruan, East Java. J Indones Tour Dev Stud 1 (1): 39-45. DOI: 10.21776/ub.jitode.2013.001.01.06. [Indonesian]

Padmakumar B, Sreekanth NP, Shanthiprabha V, Paul J, Sreedharan K, Augustine T, Jayasooryan KK, Rameshan M, Arunbabu V, Mohan M, Sylas VP, Ramasamy EV, Thomas AP. 2021. Unveiling tree diversity and carbon density of homegarden in the Thodupuzha urban region of Kerala, India: a contribution towards urban sustainability. Trop Ecol 62 (4): 508-524. DOI: 10.1007/s42965-021-00149-2.

Panyadee P, Balslev H, Wangpakapattanawong P, Inta A. 2018. Karen homegardens: Characteristics, functions, and species diversity. Econ Bot 72: 1-19. DOI: 10.1007/s12231-018-9404-8.

Pardo-de-Santayana M. 2003. Las Plantas En La Cultura Tradicional De La Antigua Merindad De Campoo. [Dissertation]. Universidad Autónoma de Madrid, Spain. [Spanish]

Park JH, Woo SY, Kwak MJ, Lee JK, Leti S, Soni T. 2019. Assessment of the diverse roles of home gardens and their sustainable management for livelihood improvement in West Java, Indonesia. Forests 10 (11): 970. DOI: 10.3390/f10110970.

Partasasmita R, An'amillah A, Iskandar J, Mutaqin AZ, Annisa. 2017. Karangwangi people's local knowledge of bamboo and its role: Implications for management of cultural keystone species. Biodiversitas 18 (1): 275-282. DOI: 10.13057/biodiv/d180136.

Prihatini J, Iskandar J, Partasasmita R, Nurjaman D. 2018. The impacts of traditional homegarden conversion into the commercial one: A case study in Sukapura Village of the Upstream Citarum Watershed, West Java, Indonesia. Biodiversitas 19 (5): 1926-1940. DOI: 10.13057/biodiv/d190545.

Putri AN, Husnayain F, Fauziah F, Nurjannah K, A'yun NQ, Al-Atsariyah NH, Rohana N, Janah RR, Hidayat F, Khoeruzaad B. 2024. The relevance of weton calculation tradition in Javanese culture in determining marriage contracts: A sharia perspective. Demak Universal J Islam Sharia 2 (3): 243-256. DOI: 10.61455/deujis.v2i03.139.

Reyes-García V, Huanca T, Vadez V, Leonard W, Wilkie D. 2006. Cultural, practical, and economic value of wild plants: A quantitative study in the Bolivian Amazon. Econ Bot 60 (1): 62-74. DOI: 10.1663/0013-0001(2006)60[62:CPAEVO]2.0.CO;2.

Setiani S, Setiawan E, Huang WC. 2022. Taneyan lanjang shared home gardens and sustainable rural livelihoods of ethnic Madurese in Madura Island, Indonesia. Sustainability 14 (10): 5960. DOI: 10.3390/su14105960.

Setiawati T, Mutaqin AZ, Irawan B, Anamillah A, Iskandar J. 2017. Species diversity and utilization of bamboo to support lifes the community of Karangwangi Village, Cidaun Sub-District of Cianjur, Indonesia. Biodiversitas 18 (1): 58-64. DOI: 10.13057/biodiv/d180109.

Suciyati A, Suryadarma IGP, Paidi, Abrori FM. 2021. Ethnobotanical study based on the five dimensions of basic life needs in Tidung Tribe of North Kalimantan, Indonesia. Biodiversitas 22 (6): 3199-3208. DOI: 10.13057/biodiv/d220623.

Sujarwo W, Keim AP. 2017. Ethnobotanical study of traditional building materials from the island of Bali, Indonesia. Econ Bot 71: 224-240. DOI: 10.1007/s12231-017-9385-z.

Surya R, Romulo A, Nurkolis, F, Kumalawati DA. 2024. Compositions and health benefits of different types of *jamu*, traditional medicinal drinks popular in Indonesia. In Mérillon JM, Riviere C, Lefèvre G. (eds.). Natural Products in Beverages. Reference Series in Phytochemistry. Springer, Cham. DOI: 10.1007/978-3-031-38663-3_123

Suwardi AB, Navia ZI, Mubarak A, Mardudi M. 2023. Diversity of home garden plants and their contribution to promoting sustainable livelihoods for local communities living near Serbajadi protected forest in Aceh Timur region, Indonesia. Biol Agric Hortic 39 (3): 170-182. DOI: 10.1080/01448765.2023.2182233.

Suwartapradja OS, Iskandar J, Iskandar BS, Mulyanto D, Suroso, Nurjaman D, Nisyapuri FF. 2023. Plants diversity and socioecological functions of homegarden in Sundanese rural area: A case in Sumedang District, West Java, Indonesia. Biodiversitas 24 (1): 156-175. DOI: 10.13057/biodiv/d240120.

Thamilin J, Wekumbura C, Mohotti AJ, Kumara AP, Kudagammana ST, Silva KDRR, Frossard E. 2019. Organized homegardens contribute to micronutrient intakes and dietary diversity of rural households in Sri Lanka. Front Sustain Food Syst 3: 94. DOI: 10.3389/fsufs.2019.00094.

Trisulowati R. 2003. Traditional residential buildings of Central Java. Mintakat: J Arsitektur 4 (1): 31-38. DOI: 10.26905/mintakat.v4i1.1957. [Indonesian]

Whitney C. 2021. Quantitative ethnobotany analysis with ethnobotany R. Available from: https://cran.r-project.org/web/packages/ethnobotanyR/vignettes/ethnobotanyr_vignette.html. Accessed 27 June 2024.

Whitney CW, Luedeling E, Hensel O, Tabuti JRS, Krawinkel M, Gebauer J, Kehlenbeck K. 2018. The role of homegardens for food and nutrition security in Uganda. Hum Ecol 46: 497-514. DOI: 10.1007/s10745-018-0008-9.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025
Pages: 92-103

E-ISSN: 2580-4510
DOI: 10.13057/asianjethnobiol/y080108

Diversity of natural food coloring plants in the city of Surakarta, Central Java, Indonesia

AYU SULISTIYANING UTAMI[1], ABIZAN RAMADAN TORIMBANU[2], AFFANDI FIRMAN SAPUTRA[2], AHMAD ASFAR AULIA[2], ALIFIA NAMIRA UTOMO[2], JOHAN ISKANDAR[3], DARLINA MD. NAIM[4], AHMAD DWI SETYAWAN[2,5,♥]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia
[2]Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: volatileoils@gmail.com
[3]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran. Jl. Raya Bandung-Sumedang Km. 21 Jatinangor, Sumedang 45363, West Java, Indonesia
[4]School of Biological Sciences, Universiti Sains Malaysia.1112, Persiaran Sains, 11800 Gelugor, Pulau Pinang, Malaysia
[5]Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

Manuscript received: 12 May 2024. Revision accepted: 22 May 2025.

Abstract. *Utami AS, Torimbanu AR, Saputra AF, Aulia AA, Utomo AN, Iskandar J, Naim DMd., Setyawan AD. 2025. Diversity of natural food coloring plants in the city of Surakarta, Central Java, Indonesia. Asian J Ethnobiol 8: 92-103.* The use of plant-derived food colorants is a longstanding culinary tradition in Indonesia, reflecting both ecological knowledge and cultural heritage. This study aimed to document and analyze the diversity of natural food coloring plants used in Surakarta City, Central Java, and to examine their cultural relevance, usage patterns, and conservation status. A total of 137 respondents across three urban villages—Mojosongo, Keprabon, and Baluwarti—were selected purposively and interviewed using ethnobotanical approaches including field visits and visual confirmation. Seventeen plant species from 13 families were identified as sources of eight major color types: yellow, green, red, purple, brown, white, orange, and blue. The most frequently used species included *Curcuma longa*, *Pandanus amaryllifolius*, and *Clitoria ternatea*, with coloring parts ranging from flowers and leaves to rhizomes and wood sap. While some plants were cultivated at home, others were purchased from traditional markets. The majority of species were classified as Least Concern, but one species (*Caesalpinia sappan*) was listed as Vulnerable, and several others remained unevaluated or Data Deficient. The results highlight how gender, age, and spatial context influence knowledge transmission, with older women, who play a central role, emerging as key custodians of biocultural knowledge. Although urbanization poses a threat to the sustainability of this knowledge, opportunities exist for revitalization through home gardening, school-based learning, and community-based conservation efforts. The study underscores the importance of safeguarding biocultural knowledge in rapidly modernizing urban environments as part of resilient food and cultural systems.

Keywords: Coloring, culinary, food, local community, natural dyes, plant

INTRODUCTION

Food coloring is crucial in food production because it enhances the aesthetics and appeal of food. Food coloring can be obtained from plants, animals, insects, and minerals (Arshimny and Syamsu 2020). Some consumers are also aware that natural dyes obtained from fruits or vegetables can produce not only aesthetically pleasing food but also numerous health benefits (de Mejia et al. 2020). Several types of flowers can be used as food coloring, such as red hibiscus, red roses, red pineapple sage, red clover, and pink blossoms. Green vegetables that can be used as green coloring in foods such as spinach, fenugreek leaves, coriander leaves, bell peppers, broccoli, green cabbage, green beans, green radishes, and green chilies (Malabadi et al. 2022). There are plants native to Indonesia that are commonly used in food coloring, such as pandan and suji leaves (Suryani et al. 2020).

Natural plant pigments, such as anthocyanins, betalains, chlorophyll, and carotenoids, not only enhance the appearance of food but also provide antioxidant, anti-inflammatory, and protective health benefits (Amalraj et al. 2016; de Mejia et al. 2020). These pigments are environmentally friendly because they are obtained from renewable sources, involve minimal chemical processes, and are biodegradable. However, replacing synthetic dyes with natural alternatives still faces challenges, including variability in pigment stability, extraction methods, and market availability. Factors such as pH, light, temperature, and solvent type influence the efficacy of natural pigments (Jadhav and Bhujbal 2020).

Although synthetic dyes are still widely used due to their low cost and processing flexibility, concerns regarding their toxicity, especially in children, have prompted renewed interest in natural coloring agents (Suryani et al. 2020; Luong et al. 2023). Natural dyes are not only safer but also enrich the culinary identity and cultural continuity of local communities. This is particularly relevant in culturally diverse countries like Indonesia, where food traditions are strongly tied to identity, ritual, and place (Amrul et al. 2022).

Indonesia is a mega biodiversity country, not only in terms of natural resources but also in terms of cultural diversity. Each region has a unique culture, including knowledge, beliefs, arts, law, morals, customs, and community characteristics (Sutrisno et al. 2021). Natural dyes, such as those found in traditional foods, are closely tied to people's daily lives (Luong et al. 2023). Food plays a crucial role in the human body and is also closely tied to various aspects of human life, including sociocultural aspects. Food can be the identity of a region or ethnicity and adds value to cultural tourism (Annisa et al. 2023). Indonesia is a country rich in culture, one of which is its traditional food (Wijaya 2019); this is particularly important for ethnic communities because each food has a symbolic meaning; hence, coloring plants are important (Luu-dam et al. 2016). Surakarta is one of Indonesia's cities with numerous interesting tourist attractions and a cultural center that represents the wholeness of the Javanese people through their local wisdom. Surakarta has typical foods with historical and sociocultural symbols such as *nasi liwet*, *cabuk rambak*, *serabi*, *peek*, and *tengkleng* (Hermawan 2021).

Despite this rich tradition, little attention has been paid to systematically documenting the diversity and use of natural food-coloring plants in urban centers like Surakarta, which are undergoing rapid socio-ecological change. As modern food systems increasingly rely on industrial additives, the knowledge of naturally derived food dyes—especially those rooted in community practice—is at risk of being lost. Therefore, ethnobotanical documentation of these plants and their uses is urgently needed to support cultural preservation, public health, and sustainable food innovation.

Knowledge of natural food coloring is crucial, as it is linked to socioeconomics and traditional wisdom in local cuisine. It includes information about the types of plants used as natural dyes, the parts of the plants used, the resulting colors, and their purposes. This knowledge helps raise awareness about the maximum utilization of plants. Unfortunately, the use of natural dyes is declining due to the prevalence of artificial dyes, resulting in a decrease in the number of people experienced in processing natural dyes. Additionally, the younger generation is less interested in this area.

This study aims to document the diversity of natural food-coloring plants used by the community in three culturally significant villages of Surakarta City, Central Java, Indonesia. It also examines the parts used, color range, modes of acquisition, and conservation status of the species, providing a basis for safeguarding local culinary biocultural heritage in the face of modernization.

MATERIALS AND METHODS

Study site

This research was carried out in December 2023 in three villages of Surakarta City, Central Java, Indonesia: Mojosongo Village (Jebres Sub-district: 7°32'34"S, 110°51'7"E), Keprabon Village (Banjarsari Sub-district: 7°33'45.6"S, 110°49'12.6"E), and Baluwarti Village (Pasar Kliwon Sub-district: 7°33'41.4"S, 110°49'24.0" E) (Figure 1). Surakarta City is an urban area with a total area of 44.04 km² and a population of 528,044 (as of 2024), resulting in a density of 11,302.31 people per km² and a human development index of 83.54. Almost half of its economy is supported by the construction and trade services sector (BPS 2024). These villages were selected due to their rich cultural heritage and continuity of traditional culinary practices, making them ideal for studying community-based knowledge of natural food colorants.

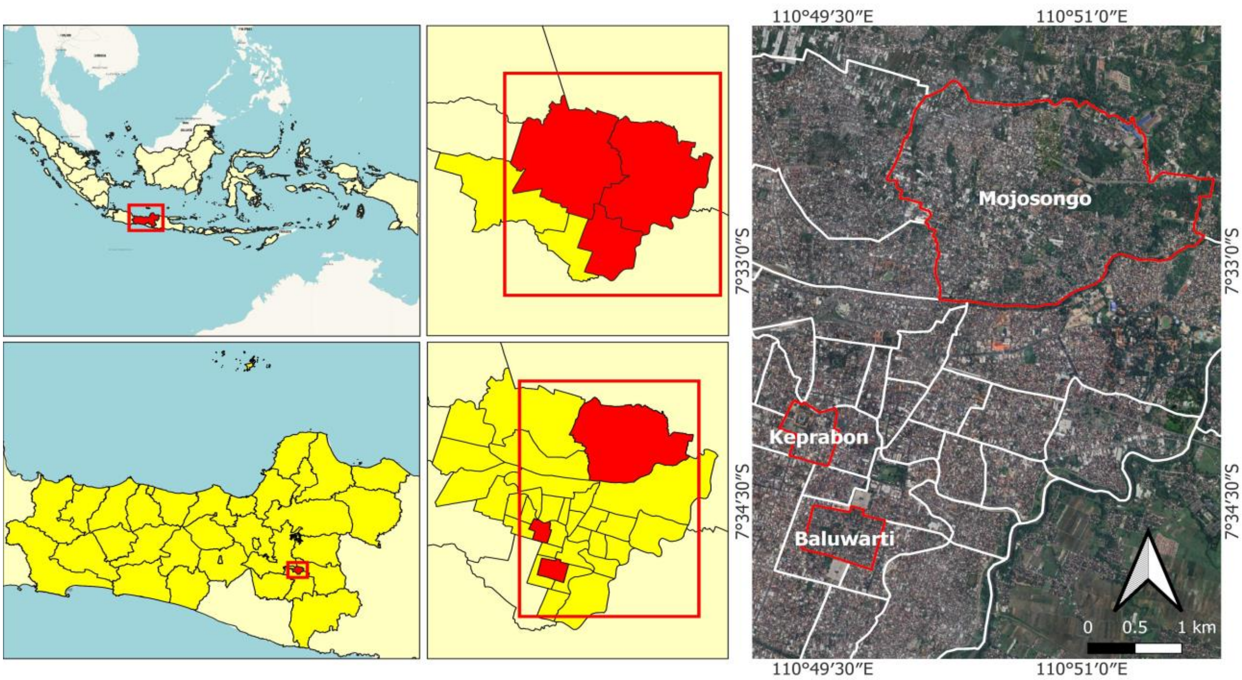


Figure 1. The location of Mojosongo, Keprabon, and Baluwarti Villages of Surakarta City, Central Java Province, Indonesia

Data collection

Data were collected using structured and semi-structured interviews with purposively selected respondents in the three target villages. Respondents were chosen based on their knowledge and use of natural food coloring plants. A total of 137 individuals participated, with an age range between 25-70 years and a gender distribution of 79% women and 21% men. The interview guide included questions on local plant names, parts used, colors produced, types of food colored, and the source (cultivated, purchased). Respondents were also asked to cite examples of local foods and drinks in which the plants were used. Interviews were conducted in Javanese and Indonesian, depending on the respondent's preference.

Data verification and analysis

The plant species mentioned by respondents were collected, photographed, and identified through field visits. Scientific names were confirmed using online databases, specifically Plants of the World Online (POWO, https://powo.science.kew.org/) and Global Biodiversity Information Facility (GBIF, https://www.gbif.org/). The conservation status of each species was validated using the IUCN Red List (https://www.iucnredlist.org/). Quantitative data, such as the frequency of citation, plant parts used, and origin (cultivated or purchased), were analyzed descriptively using percentage values. Visual summaries were presented in tables and figures.

RESULTS AND DISCUSSION

Socio-demographic profile of respondents

This study involved 137 respondents from Mojosongo, Keprabon, and Baluwarti Villages in Surakarta City, Central Java. As shown in Table 1, the majority of respondents were women (79%), while men accounted for only 21%. This gender imbalance reflects the role of women as primary custodians of domestic food knowledge in Javanese households, especially in matters related to food preparation, traditional culinary practices, and the use of natural ingredients.

In terms of age distribution, respondents were mostly in the 46-55 year age group (31%), followed by those aged 25-35 years (24%), 36-45 years (19%), 56-65 years (16%), and over 65 years (10%). The predominance of middle-aged and older respondents suggests a generational gap in the transmission of knowledge regarding the use of natural food colorants. This pattern aligns with studies in other regions of Southeast Asia, where younger generations are increasingly disconnected from traditional food practices due to urbanization and modern lifestyles (Luong et al. 2023).

The socio-demographic structure of the respondents provides an important context for understanding the continuity and vulnerability of ethnobotanical knowledge. Older women, in particular, serve as cultural transmitters of plant-based culinary knowledge, often accumulated through lived experience rather than formal education. However, without deliberate intergenerational transfer, this knowledge may be lost over time.

These findings underscore the importance of targeting women—especially those in older age cohorts—in future education or conservation programs aimed at revitalizing natural food dye practices. Integrating such knowledge into school curricula, community workshops, or digital documentation platforms may help bridge this generational divide and ensure the sustainability of culinary biocultural heritage.

Diversity of food coloring plant species

A total of 17 plant species from 13 families were recorded as sources of natural food coloring in Surakarta, with detailed information provided in Table 2. These species include both widely cultivated and commonly purchased plants, reflecting a blend of home-based and market-based knowledge systems. The most frequently used species were *Curcuma longa* (turmeric), *Pandanus amaryllifolius* (pandan), *Clitoria ternatea* (butterfly pea), *Dracaena angustifolia* (suji), and *Cocos nucifera* (coconut), all of which are well-integrated into traditional Javanese food culture. These five species showed the highest citation frequencies among respondents and represent a core group of versatile and culturally significant food colorants.

Based on Table 3, the taxonomic distribution shows that the 17 species are evenly distributed between two major clades of angiosperms: eudicots (9 species, 53%) and monocots (8 species, 47%). At the family level, notable contributors include Zingiberaceae, Myrtaceae, and Fabaceae, with Zingiberaceae being the most frequently represented family, indicating its central role in Javanese culinary and medicinal traditions.

Table 1. Socio-demographic profile of respondents in Baluwarti, Keprabon, and Mojosongo Villages, Surakarta City, Central Java, Indonesia

Variable	Category	Total	Percentage
Gender	Male	29	21.2%
	Female	108	78.8%
Age group	25-35	33	24.1%
	36-45	26	19.0%
	46-55	42	30.7%
	56-65	22	16.1%
	>65	14	10.2%
Education	Elementary School	35	25.5%
	Junior High School	25	18.2%
	Senior High School	52	38.0%
	Higher Education	25	18.2%
Occupation	Housewife	70	51.1%
	Traditional Food Vendor	30	21.9%
	Civil Servant	10	7.3%
	Other (retired, informal)	27	19.7%

Table 2. List of coloring plants in city of Surakarta, Central Java, Indonesia

Family	Scientific name	Vernacular name	Local name	Part-use	Life-form	Color	Origin	Frequency	Food type	Local food/drinks
Eudicots										
Apiaceae	*Apium graveolens* L.	Celery	*Seledri*	Leaves	Herbaceous	Green	1	1 (*)	Drink	*Jus sledri, jus campur*
Arecaceae	*Cocos nucifera* L.	Palm sugar, Coconut cream	*Gula jawa*♣ *Santan*	Sap Fruit	Wood	Brown White	1	22 (3*)	Drink Porridge	*Kolak, cendol/dawet, bandrek* *Agar-agar gula jawa* *Jenang, sumsum,grendul, bubur gaplek*
									Cake	*Dodol/jenang lot, klepon, kuwe cucur, wajik sokelat, nogosari*
									Soup	*Sayur lodeh*
Asparagaceae	*Dracaena angustifolia* (Medik.) Roxb.	Suji leaves	*Suji*	Leaves	Bush	Green	1, 2	25 (3*)	Cake	*Klepon, wajik ijo, kue lapis, nogosari ijo*
Cactaceae	*Hylocereus polyrhizus* (F.A.C. Weber) Britton & Rose	Dragon fruit	*Buah naga*	Fruit	Creepers	Purple	1, 2	15 (2*)	Drink Cake	*Jus buah naga, jus campur* *Kue bolu*
Convolvulaceae	*Ipomoea batatas* (L.) Lam.	Purple sweet potato	*Ubi ungu*	Tubers	Bush	Purple	1	12 (2*)	Cake	*Kue bolu, kue talam, kue lapis*
Fabaceae	*Clitoria ternatea* L.	Telang flower	*Telang*	Flower	Creepers	Blue	1, 2	31 (3*)	Drink	*Teh bunga telang*
	Caesalpinia sappan L.	Sappan plant	*Secang*	Wood	Wood	Orange	1	1 (*)	Drink	*Wedang uwuh*
Malvaceae	*Hibiscus sabdariffa* L.	Rosella plant	*Rosella*	Flower	Wood	Red	1	3 (*)	Drink	*Teh bunga rosela*
Monocots										
Myrtaceae	*Syzygium polyanthum* (Wight) Walp.	Bay leaf	*Salam*	Leaves	Wood	White ♥	1, 2	7 (*)	Rice Soup	*Nasi liwet* *Sayur asem*
	Syzygium aromaticum (L.) Merr. & L.M. Perry	Clove	*Cengkeh*	Flower	Wood	Brown	1	1 (*)	Drink	*Bandrek, wedang jahe*
Pandanaceae	*Pandanus amaryllifolius* Roxb.	Pandan plant	*Pandan*	Leaves	Bush	Green	1, 2	62 (3*)	Cake Drink Porridge	*Kue bolu, kuwe cucur hijau* *Cendol/dawet* *Jenang/bubur*
Poaceae	*Cymbopogon citratus* (DC.) Stapf	Lemongrass	*Sereh*	Stem	Herbaceous	Brown	1	3 (*)	Drink	*Bandrek, wedang jahe*
Rosaceae	*Rosa* sp.	Rose	*Mawar merah*	Flower	Wood	Red	1	2 (*)	Drink Cake	*Sirup/teh bunga mawar* *bolu pelangi*
Solanaceae	*Capsicum frutescens* L.	Chili	*Cabe*	Fruit	Herbaceous	Red	1	1 (*)	Soup	*Sambal goreng krecek,*
Zingiberaceae	*Curcuma longa* L.	Turmeric	*Kunyit*	Rhizome	Herbaceous	Yellow	1, 2	77 (3*)	Rice Soup	*Nasi kuning, tumpeng* *tengkleng, gulai, opor, kare, soto*
	Elettaria cardamomum (L.) Maton	Cardamom	*Kapulaga*	Fruit	Herbaceous	Brown	1	1 (*)	Drink	*Bandrek, wedang jahe*
	Zingiber officinale Roscoe	Ginger	*Jahe*	Rhizome	Herbaceous	Brown	1	1 (*)	Drink Soups	*Bandrek, wedang jahe, ronde* *Tengkleng, gulai, opor, kare, soto*

Note: (1): Buy; (2): Cultivated; 3*: Frequently used species; 2*: Occasionally used species; *: Rarely used. ♣ This could also be derived from *Arenga pinnata* (Wurmb.) Merr. ♥ This designation reflects community perception rather than direct pigment contribution; the actual color intensity is minimal

Table 3. Plant diversity and taxonomy

Phylum	Family	Percentage	Genera	Percentage	Species	Percentage
Angiospermae	13		16		17	
Eudicots	7	54%	8	50%	8	47%
Monocots	6	46%	8	50%	9	53%

These findings reflect the richness of angiosperm-derived pigments, as plants in this group produce a broad spectrum of natural compounds, including anthocyanins, chlorophylls, carotenoids, and betalains (Hop et al. 2022). The balance between monocots and eudicots also suggests that food-coloring knowledge is not biased toward any single morphological or ecological group, but rather reflects a practical selection based on availability, effectiveness, and cultural preference.

Several species, such as *C. ternatea*, *Hylocereus polyrhizus*, *Ipomoea batatas*, and *Hibiscus sabdariffa*, are known to produce vibrant purples and reds that align with global studies on anthocyanin-rich species (Luu-dam et al. 2016; Mahmud et al. 2023). Meanwhile, *C. longa* produces a strong yellow pigment due to its curcuminoid content (Amalraj et al. 2016), and *P. amaryllifolius* and *D. angustifolia* provide chlorophyll-based green coloring (Indrasti et al. 2018).

The widespread use of these 17 species across various food categories—ranging from drinks and cakes to rice and porridge—demonstrates the embeddedness of natural dyes in both daily and ceremonial cuisine. More than 40 local dishes were reported to rely on these species, many of which are associated with tradition and identity, such as *nasi kuning*, *tumpeng*, *dawet*, and *klepon* (Table 2; Figure 2).

The diversity of food-coloring species in Surakarta not only reflects botanical richness but also highlights the functional role of biodiversity in promoting cultural resilience and ensuring food security. Unlike synthetic dyes, these plant-based pigments carry layered meanings, including medicinal values, ritual significance, and aesthetic preferences. Therefore, their continued use is not only a matter of culinary tradition but also a matter of biocultural continuity.

Plant parts used for coloring

The food-coloring plants recorded in this study utilize a variety of plant parts to produce pigments, including flowers, leaves, fruits, rhizomes, tubers, stems, and wood (Figure 3). Among these, flowers were the most frequently used plant part, accounting for 29.4% of species. Plants such as *C. ternatea*, *Rosa* sp., *H. sabdariffa*, *Syzygium aromaticum*, and *Cocos nucifera* (sap for palm sugar) are commonly employed for their visually striking pigments.

Leaves represented the second most commonly used part (23.5%), with species such as *Dracaena angustifolia* (suji), *P. amaryllifolius* (pandan), *Apium graveolens* (celery), and *Syzygium polyanthum* (bay leaf). These plants typically contribute green hues due to their chlorophyll content, although, as discussed previously, the actual pigment contribution of bay leaves may be more perceived than visual.

Fruits comprised 17.6% of the colorant sources. *Hylocereus polyrhizus* (dragon fruit), *Capsicum frutescens* (chili), and *Elettaria cardamomum* (cardamom) were cited for their purple, red, and brown pigments, respectively. Dragon fruit, in particular, provides a vivid purple pigment due to its high betacyanin content, a finding supported by Mahmud et al. (2023). Rhizomes (11.8%), such as those of *Zingiber officinale* (ginger) and *C. longa* (turmeric), are valued not only for their strong pigments—yellow and brown—but also for their multifunctional use as spices and medicinal ingredients. The relative durability and storability of rhizomes may explain their widespread use (Maha et al. 2019; Nurshillah et al. 2022).

Less commonly used parts include wood (*Caesalpinia sappan*, 5.9%), tubers (*I. batatas*, 5.9%), and stems (*Cymbopogon citratus*, 5.9%). Although these parts are less prevalent, they offer unique pigments. Sappan wood provides an orange to red hue, depending on the pH (Luu-dam et al. 2016), while purple sweet potato and lemongrass lend their distinctive colors to cakes and drinks.

The selective use of certain plant parts reflects both practical and cultural considerations, such as pigment stability, ease of processing, culinary tradition, and symbolism. Flowers and rhizomes, for example, are often associated with festivities and rituals, whereas leaves and fruits are commonly used in everyday food preparation.

These results demonstrate that local knowledge encompasses not only which species to use, but also which plant parts yield the desired aesthetic and functional outcomes in food. Such specificity underlines the sophistication of traditional culinary systems and the importance of preserving this knowledge amid changing dietary habits (Amrul et al. 2022).

Plant life forms and their roles

The 17 species used as food colorants in this study represent a range of plant life forms, including woody plants (35.3%), herbaceous plants (35.3%), bushes (17.7%), and creepers (11.8%) (Figure 4). Woody plants include *C. nucifera*, *H. sabdariffa*, *Rosa* sp., *Syzygium polyanthum*, *S. aromaticum*, and *C. sappan*. These species are often perennial and multifunctional, producing flowers, fruits, wood, or sap used in various food preparations. Their relatively large size and longevity make them suitable for home gardens, especially in the peri-urban and rural areas of Surakarta, where space still allows for the cultivation of trees.

Herbaceous species, such as *C. longa*, *Z. officinale*, *C. citratus*, *A. graveolens*, *C. frutescens*, and *E. cardamomum*, offer flexibility in planting and harvesting. Their short life cycles, adaptability to pots or narrow plots, and culinary relevance contribute to their continued use, even in constrained urban spaces.

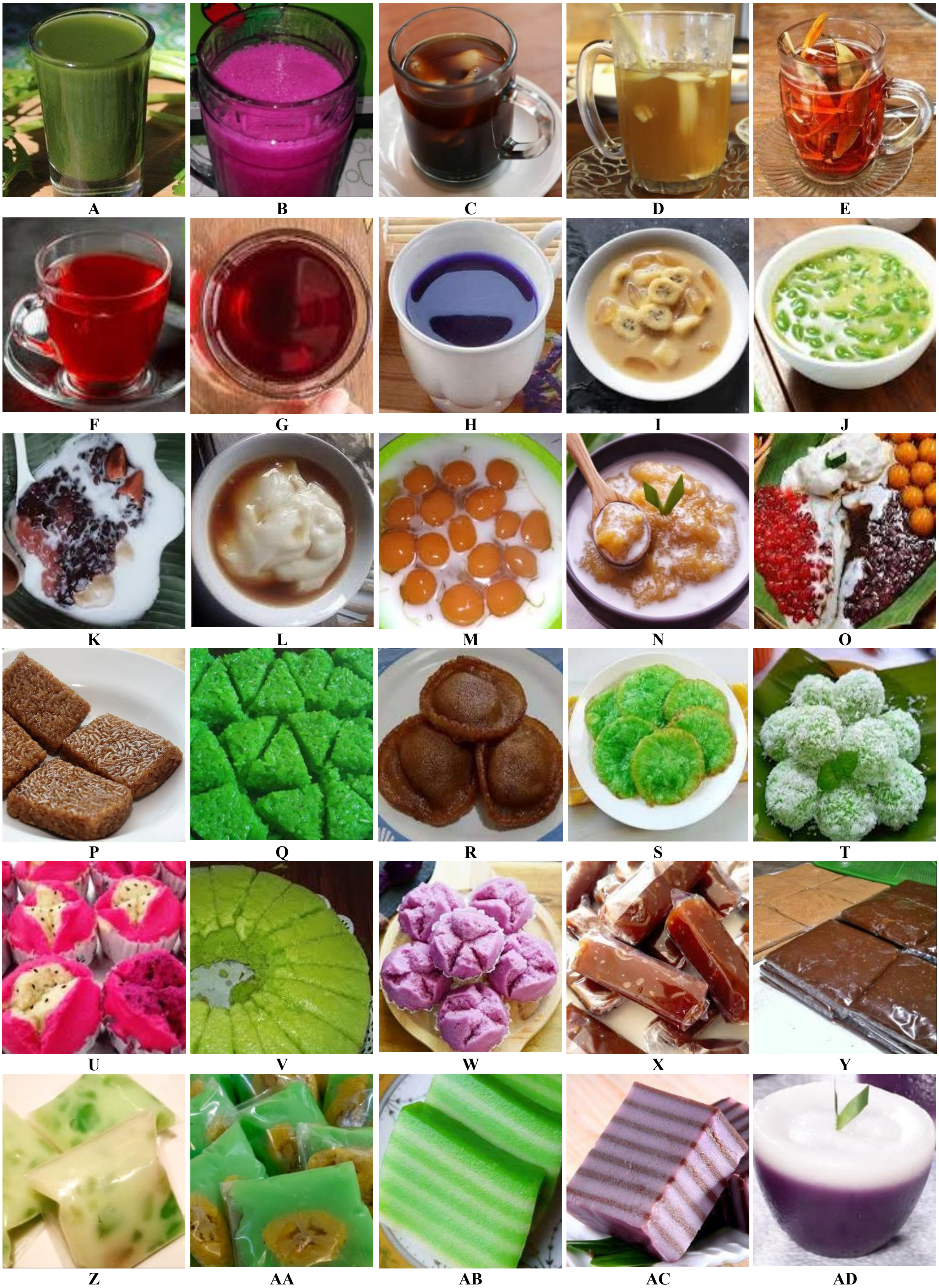

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z
AA
AB
AC
AD

Figure 2. Several types of food and beverages with natural coloring plants from Surakarta City, Indonesia. Drinks (A-J): A. *Jus daun sledri*, B. *Jus buah naga*, C. *Wedang bandrek*, D. *Wedang jahe*, E. *Wedang uwuh*, F. *Teh bunga mawar merah*, G. *Teh bunga rosela*, H. *Teh bunga telang*, I. *Kolak*, J. *Dawet/cendol*. Porridges (K-O): K. *Jenang*, L. *Jenang sumsum*, M. *Jenang grendul*, N. *Bubur/jenang gaplek/singkong*, O. *Aneka jenang*. Cakes (P-T): P. *Wajik sokelat*, Q. *Wajik ijo*, R. *Kuwe cucur sokelat,* S. *Kuwe cucur ijo*, T. *Klepon*, U. *Bolu buah naga*, V. *Bolu ijo/pandan*, W. *Bolu ubi ungu*, X. *Dodol*, Y. *Jenang lot/alot*, Z. *Nogosari*, AA. *Nogosari ijo*, AB. *Kuwe lapis ijo*, AC. *Kuwe lapis ubi ungu*, AD. *Kuwe talam.* Rice (AE-AG): AE. *Nasi/sego liwet*, AF. *Nasi/sego kuning*, AG. *Tumpeng*. Soups (AH-A) AH. *Sayur asem*, AI. *Sayur lodeh*, AJ. *Soto*, AK. *Kari/kare*, AL. *Tengkleng*, AM. *Gulai*, AN. *Opor*. (photographs from many sources)

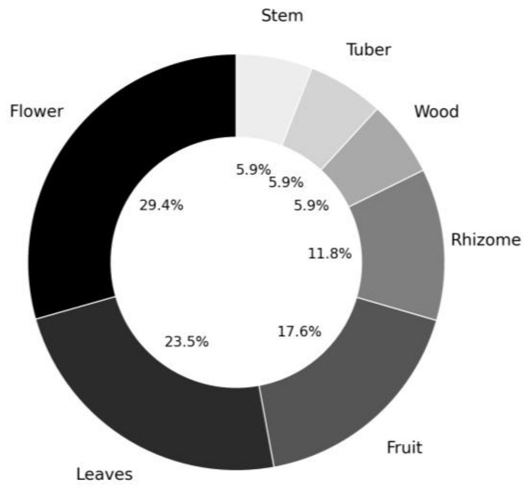


Figure 3. The part used by the food coloring plants in Surakarta City, Indonesia

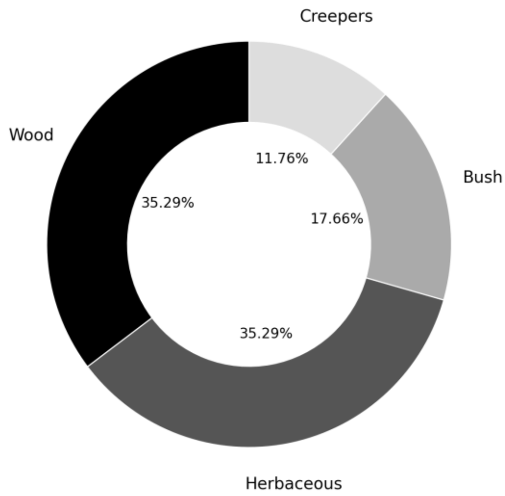


Figure 4. Diversity of life forms of food coloring plants in Surakarta City, Indonesia

Bushes—including *Dracaena angustifolia*, *P. amaryllifolius*, and *Ipomoea batatas*—are moderately sized and often grown for their leaves or tubers. Their compact form allows for integration into household agroecosystems, particularly in compounds with limited land availability. *D. angustifolia* and *P. amaryllifolius* are well known for their shade tolerance and utility in ornamental landscaping, making them dual-purpose plants.

Creepers, represented by *Clitoria ternatea* and *Hylocereus polyrhizus*, are commonly trained along fences or vertical supports. Their vertical growth habit makes them space-efficient and accessible to urban households. The popularity of butterfly pea flowers in tea and beverages has increased recently due to their antioxidant content and striking color properties, encouraging home cultivation even in small plots (Saati et al. 2018; Luong et al. 2023).

This distribution of plant life forms suggests a high degree of ecological and spatial adaptability among food-coloring plants, which enhances their relevance for both traditional and contemporary urban lifestyles. Households can select plant types based on available space, desired color output, and frequency of use. Additionally, the presence of woody and herbaceous plants in near-equal proportions reflects a well-balanced agroecological system.

In ethnobotanical terms, the diversity of growth forms also reflects how communities engage with plants not only as functional materials but as elements of the cultural landscape. Trees provide permanence and symbolism, while herbs and vines allow for dynamic, seasonal interaction with food traditions.

Color types and cultural use patterns

The 17 species documented in this study were used to produce eight major color groups in local foods and beverages: yellow, green, red, brown, purple, white, orange, and blue (Figure 5). Among these, brown was the most frequently represented color, derived from species such as *C. nucifera* (palm sugar), *Z. officinale* (ginger), *C. citratus* (lemongrass), *E. cardamomum* (cardamom), and *S. aromaticum* (clove). Brown pigments are commonly associated with traditional drinks and desserts, offering both color and a distinctive aromatic profile.

Yellow was the second most dominant color, primarily produced by *C. longa* (turmeric), which contains curcuminoids with strong pigment and medicinal value. In Javanese culinary culture, yellow symbolizes festivity, sanctity, and prosperity, and is prominently featured in celebratory dishes such as *nasi kuning* and *tumpeng*.

Green hues were obtained from chlorophyll-rich leaves of *P. amaryllifolius* (pandan) and *D. angustifolia* (suji). These plants are widely used in both sweet and savory preparations, particularly in traditional cakes like *klepon*, *putu ayu*, and *nagasari*, which are popular in markets and ceremonial settings (Murtini et al. 2020).

Red tones were contributed by *C. frutescens* (chili) and *Rosa* sp. (rose), with occasional references to *S. aromaticum* (clove), although its pigment is more accurately classified as brown. While these species are not primarily cultivated for coloring, they impart reddish or warm hues when used in sambals, herbal infusions, or decoctions.

Purple tones were extracted from *Ipomoea batatas* and *Hylocereus polyrhizus*, both of which are gaining popularity in urban food innovation due to their vibrant pigments and nutritional value. These plants are commonly used in pudding, steamed cakes, and cold beverages.

White, although not traditionally considered a color in dye taxonomy, was identified as a perception-based category. As previously noted, some respondents included *Syzygium polyanthum* (bay leaf) and *Apium graveolens* (celery) under this group, believing they contributed to a clearer or whiter appearance in dishes such as *sayur asem* and *nasi liwet*. Although the pigment contribution is minimal, this perception-based categorization highlights the emic perspective on culinary aesthetics.

Blue coloration was solely attributed to *Clitoria ternatea*, whose anthocyanin-rich petals are used in herbal drinks (*wedang telang*), rice (*nasi biru*), and desserts. Orange hues were derived from *Caesalpinia sappan*, used in health drinks and syrups, especially during festive occasions.

These findings underscore the profound connection between color choices in traditional cuisine and the interplay of symbolic, aesthetic, and functional considerations. Bright and bold colors are often associated with festivity, while subtle colors such as white or green imply purity and freshness. The cultural embeddedness of these hues makes natural dyes not only functional additives but also carriers of meaning and memory.

Acquisition mode: Purchased vs. Cultivated

The coloring plants identified in this study were accessed through two primary modes: cultivated in home gardens or urban spaces, and purchased from traditional markets or street vendors. According to Figure 6, nine species (52.9%) were purchased, while eight species (47.1%) were grown at home or cultivated locally.

Cultivated species include *C. longa*, *D. angustifolia*, *P. amaryllifolius*, and *C. ternatea*, which were reported by respondents as commonly grown in home gardens. These plants are typically easy to grow, tolerant of various microclimates, and require low maintenance. Their cultivation reflects local ecological knowledge and the use of micro-agroecosystems to sustain daily food needs, especially among older women who manage home gardens. Other species, such as *C. citratus*, *C. frutescens*, *S. polyanthum*, and *A. graveolens*, were more often purchased from traditional markets, although they may occasionally be cultivated.

In contrast, species such as *Z. officinale*, *H. sabdariffa*, *C. nucifera*, *Rosa* sp., *I. batatas*, *E. cardamomum*, *C. sappan*, and *H. polyrhizus* were purchased more frequently. These species are either not commonly grown in constrained urban spaces, not available year-round, or are perceived as higher quality when obtained from specialized sellers.

The dominance of purchased colorants suggests an increasing reliance on market-based access, possibly linked to changes in land use, housing density, and urban livelihood patterns. In highly urbanized areas such as Keprabon and Baluwarti, limited space and shifts toward wage labor have contributed to a decline in the capacity for plant cultivation. However, the fact that nearly half of the species are still cultivated reflects the persistence of traditional agroecological practices, especially in peripheral areas like Mojosongo. These practices support not only self-sufficiency but also the in situ conservation of plant genetic resources.

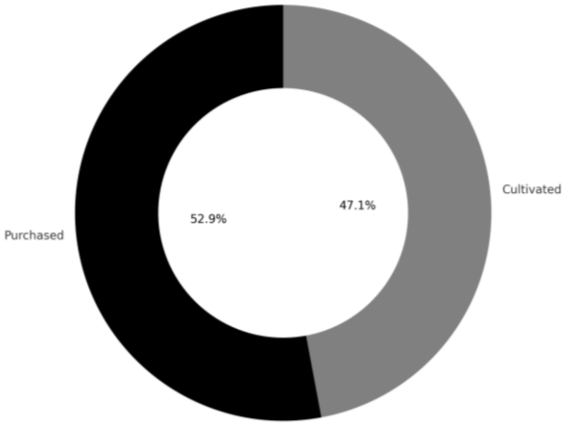


Figure 5. Mode of acquisition of food coloring plants in Surakarta City, Indonesia

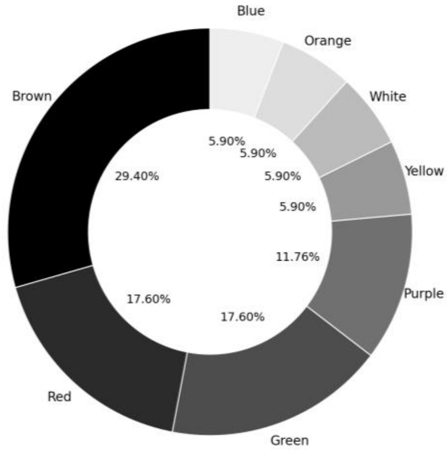


Figure 6. Diversity of food coloring plants in Surakarta City, Indonesia

From an ethnobotanical perspective, acquisition mode is not only a matter of access but also reflects social values, economic constraints, and shifts in cultural foodways. Plants cultivated in households tend to be embedded in household routines and intergenerational knowledge, while market-purchased species may indicate the commodification of traditional practices. Understanding how communities acquire these plants offers insights into the dynamics of food system resilience, dietary change, and the sustainability of biocultural heritage in urban settings.

Conservation status of dye plants

To assess the sustainability of food coloring plant use in Surakarta, we examined the conservation status of the 17 recorded species based on the IUCN Red List. As shown in Table 4, 5 species (29.4%) are categorized as Least Concern (LC), 1 species (5.9%) as Vulnerable (VU), 4 species (23.5%) as Data Deficient (DD), and 7 species (41.2%) have Not Yet Been Evaluated (NE).

The relatively low proportion of LC species, including *C. longa*, *C. citratus*, *S. polyanthum*, *C. frutescens*, and *C. nucifera*, suggests that only a fraction of the commonly used colorant plants have been formally assessed and are considered not at risk under current usage patterns. These species are generally widespread, adaptable, and often cultivated, indicating a relatively low ecological threat level.

However, *C. sappan*, the only species listed as Vulnerable (VU), raises concern. Its hardwood is valued for producing red dye and is widely used in herbal remedies and traditional beverages. Due to increasing market demand and overharvesting, this species faces significant pressure in the wild. Sustainable harvesting protocols and cultivation-based conservation efforts are urgently needed to ensure its continued availability.

Four species—*D. angustifolia*, *Z. officinale*, *C. longa*, and *I. batatas*—are classified as Data Deficient (DD), indicating a lack of adequate population and distribution data despite their frequent local use. This emphasizes the need for targeted conservation research that incorporates ethnobotanical significance and regional usage patterns.

In addition, seven species—*A. graveolens*, *P. amaryllifolius*, *H. polyrhizus*, *E. cardamomum*, *C. ternatea*, *H. sabdariffa*, and *Rosa* sp.—have Not Yet Been Evaluated (NE) on the IUCN Red List. This large proportion underscores the gap between global conservation assessments and culturally important plant taxa used in traditional food systems.

Bridging this gap is essential to support inclusive and locally relevant biodiversity conservation, especially in urbanizing regions where traditional ecological knowledge can inform both scientific priorities and sustainable resource use.

While the overall conservation status may not raise immediate alarm, ongoing use of wild-sourced or under-documented species necessitates vigilance, particularly in the face of habitat loss, urbanization, and changing agricultural practices. Promoting in situ and ex situ conservation, as well as encouraging the cultivation of culturally significant dye plants at home, can support both biodiversity and food heritage preservation.

Furthermore, community-based monitoring and participatory conservation strategies—especially involving women and elders who are key holders of culinary knowledge—can enhance plant protection efforts while maintaining cultural continuity.

Ethnobotanical reflections and urban challenges

The use of natural food coloring plants in Surakarta reflects more than culinary preferences—it embodies a dynamic ethnobotanical tradition rooted in ecological adaptation, symbolic meaning, and intergenerational knowledge. As demonstrated in previous sections, coloring plants are selected not only for their visual effects but also for their roles in ritual, identity, and sensory experience, forming an inseparable part of Javanese foodways.

However, urbanization introduces significant challenges to the continuity of this knowledge. In the more densely populated areas of Keprabon and Baluwarti, traditional food plants are being increasingly replaced by store-bought products, and the practice of cultivating dye plants is in decline. Younger generations show reduced familiarity with food-coloring species, relying more on synthetic food dyes or pre-packaged ingredients that offer convenience but little cultural meaning.

This erosion of practical knowledge is compounded by shrinking green spaces, time constraints, and dietary modernization, all of which limit opportunities for experiential learning. Many respondents noted that plant-based dyes are now used mainly during religious holidays or special occasions, and are no longer an integral part of everyday cooking routines. The cultural knowledge, once ubiquitous, now risks becoming a specialized, nostalgic domain.

At the same time, a growing interest in organic food, heritage cuisine, and natural ingredients presents opportunities for revival. Urban agriculture movements, herbal drink entrepreneurship, and culinary tourism may offer new platforms for revaluing traditional food dyes. Schools, markets, and family spaces can serve as loci of knowledge transmission, especially if younger people are engaged through creative and participatory methods.

Preserving the use of natural coloring plants thus requires both cultural and ecological strategies. On the one hand, documentation and education efforts must center on elders—especially women—as key knowledge holders; on the other hand, policy and infrastructure should support home gardening, plant exchanges, and biodiversity-based livelihoods. This dual approach can help embed ethnobotanical traditions into the future fabric of urban life.

Ultimately, the study of coloring plants in Surakarta reveals how biocultural knowledge is constantly negotiated within changing landscapes. Recognizing and supporting this knowledge not only honors local identity but also contributes to broader goals of food sovereignty, sustainability, and cultural resilience.

This study documented the ethnobotanical knowledge of 17 food-coloring plant species used by communities in Mojosongo, Keprabon, and Baluwarti Villages in Surakarta, Indonesia. These species represent diverse plant families, parts used, life forms, and acquisition modes, producing a spectrum of eight color categories in traditional foods and beverages. Although only a minority of these species are currently listed as Least Concern by the IUCN, many remain unevaluated or classified as Data Deficient or Vulnerable, highlighting the urgency of targeted conservation efforts (Cazalis et al. 2023).

The study reveals that food coloring practices are embedded in cultural values, gendered knowledge systems, and spatial dynamics, with older women serving as key knowledge holders. Yet, urbanization, market dependency, and lifestyle changes pose significant threats to the continuity of this tradition. Sustaining the use of natural dyes requires an integrated approach that combines household-based cultivation, formal and informal knowledge transmission, and community-based conservation strategies. Recognizing the cultural and ecological significance of these plants is critical not only for preserving food heritage but also for promoting urban biodiversity and resilient local food systems in a rapidly modernizing landscape.

The diversity of parts used

Figure 3 shows that the diversity of plant parts used as food coloring consists of seven parts: leaves, flowers, fruit, tubers, rhizomes, wood, and stems; the most widely used plant parts are the flowers of five plant species, accounting for 29.40%. These plants include butterfly flowers (*C. ternatea*), coconut flowers (*C. nucifera*), rose flowers (*Rosa* sp.), cloves (*S. aromaticum* (L.) Merr. & L.M.Perry), and rosella flowers (*H. sabdariffa* L.). Furthermore, plants that utilize the leaves are four species or 23.50%, including *suji* leaves (*D. angustifolia*), *pandan* leaves (*P. amaryllifolius*), bay/*salam* leaves (*S. polyanthum* (Wight) Walp.), and celery leaves (*A. graveolens* L.). The next part of the plant is fruit, which has three or 17.60%, i.e., dragon fruit (*Hylocereus polyrhizus* (F.A.C.Weber) Britton & Rose), chilies (*C. frutescens* L.), and cardamom (*E. cardamomum* (L.) Maton). The dragon fruit's inside parts are also used in food coloring, and the flowers, fruit skin, and leaves are also used as herbal medicine (Luu et al. 2021).

Table 4. Species with conservation status

Family	Scientific name	Local name	IUCN Conserv. Status (2022)
Arecaceae	*Cocos nucifera* L.	*Gula Jawa*	Least Concern (LC)
Apiaceae	*Apium graveolens* L.	*Seledri*	Least Concern (LC)
Asparagaceae	*Dracaena angustifolia* (Medik.) Roxb.	*Suji*	Vulnerable (VU)
Cactaceae	*Hylocereus polyrhizus* (F.A.C.Weber) Britton & Rose	*Buah naga*	Data Deficient (DD)
Convolvulaceae	*Ipomoea batatas* (L.) Lam.	*Ubi ungu*	Data Deficient (DD)
Fabaceae	*Caesalpinia sappan* L.	*Secang*	Least Concern (LC)
Fabaceae	*Clitoria ternatea* L.	*Telang*	Not evaluated (NE)
Malvaceae	*Hibiscus sabdariffa* L.	*Rosela*	Not evaluated (NE)
Myrtaceae	*Syzygium polyanthum* (Wight) Walp.	*Salam*	Least Concern (LC)
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	*Cengkeh*	Not evaluated (NE)
Pandanaceae	*Pandanus amaryllifolius* Roxb.	*Pandan*	Data Deficient (DD)
Poaceae	*Cymbopogon citratus* (DC.) Stapf	*Serai*	Not evaluated (NE)
Rosaceae	*Rosa* sp.	*Mawar*	Not evaluated (NE)
Solanaceae	*Capsicum frutescens* L.	*Cabe*	Least Concern (LC)
Zingiberaceae	*Zingiber officinale* Roscoe	*Jahe*	Data Deficient (DD)
Zingiberaceae	*Curcuma longa* L.	*Kunyit*	Data Deficient (DD)
Zingiberaceae	*Elettaria cardamomum* (L.) Maton	*Kapulaga*	Not evaluated (NE)

The next part of the plant is the rhizome, which has two (or 11.80%), more specific: ginger (*Z. officinale*) and turmeric (*C. longa*). The least used plant parts are stems, tubers, and wood, each of which is used in only one (or 5.90%) case, such as sappan wood (*C. sappan*), purple sweet potato tuber (*I. batatas*), and lemongrass (*C. citratus*). People only use certain parts of plants (such as flowers, rhizomes, and fruits) because they have limited knowledge regarding the natural coloring of plants. Rhizomes are widely used because there are many types, and in addition, they tend not to be easily damaged and can be used either fresh or dry (Nurshillah et al. 2022). Additionally, wood is rarely used because it is difficult to process into a food coloring. According to Bayram et al. (2015), certain flowering plants, such as saffron (*Crocus sativus* L.), roselle (*H. sabdariffa*), and marigold (*Calendula officinalis* L.), are edible and can also serve as natural food coloring agents.

Diversity of life forms

Figure 4 revealed that herbaceous plants accounted for 35.29% of the total, bushes for 17.66%, wood for 35.29%, and creepers for 11.76%, which aligns with the life form plant diversity of the people in Mojosongo, Keprabon, and Baluwarti villages, as shown in Table 2. In those three villages, six species were at tree categories growth form (*C. nucifera, H. sabdariffa, S. aromaticum, Rosa* sp., *S. polyanthum,* and *C. sappan*), then herbaceous with six species (*C. frutescens, C. citratus, E. cardamomum, A. graveolens, C. longa,* and *Z. officinale*), bush with three species (*D. angustifolia, P. amaryllifolius,* and *I. batatas)*, and creepers with two species (*H. polyrhizus* and *C. ternatea*). These results showed that people used palm sugar, rosella, cloves, roses, *salam*, and *secang* more often as food coloring in the habitus wood category. Then, the people on sites still use chilies (*C. frutescens*), cardamom (*E. cardamomum*), celery (*A. graveolens*), turmeric (*C. longa*), and ginger (*Z. officinale*) as food coloring in the herbaceous category.

Plant origin

People are drawn to a diverse range of natural ingredients for food coloring, including dragon fruit, chili, cardamom, palm sugar, *telang* flower, rosella, cloves, roses, celery, *suji* leaves, bay leaf, *pandan* leaves, lemongrass, *secang*, turmeric, ginger, and purple sweet potatoes. Although most plants were obtained through purchase (71%) or home cultivation (29%), none of the respondents mentioned obtaining plants through social sharing or neighbor donations. This may reflect the urban character of Surakarta, where limited yard space and reduced social-agrarian ties have led to a decline in such practices. Furthermore, five species of plants, including turmeric, roses, pandan, suji, and *telang*, make up the remaining 29.4% of the cultivated species (Table 2; Figure 5). Providing plant dyes by purchasing them is preferable to growing them yourself or asking your neighbors, because many people do not have yards or gardens for cultivation, and some people prefer to grow ornamental plants rather than food plants.

People living in urban or rural areas often have dye plants planted in their yards or gardens, and they can also purchase them at local markets or supermarkets. Research conducted in Vietnam indicates that individuals residing in cities or urban areas tend to use dye plants more frequently than those living near forests. Ethnic communities only use dye plants in a few ceremonies (Luong et al. 2023).

In conclusion, this study documented the diversity and ethnobotanical relevance of 17 plant species used as natural food colorants by communities in Mojosongo, Keprabon, and Baluwarti Villages of Surakarta, Central Java. These species vary in taxonomy, plant parts utilized, life forms, and modes of acquisition, and are employed to produce a wide range of color categories in traditional foods and beverages. The findings highlight that natural food coloring practices are deeply embedded in cultural identity, ritual expression, and gendered knowledge systems, particularly among older women. However, only a small proportion of the species are classified as Least Concern by the IUCN, while others remain Data Deficient, Vulnerable, or have not yet been evaluated, indicating an urgent need for ethnobotany-informed conservation strategies. In the face of urbanization and declining intergenerational knowledge transmission, sustaining the use of natural food dyes requires a combination of home-based cultivation, community awareness, and integration into food heritage education. Protecting and revitalizing this biocultural knowledge not only contributes to culinary diversity and public health but also supports urban ecological resilience and plant conservation efforts.

ACKNOWLEDGEMENTS

Many parties have guided and supported the authors in the preparation of this paper. The authors would like to express their sincere gratitude to all individuals and institutions who contributed in various ways to the completion of this research. Special thanks are extended to the village heads and residents of Mojosongo, Keprabon, and Baluwarti in Surakarta City, Indonesia, for their warm welcome, cooperation, and valuable local knowledge shared during the fieldwork.

REFERENCES

Amalraj A, Pius A, Gopi S. 2017. Biological activities of curcuminoids, other biomolecules from turmeric and their derivatives-A review. J Tradit Complement Med 7 (2): 205-233. DOI: 10.1016/j.jtcme.2016.05.005

Amrul HMZN, Pasaribu N, Harahap RH, Aththorick TA. 2022. Ethnobiology study of hare, a traditional food in the *Parmalim* community North Sumatra, Indonesia. Biodiversitas 23 (11): 6082-6088. DOI: 10.13057/biodiv/d231165.

Annisa SY, Darmawan R, Ritonga AK. 2023. Development of traditional culinary as a tourism attraction in Surakarta City. EDUTOURISM: J Tour Res 5 (2): 218-229. DOI: 10.53050/ejtr.v5i02.688.

Arshimny NA, Syamsu K. 2020. Production and charateristic of natural coloring and flavoring preparations from pandan leaves (*Pandanus amarillifolius*). IOP Conf Ser: Earth Environ Sci 472 (1): 012014. DOI: 10.1088/1755-1315/472/1/012014.

Bayram O, Sagdic O, Ekici L. 2015. Natural food colorants and bioactive extracts from some edible flowers. J Appl Bot Food Qual 88 (1): 170-176. DOI: 10.5073/jabfq.2015.088.024.

BPS. 2024. Surakarta Municipality in Figures 2024. BPS-Statistics Surakarta Municipality, Surakarta. [Indonesian]

Cazalis V, Santini L, Lucas PM, González-Suárez M, Hoffmann M, Benítez-López A, Pacifici M, Schipper AM, Böhm M, Zizka A, Clausnitzer V. 2023. Prioritizing the reassessment of data-deficient species on the IUCN Red List. Conserv Biol 37 (6): e14139. DOI: 10.1111/cobi.14139.

De Mejia EG, Zhang Q, Penta K, Eroglu A, Lila MA. 2020. The colors of health: Chemistry, bioactivity, and market demand for colorful foods and natural food sources of colorants. Ann Rev Food Sci Technol 11: 145-182. DOI: 10.1146/annurev-food-032519-051729.

Hermawan ES. 2021. Actualization and modernization of history-based traditional culinary for preserving Surakarta local wisdom. Indones J Soc Stud 4 (2): 90-99. DOI: 10.26740/ijss.v4n2.p90-99.

Hop NV, Quy NV, Ha NT, Huong KM. 2022. Diversity of colourant plants in Vietnam. Intl J Ecol Environ Sci 4 (2): 93-99.

Indrasti D, Andarwulan N, Purnomo EH, Wulandari N. 2018. Stability of chlorophyll as natural colorant: A review for suji (*Dracaena angustifolia*) (Medik.) Roxb.) leaves case. Curr Res Nutr Food Sci 6 (3): 609-625. DOI: 10.12944/crnfsj.6.3.04.

IUCN. 2023. IUCN Red List of Threatened Species. https://www.iucnredlist.org/.

Jadhav RV, Bhujbal SS. 2020. A review on natural food colors. Pharm Reson 2 (2): 12-20.

Luong NT, Hop NV, Quy NV, Hoan VM. 2023. Diversity of plant species for food coloring in Vietnam. Nusantara Biosci 15 (1): 95-105. DOI: 10.13057/nusbiosci/n150112.

Luu T-T-H, Le T-L, Huynh N, Quintela-Alonso P. 2021. Dragon fruit: A review of health benefits and nutrients and its sustainable development under climate changes in Vietnam. Czech J Food Sci 39 (2): 71-94. DOI: 10.17221/139/2020-cjfs.

Luu-dam NA, Ninh BK, Sumimura Y. 2016. Ethnobotany of colorant plants in ethnic communities in northern Vietnam. Anthropology 4 (1): 1000158. DOI: 10.4172/2332-0915.1000158.

Maha HL, Sitompul E, Silalahi J. 2019. The effect of turmeric extract (*Curcuma domestica* Val) against the durability of yellow rice storage. Indones J Pharm Clin Res 2 (1): 30-36. DOI: 10.32734/idjpcr.v2i1.950.

Mahmud MH, Raihan MT, Shakhik MTZ, Khan FT, Islam MT. 2023. Dragon fruit (*Hylocereus polyrhizus*): A green colorant for cotton fabric. Colorants 2 (2): 230-244. DOI: 10.3390/colorants2020015.

Malabadi RB, Kolkar KP, Chalannavar RK. 2022. Plant natural pigment colorants-health benefits: Toxicity of synthetic food colorants. Intl J Innov Sci Res Rev 4 (10): 3418-3429.

Murtini ES, Yuwono SS, Setyawan HY, Nadzifah N. 2020. Pandan leaf powder: Characteristics and its application in pandan sponge cake making. IOP Conf Ser: Earth Environ Sci 475: 012041. DOI: 10.1088/1755-1315/475/1/012041.

Nurshillah C, Anggorowati D, Putri ER, Balgis M, Nurwulandari M, Murtiningsih, Agustina N, Wulandari P, Liza N, Himawan W, Setyawan AD. 2022. Diversity of edible plants traded in Legi Traditional Market, Surakarta, Indonesia. Asian J Ethnobiol 5 (1): 52-61. DOI: 10.13057/asianjethnobiol/y050106.

Saati EA, Mulandari RD, Wachid M, Winarsih S. 2018. The utilization of telang flower as a healthy, natural food coloring in *dawet* drink. AIP Conf Proc 2024: 020070. DOI: 10.1063/1.5064356.

Suryani CL, Wahyuningsih TD, Supriyadi, Santoso U. 2020. The potential of mature pandan leaves as a source of chlorophyll for natural food colorants. Jurnal Teknologi dan Industri Pangan 31 (2): 127-137. DOI: 10.6066/jtip.2020.31.2.127.

Sutrisno IH, Suwardi AB, Navia ZI, Baihaqi, Fadhilah MA. 2021. Documentation of the traditional Alas food in Southeast Aceh District, Indonesia. Biodiversitas 22 (8): 3243-3249. DOI: 10.13057/biodiv/d220818.

Wijaya S. 2019. Indonesian food culture mapping: A starter contribution to promote Indonesian culinary tourism. J Ethn Foods 6: 9. DOI: 10.1186/s42779-019-0009-3.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025
Pages: 104-115
E-ISSN: 2580-4510
DOI: 10.13057/asianjethnobiol/y080109

Ethnoecological perspectives on biodiversity conservation in volcanic landscapes of Mount Merapi National Park, Central Java, Indonesia

MUHAMMAD HANIF AHSANI TAQWIM[1], MUHAMMAD NUR FITRIAWAN[1], NAILA MAULIDA IBRIZA[1], NIDA ULHAQ FIL'ARDIANI[1], KIRANA NURUL ARIFIANI[1], SUTOMO[2], AHMAD DWI SETYAWAN[1,3,♥]
[1]Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: volatileoils@gmail.com.
[2]Bali Botanic Gardens, Research Center for Plant Conservation, Botanic Gardens and Forestry, National Research and Innovation Agency. Jl. Kebun Raya, Candikuning, Baturiti, Tabanan 82191, Bali, Indonesia
[3]Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

Manuscript received: 14 July 2024. Revision accepted: 29 May 2025.

Abstract. *Taqwim MHA, Fitriawan MN, Ibriza NM, Fil'ardiani NU, Arifiani KN, Sutomo, Setyawan AD. 2025. Ethnoecological perspectives on biodiversity conservation in volcanic landscapes of Mount Merapi National Park, Central Java, Indonesia. Asian J Ethnobiol 8: 104-115.* Volcanic protected areas such as Mount Merapi National Park (TNGM) in Indonesia hold exceptional ecological and cultural significance yet face complex conservation challenges due to ecological volatility and socio-economic vulnerability. This study explores ethnoecological perspectives on biodiversity conservation among residents of Tegalmulyo and Sidorejo, two villages located in the national park's buffer zone. Using a qualitative descriptive approach, data were collected through structured interviews with 87 respondents, supported by culturally adapted questionnaires and field observations. Results reveal high levels of community awareness regarding biodiversity regulations and intergenerational heritage values. Conservation is widely perceived as a moral and cultural obligation, expressed through non-extractive practices, taboos, and collective activities such as tree planting and forest monitoring. Local belief systems, including spiritual reverence for forested landscapes and communal ethics such as *gotong royong,* emerge as key drivers of conservation behavior. The study underscores the crucial role of community engagement in biodiversity conservation, as demonstrated by the sustained initiatives of these communities through social cohesion and informal institutions such as the Fire Care Community (*Masyarakat Peduli Api*/MPA) and Forest Police Partner Community (*Marakat Mitra Polhut*/MMP). Unlike previous studies, this research provides in-depth ethnoecological insights from disaster-prone volcanic regions, emphasizing culturally embedded conservation practices that remain underexplored in formal policy discourses. The findings highlight the need to incorporate local ecological knowledge and community values into co-management strategies for more inclusive and adaptive biodiversity governance.

Keywords: Biodiversity conservation, community-based conservation, ethnoecology, traditional knowledge, volcanic landscapes

INTRODUCTION

Indonesia is one of the most megadiverse countries globally, hosting an extraordinary range of flora, fauna, and ecosystems across its vast archipelago. This biological wealth is shaped by complex topography, diverse climatic conditions, and a tapestry of cultural traditions that influence how natural resources are managed (Yunita et al. 2020). Biodiversity conservation in Indonesia is thus not only an ecological priority but also a socio-cultural obligation, especially in ecologically sensitive and culturally significant areas such as national parks. Setiawan (2022) identified at least 74 distinct ecosystems—both natural and human-modified—that face growing threats from environmental changes and anthropogenic pressures.

Conservation in Indonesia typically follows two complementary approaches: in-situ and ex-situ. The in-situ strategy prioritizes the protection of ecosystems in their native context, while ex-situ methods focus on preserving components of biodiversity outside their original environments (Mulyaningsih et al. 2020; Dako et al. 2021). In areas such as volcanic zones, in-situ approaches are crucial due to the dynamic nature of ecological succession and community adaptation to frequent disturbances. However, recent studies warn of a continued decline in critical biodiversity indicators, calling for transformative conservation models that integrate scientific knowledge and local lived experiences (McPhearson et al. 2021; García-Roselló et al. 2023).

Mount Merapi National Park (Taman Nasional Gunung Merapi or TNGM) exemplifies the interplay between ecological preservation, active volcanism, and deep-rooted cultural values. Straddling Central Java and Yogyakarta provinces, the park harbors endemic and endangered species and is revered for its spiritual and historical significance (Djuwantoko et al. 2005). As a conservation area, TNGM bears responsibility for sustaining both biodiversity and the socio-ecological systems upon which it depends. Tegalmulyo and Sidorejo—two villages in the park's buffer zone—are inhabited by farming communities that are actively involved in both resource use and conservation efforts (Torimbanu et al. 2024). Their dual roles underscore the importance of understanding local knowledge, perception, and meaningful participation in conservation.

Local Ecological Knowledge (LEK)—the culturally transmitted body of ecological understanding accumulated through generations—plays a pivotal role in community-based conservation (Berkes 2018; Fielding et al. 2023). Embedded in beliefs, rituals, and taboos, LEK often functions as a form of informal environmental governance aligned with conservation goals. On Mount Merapi, cultural notions of sacredness, land-use ethics, and environmental taboos have historically reinforced biodiversity protection—often long before formal policies were introduced. Turo and Medeghini (2021) argue that such values can enhance environmental stewardship when supported by inclusive governance frameworks.

Despite this potential, community participation in formal park management remains limited. Although Law No. 41/1999 on Forestry mandates public involvement, practical implementation is often hindered by unclear tenure rights, weak institutional coordination, and insufficient environmental education (Qodriyatun 2020; Firnanda et al. 2024). In TNGM, zoning schemes and outreach efforts have been initiated (Wijayati and Rijanta 2020), yet there remains a need to assess how communities interact with these mechanisms and what cultural or socio-economic factors shape their engagement.

Empirical research confirms that community perceptions strongly influence conservation outcomes. Ernawati et al. (2018) found that perceptions of ecological value are positively associated with rule compliance. Moreover, information-sharing by park officers and community leaders significantly improves conservation behavior (Purwatiningsih 2022). However, perception does not always translate to participation, especially where livelihoods depend heavily on natural resources. Therefore, a comprehensive ethnoecological perspective—examining both awareness and active engagement—is essential to evaluate conservation effectiveness.

This study investigates the ethnoecological dimensions of community awareness and participation in biodiversity conservation within Tegalmulyo and Sidorejo Villages, located in the buffer zone of Mount Merapi National Park. It focuses on how local knowledge systems, regulatory awareness, and voluntary engagement intersect in a landscape marked by ecological risk and cultural endurance. By centering on community voices and experiential insights, this research offers a deeper understanding of conservation that connects policy frameworks with ground-level realities. Unlike earlier studies, it foregrounds culturally embedded conservation practices in disaster-prone volcanic settings—an area still underrepresented in biodiversity governance discourse.

MATERIALS AND METHODS

Study area

Mount Merapi National Park (TNGM) is a protected area located on the border of Central Java and Yogyakarta, Indonesia (Figure 1). It spans several administrative districts and serves as a crucial biodiversity sanctuary and ecological buffer within a volcanically active zone. Positioned between 7°26′-7°48′ S and 110°21′-110°36′ E, the park encompasses lowland forests, montane vegetation, and human-modified landscapes. Its role as a water catchment and its richness in endemic species give it significant ecological and hydrological value (Djuwantoko et al. 2005). TNGM is also situated in a culturally and spiritually important landscape, where local cosmologies influence interactions with nature.

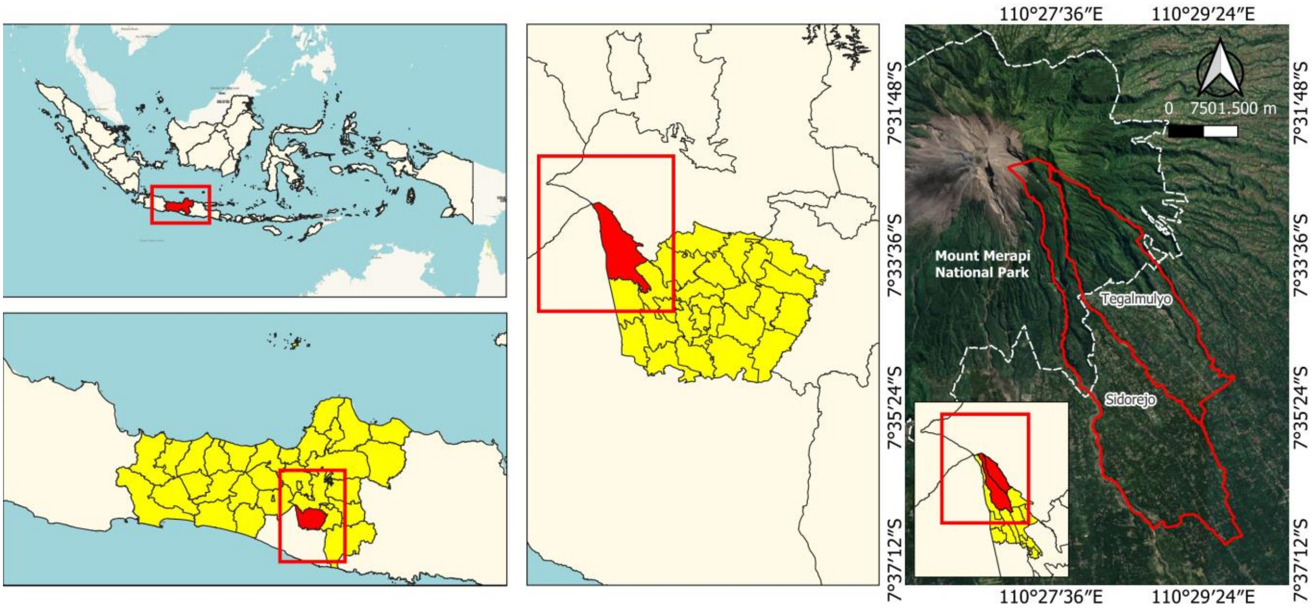


Figure 1. Location in the buffer zone of Mount Merapi National Park, Tegalmulyo and Sidorejo Villages, Kemalang Sub-district, Klaten District, Central Java, Indonesia

This study focuses on two villages in the park's buffer zone: Tegalmulyo and Sidorejo, both in Kemalang Sub-district, Klaten District. Tegalmulyo lies at -7.5671945, 110.4768555, while Sidorejo is slightly southward at -7.6003677, 110.4798348. These villages are approximately 10 kilometers from Klaten town and feature slopes shaped by volcanic activity. The land cover includes mixed dryland farming, forest remnants, and scattered dwellings.

The villages are inhabited mainly by Javanese farmers who depend on seasonal agriculture, livestock, and minor forest extraction such as firewood and grass. Traditional ecological knowledge and awareness of conservation regulations shape their land use (Whittington and Pagiola 2012). Cultural elements like *pamali* (taboos), *adat* (customary law), and religious beliefs reinforce environmental stewardship and influence compliance with formal conservation policies.

The local biodiversity includes tree species such as *puspa* (*Schima wallichii*), *gondang* (*Ficus* spp.), and *ricen* (*Eugenia* spp.), alongside orchids and coffee plants cultivated in home gardens. These species hold both ecological and cultural value (Aji et al. 2022; Marhaento and Faida 2015). Wildlife includes birds, reptiles, and primates like *Macaca fascicularis* and *Trachypithecus auratus*, which interact with both cultivated and forested habitats.

Both villages fall within volcanic disaster-prone zones designated by the Indonesian Disaster Management Agency (BPBD). Tegalmulyo lies in *Kawasan Rawan Bencana*/KRB II (moderate to high risk), and Sidorejo in KRB III (lower but still notable risk), reflecting threats from lava flows, pyroclastic surges, and lahars, based on the 2006 and 2010 eruptions (BPBD Klaten 2023). As shown in Figure 1, their location on the southern slope of Mount Merapi makes them highly vulnerable to disturbances, underscoring the urgency of conservation efforts.

In such volatile environments, community-based conservation must navigate ecological risks and socio-cultural realities. Residents face the challenge of balancing resource use, tradition, and disaster preparedness. Thus, conservation in TNGM must incorporate the ethnoecological perspectives of these communities to build models that are both ecologically and socially resilient (Gavin et al. 2015).

Research design

This study employed a qualitative descriptive approach to explore community awareness, local ecological knowledge, and participation in biodiversity conservation within the buffer zone of Mount Merapi National Park (TNGM). This approach was chosen to capture the depth and contextual richness of community experiences and perceptions, which are often embedded in social relations, oral traditions, and everyday interactions with nature. Unlike quantitative methods aimed at generalization, qualitative inquiry allows for nuanced interpretation grounded in participant narratives and cultural meaning systems (Fielding et al. 2023). The descriptive character of the study helped reveal how local residents articulate conservation values and engage in ecological stewardship.

The ethnobiological perspective informed this methodological choice, emphasizing the cultural embeddedness of ecological understanding. In TNGM, residents of Tegalmulyo and Sidorejo possess long-standing knowledge of species and ecological functions. This knowledge supports local resource management and helps shape community-driven conservation strategies. Open-ended, culturally sensitive interviews were used to elicit both explicit rules and implicit values such as spiritual beliefs and taboos (Berkes 2018).

To uphold ethical integrity, the study incorporated community consent and adhered to protocols from the International Society of Ethnobiology (ISE 2006). Prior to data collection, researchers consulted with village leaders and explained the research in both Indonesian and Javanese. Participants were informed of their rights, and all responses were anonymized. Cultural norms were respected throughout.

Additionally, the study aimed to empower communities by recognizing local conservation practices and facilitating knowledge exchange. Informal discussions with farmer groups and volunteers enriched the data and helped validate interpretations. Multiple community voices were included to ensure reciprocity and align with participatory principles (Cunningham 2001).

By combining qualitative methods with ethnobiological values, this study provides a holistic understanding of conservation as a culturally rooted process. It highlights that effective biodiversity protection arises not merely from regulation, but from the dynamic interface between ecological realities and lived cultural practices—especially in fragile volcanic landscapes like Mount Merapi.

Data collection

Respondent selection and sampling strategy

Data collection was conducted in Tegalmulyo and Sidorejo Villages, which are located in the buffer zone of Mount Merapi National Park. These two sites were selected purposively due to their ecological significance and socio-cultural proximity to the conservation area. The population consists primarily of farmers and livestock keepers who interact directly with the forest ecosystem, making them ideal subjects for examining ethnoecological knowledge and conservation practices. A total of 87 respondents were selected through random household sampling, ensuring that diverse demographic groups—including age, gender, and educational background—were represented. The final sample consisted of 44 males (50.6%) and 43 females (49.4%), with the majority falling within the productive age group of 30-69 years (Table 1).

Questionnaire and interview structure

The study employed a semi-structured interview method supported by a culturally adapted questionnaire designed to explore both general awareness and specific conservation practices. The questionnaire included both closed and open-ended questions organized into three main themes: (i) basic understanding of biodiversity and regulations, (ii) perceptions of human impact and conservation urgency, and (iii) participation in community-based conservation efforts. Open-ended questions were used to allow respondents to elaborate on their personal experiences, local beliefs, and ecological observations. For instance, they were asked about customary rules governing forest use, knowledge of species they considered sacred or useful, and any changes they had observed in forest health. This flexible format helped accommodate the complexity and variability of ethnoecological knowledge across households (Susandi et al. 2021).

Use of local language and cultural adaptation

All interviews were conducted in Indonesian and Javanese, depending on the respondent's preference and linguistic comfort. The use of the local language was essential not only for clarity and rapport but also to maintain the conceptual integrity of indigenous terms, metaphors, and expressions that often have no direct equivalents in formal Indonesian or English. Before the fieldwork, the research team conducted a cultural familiarization session with local leaders to refine the questionnaire and align it with community norms and sensitivities. Key ecological terms such as *leres alas* (forest order), *pamali* (taboo), and *kawasan keramat* (sacred zone) were retained throughout interviews to capture their contextual meanings. This process of linguistic and cultural adaptation ensures that the data collection is respectful, accurate, and reflective of the local worldview (Turo and Medeghini 2021).

Duration and logistics of fieldwork

Field data were collected over two consecutive days, from 9 to 10 March 2024, with interviews conducted at the respondent's homes or communal spaces such as *pos ronda* (village guard posts) and farmer group meeting places. The research team consisted of trained enumerators and a field coordinator familiar with the area and local dialect. Each interview lasted between 20 and 40 minutes, depending on the depth of response and the need for clarification. All responses were recorded manually on printed tally sheets and notebooks due to limited digital access in certain areas. Observational notes were also taken on non-verbal cues and situational contexts, such as household surroundings, the presence of home gardens, or conservation posters, which later informed the qualitative interpretation. Fieldwork logistics were supported by prior coordination with village heads and the TNGM field office, ensuring smooth community access and cooperation.

Data analysis

The data collected from interviews were analyzed using a qualitative-descriptive approach, supported by simple statistical tabulation for categorical variables. The main goal was to identify patterns of awareness and participation and relate them to local ecological knowledge systems. Analysis began with manual tabulation of structured responses concerning conservation awareness, participation, regulation knowledge, and ecological threats like hunting and overharvesting. Closed-ended responses were categorized (e.g., Yes/No, Agree/Neutral/Disagree) and presented as frequency distributions (Tables 2 and 3).

In parallel, thematic coding of open-ended responses and field notes was conducted inductively, identifying themes such as forest heritage, *adat* compliance, perceived risk, and willingness to act without incentives. These were interpreted within the context of formal conservation frameworks, including Forestry Law No. 41/1999 and the TNGM zoning system (Wijayati and Rijanta 2020). This dual analysis enabled linkage between individual perceptions and broader socio-ecological dynamics. Awareness data were grouped into agree, neutral, and disagree categories to assess alignment with conservation principles. Participation data were classified as active, passive, or non-participatory, based on self-reported actions such as tree planting, rule compliance, or group involvement.

To ensure credibility, triangulation was employed by comparing interview responses with field observations—such as presence of seedlings, certificates, or conservation posters. This cross-validation improved internal consistency and interpretive accuracy. While statistical inference was not applied due to the study's qualitative focus, the integration of quantified patterns and ethnographic insight yielded a holistic understanding of community dynamics. The focus on both awareness and participation reflected what people know and do regarding conservation—core to ethnobiological research principles (Fielding et al. 2023). Acknowledged limitations included potential social desirability bias and interpretive ambiguity. These were mitigated by consulting local key informants to clarify meanings and ensure cultural fidelity in the findings.

RESULTS AND DISCUSSION

Demographic profile of respondents

Understanding a community's demographic composition is essential for interpreting patterns of ecological awareness and participation. In this study, about 87 respondents from Tegalmulyo and Sidorejo Villages participated in structured interviews. As shown in Table 1, the demographic profile covered variables including age, gender, level of education, and primary occupation.

In terms of age distribution, the majority of respondents were within the productive age range. Specifically, 30 respondents (34.5%) were between 30-49 years old, followed closely by 20 respondents (23.0%) aged 50-69 years. Meanwhile, younger individuals aged 17-29 made up 18.4%, and elders above 70 years constituted only 9.3% of the total sample. The dominance of the middle-aged cohort not only suggests a potential for active involvement in conservation programs but also underscores the importance of their role, as this age group typically possesses both physical capability and decision-making influence within households (Dewi et al. 2021).

Table 1. Demographic characteristics of respondents from Tegalmulyo and Sidorejo Villages, Klaten District, Indonesia

Demographic Variable	Category	Frequency	Percentage (%)
Age	17-29 years	16	18.4
	30-49 years	30	34.5
	50-69 years	20	23.0
	>70 years	11	9.3
Gender	Male	44	50.6
	Female	43	49.4
Education	No schooling	20	23.0
	Elementary school	35	40.2
	Junior high school	19	21.8
	Senior high school	12	13.8
	University	1	1.1
Occupation	Farmer	66	75.8
	Housewife	8	9.2
	Self-employed	4	4.6
	Student	3	3.4
	Government employee	4	4.6
	Driver	1	1.1
	Livestock breeder	1	1.1

Gender distribution was balanced, with 50.6% male and 49.4% female respondents. This balance allows for a comparative understanding of gendered roles in conservation, which is particularly relevant in rural Java, where both men and women engage in natural resource use and environmental practices—albeit often in different domains (e.g., men in farming and patrolling; women in home gardening and medicinal plant use).

The educational background of respondents revealed that most had limited formal schooling. As many as 40.2% are elementary school graduates, while 23.0% have never received any education. Junior high (21.8%) and senior high school (13.8%) graduates represented a smaller portion, with only 1.1% having received university-level education. This educational profile may influence conservation understanding, particularly in terms of scientific or legal aspects, although traditional ecological knowledge is often transmitted orally and independently of formal education (Indah et al. 2021).

As for occupational roles, the majority of respondents were engaged in farming (75.8%), followed by small numbers involved in household work (9.2%), self-employment (4.6%), and other informal sectors such as livestock rearing, driving, and civil service. The dominance of agricultural livelihoods indicates a strong dependency on natural resources, which reinforces the need for conservation approaches that align with rural livelihoods and ecological sustainability.

These demographic attributes have significant implications for conservation engagement. Respondents in the productive age group were more likely to participate in physically demanding conservation activities such as tree planting or forest patrols. The high proportion of farmers suggests that biodiversity initiatives should be integrated with sustainable agriculture and agroforestry schemes. While limited formal education could pose challenges to the uptake of scientific information, it also highlights the importance of leveraging oral transmission and visual methods for environmental communication. Moreover, gender-balanced participation opens up possibilities for designing conservation programs that utilize both male and female knowledge domains, such as integrating women's expertise in home-based ethnobotany and food security.

The demographic structure of the respondents reflects a community capable of and positioned for participatory conservation, provided that the strategies are contextually grounded and culturally respectful. The demographic composition of respondents is summarized in Figure 2, highlighting key variables relevant to conservation engagement.

Community awareness of biodiversity conservation

Community awareness is a critical component of effective biodiversity conservation, particularly in protected areas where local populations maintain close and ongoing interactions with the landscape. In this study, awareness was assessed through questions measuring understanding of conservation rules, the national park's heritage value, and perceived human impact on biodiversity. The results, presented in Table 2, reveal a generally high level of awareness among residents of Tegalmulyo and Sidorejo Villages regarding the ecological and legal significance of Mount Merapi National Park (TNGM).

The overwhelming majority of respondents (100%) confirmed their awareness that the national park holds important heritage values for future generations. This indicates that the idea of biodiversity as an intergenerational asset is deeply rooted in community consciousness. Such understanding aligns with findings from Ernawati et al. (2018), who reported that local communities around TNGM tend to view conservation not merely as a legal obligation but as a moral responsibility tied to ancestral respect and cultural continuity. This sentiment often takes the form of customary expressions like *warisan anak putu* (inheritance for descendants), highlighting the cultural framing of conservation as a legacy (Figure 3).

Table 2. Basic understanding of respondents regarding conservation in Mount Merapi National Park, Indonesia

Question	Yes	(%)	No	(%)
Is using plants (other than grass) and animals in the TNGM area permissible?	3	3	84	97
Is there community participation and effort in protecting plants and animals in the TNGM area?	87	100	0	0
Did you know that TNGM has heritage values that are important for future generations?	87	100	0	0

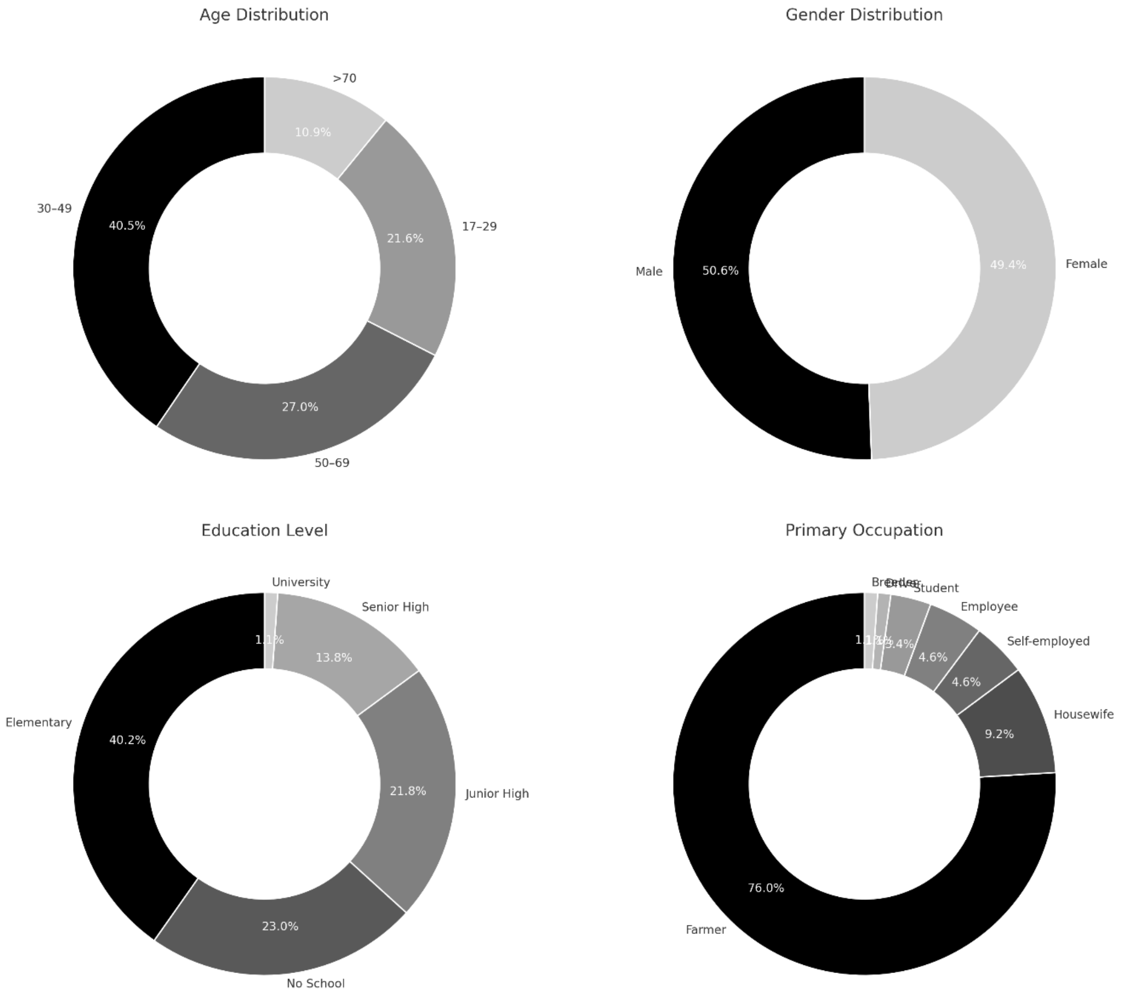


Figure 2. Demographic characteristics of respondents from Tegalmulyo and Sidorejo Villages, Klaten, Indonesia showing distributions by age group, gender, education level, and primary occupation. This profile supports the interpretation of community capacity and potential engagement in biodiversity conservation

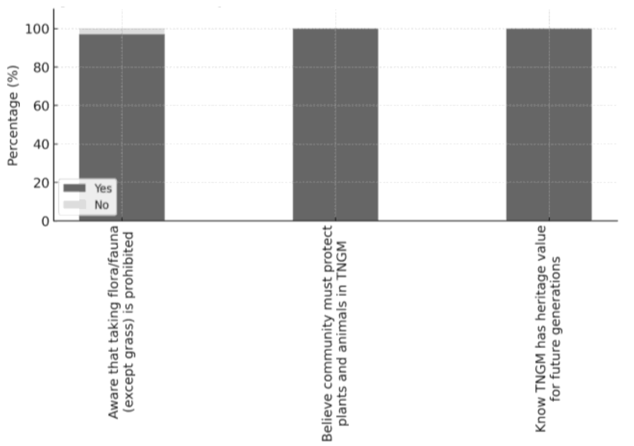


Figure 3. Community awareness levels regarding conservation rules and values in Mount Merapi National Park (TNGM) are based on three key indicators: knowledge of restrictions on flora/fauna extraction, recognition of collective responsibility in protection, and understanding of the national park's intergenerational heritage value

Furthermore, 97% of respondents indicated they were aware that using plants (other than grass) and animals in TNGM is not permissible under current regulations. This suggests strong dissemination of formal conservation laws within the community, likely the result of regular outreach activities by national park authorities and village leaders (Purwatiningsih 2022). Knowledge of such prohibitions demonstrates the successful penetration of legal awareness, although it does not automatically guarantee behavioral compliance, a gap that will be further discussed in the next section.

Another noteworthy finding is that 100% of respondents believed that the community has a role in protecting plants and animals in TNGM. While this figure may reflect an idealized or socially desirable response, it nonetheless indicates that conservation values are widely recognized within the social fabric of both villages. This recognition is essential for fostering collective responsibility and grassroots support for biodiversity governance (Fielding et al. 2023).

The consistency of high-awareness responses supports earlier assertions that conservation communication and education campaigns in the TNGM region have been effective. However, awareness is a multidimensional construct that extends beyond knowledge of rules or values. As suggested by Ajzen and Fishbein (1980), behavioral intention is shaped not only by awareness but also by perceived control and normative beliefs. In this case, while respondents knew the rules, further data (Table 3) reveal variation in their willingness or perceived capacity to act on this awareness, particularly in the form of active participation or sacrifice.

In addition to formal legal knowledge, respondents exhibited a strong understanding of the negative ecological impacts of human intervention. A total of 89% agreed that excessive interference with nature could harm biodiversity in TNGM, with the remaining 11% expressing neutrality rather than disagreement. This level of ecological literacy is vital, especially in a volcanic landscape where both natural and anthropogenic disturbances often strain ecosystem resilience. The ability of residents to articulate causal links between human activity and ecological degradation suggests that they are not only informed but also able to assess environmental risks critically.

These findings indicate that the communities of Tegalmulyo and Sidorejo possess a high degree of conservation awareness that encompasses legal knowledge and value-based commitment. This awareness provides a strong foundation for participatory conservation initiatives. However, the translation of awareness into concrete action remains contingent upon cultural, economic, and institutional factors, which are examined in the following sections.

Patterns of community participation

While awareness of conservation values in Tegalmulyo and Sidorejo Villages is high, the level and nature of actual participation in biodiversity conservation show greater variation. Participation was examined in terms of self-reported involvement in protecting plants and animals, compliance with conservation-related prohibitions, and willingness to engage in shared responsibilities. As shown in Table 3, while 96% of respondents agreed that conservation efforts in TNGM are important, only 56% believed they should personally play a role in maintaining biodiversity. This gap between recognition and responsibility highlights the complexity of community engagement in conservation initiatives.

The disparity is particularly notable when respondents described their roles as passive protectors rather than active participants. Many expressed that their contribution consisted primarily of not disturbing or not damaging the forest rather than joining organized reforestation or patrol programs. This notion of non-interference as participation reflects a culturally specific understanding of conservation rooted in restraint and respect rather than proactive management. In Javanese customary belief systems, the forest is often viewed as a space of sacred order (*leres alas*), and minimal interference is equated with harmony (Turo and Medeghini 2021).

Formal compliance was also high, with 97% of respondents aware of the prohibition against hunting plants and animals and 93% agreeing that violators should be punished. These figures suggest that legal norms are generally accepted and reinforced within the community. Local enforcement, typically in the form of community warnings and social pressure, appears to be more effective than formal policing. Respondents noted that first-time offenders are usually warned or asked to return collected species to the forest. At the same time, repeated violations may result in required participation in TNGM-led programs such as tree planting or forest education events. This graduated sanctioning system, while informal, helps maintain regulatory compliance while preserving social cohesion (Setiawan 2024). The spectrum of community attitudes toward conservation roles, ecological impact, and sanctions is visualized in Figure 4.

The study also identified perceived limitations that may constrain deeper participation. One such limitation is the economic cost associated with conservation actions. While most respondents supported the idea of conserving biodiversity, 62% disagreed with the notion that material sacrifices (e.g., money or resources) were required. For communities that rely heavily on subsistence farming, the prioritization of livelihood needs often outweighs voluntary financial contributions. Some respondents expressed that conservation is not something to be paid for but rather a communal obligation embedded in religious and cultural practice. This reflects a worldview in which conservation is a moral rather than transactional duty—a perspective that should be acknowledged in the design of participatory programs.

Table 3. Community perceptions and participation in biodiversity conservation in Mount Merapi National Park, Indonesia

Question	Agree	(%)	Neutral	(%)	Disagree	(%)
Is it important to conserve biodiversity (plants and animals) in the TNGM area?	82	96	3	3	1	1
Do you, as a resident, have a role in maintaining biodiversity in the TNGM area?	49	56	31	36	7	8
Can human activities negatively impact biodiversity in TNGM?	77	89	10	11	0	0
Are people not allowed to hunt biodiversity in the TNGM area?	84	97	0	0	3	3
Should those who violate biodiversity regulations be punished?	82	93	5	6	1	1
Do you feel the need to make material sacrifices to support conservation?	24	28	9	10	54	62

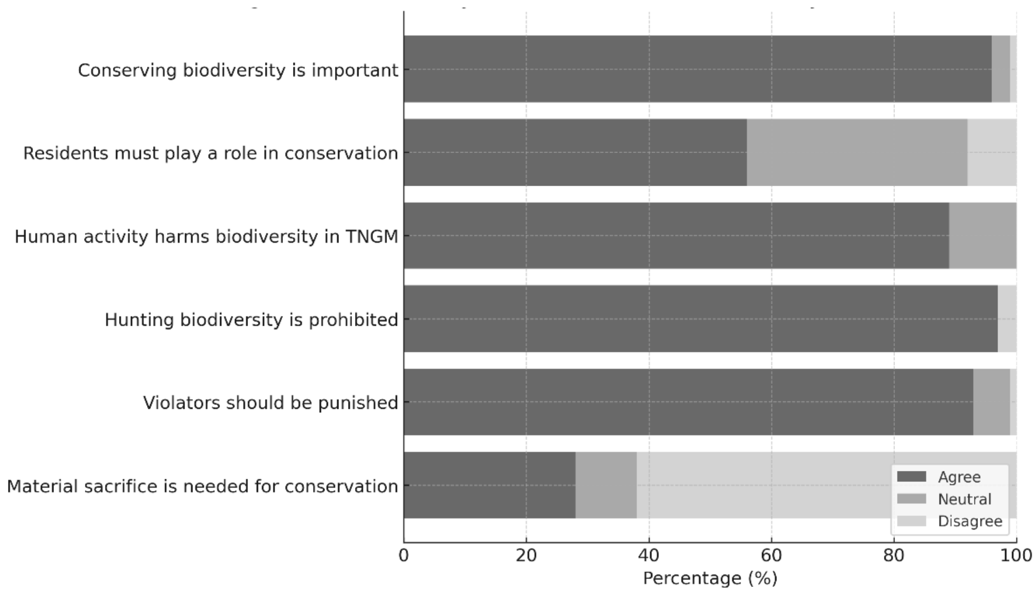


Figure 4. Community attitudes toward biodiversity conservation and participation in Mount Merapi National Park, based on six key indicators. Responses are categorized by level of agreement (agree, neutral, disagree), reflecting variations in perceived responsibility, awareness of impact, acceptance of sanctions, and views on material contribution

Community-based activities such as tree planting, seedling care, and wildlife monitoring were mostly carried out through group-based efforts led by TNGM or civil society organizations. These include local farmer groups, PKK (Family Welfare Movement), and environmental volunteer groups such as *Masyarakat Peduli Api*/MPA (Fire Care Community) and *Masyarakat Mitra Polhut*/MMP (Forest Police Partner Community) (Qodriyatun 2020). Participation in such groups is often informal and periodic, related to seasonal activities or in response to major events such as forest fires or volcanic eruptions. Although episodic, these activities are significant contributions to ecological resilience and community solidarity.

Overall, the findings indicate that compliance with conservation norms—both formal and customary—is high, but active participation remains moderate and highly context-dependent. Cultural values, economic capacity, and perceived roles mediate how conservation is interpreted and implemented in the community. Programs that aim to strengthen local participation should, therefore, build on existing ethical frameworks and avoid imposing external expectations that may not resonate with local realities (Truong 2022). Recognizing communal restraints and obligations as legitimate forms of conservation may provide a more inclusive and culturally congruent foundation for future biodiversity initiatives.

Local beliefs and conservation values

Local beliefs and cultural values play a pivotal role in shaping how communities perceive and engage with conservation efforts, especially in regions where formal state regulations intersect with traditional knowledge systems. In the case of Tegalmulyo and Sidorejo Villages, conservation is not merely understood as a scientific or legal mandate but also as a culturally embedded obligation passed down through generations. These beliefs—manifested in practices such as taboos (*pamali*), reverence for sacred groves (*alas keramat*), and traditional ceremonies—contribute to informal systems of biodiversity protection that are often more deeply respected than formal policies (Turo and Medeghini 2021).

Respondents often referred to the mystical character of Mount Merapi and the surrounding forests, which are believed to be inhabited by spiritual entities or guardians (*penunggu*). This cosmological framework discourages unauthorized or disrespectful exploitation of natural resources, reinforcing norms of self-control and ecological mindfulness. In such situations, non-compliance is feared not only for its legal consequences but also for potential supernatural retribution. These perceptions provide a strong form of social control that complements the regulatory function of national park authorities (Ernawati et al. 2018).

Cultural institutions also mediate conservation behavior through community rituals and seasonal customs. For example, certain days are considered inauspicious (*hari pantangan*) for entering the forest, while others are reserved for collective offerings to honor ancestral spirits and forest deities. These practices are not arbitrary but serve to regulate the frequency and timing of resource use, allowing forest patches to regenerate naturally. Such ethnoecological rhythms contribute to ecological balance, even in the absence of scientific monitoring or formal management. As highlighted by Berkes (2018), traditional ecological calendars and ritual cycles often function as adaptive strategies to ensure long-term sustainability.

In addition, the concept of *gotong royong* (mutual cooperation) was consistently emphasized by respondents as a foundational value underpinning collective action for conservation. Community members described planting trees, tending seedlings, and monitoring fire-prone zones as part of their social duty rather than a task requiring compensation. Participation in volunteer groups such as MPA (Fire Care Community) and MMP (Forest Police Partner Community) is not only seen as practical action but also as an expression of moral alignment with the values of harmony (*rukun*) and balance (*selaras*) between humans and nature (Qodriyatun 2020).

Despite the richness of these cultural frameworks, challenges remain in aligning traditional values with formal conservation programs. One issue is that government interventions often overlook or underutilize local belief systems, focusing instead on compliance-based enforcement. Respondents noted that conservation initiatives that disregard local wisdom or are introduced without adequate consultation tend to be viewed as top-down and less legitimate. Conversely, programs that involve traditional leaders and respect customary norms tend to receive stronger support and longer-lasting outcomes. This supports the findings by Firnanda et al. (2024), who stress the need for integrating ecological education with culturally relevant narratives.

Another tension arises when religious interpretations vary across households. While many respondents view caring for nature as a religious obligation (*amanah*), others, particularly younger or more economically marginalized individuals, may prioritize livelihood needs over conservation ideals. This diversity of views highlights the dynamic nature of cultural values, which are neither static nor uniformly held. Conservation planners must, therefore, approach communities not as monolithic entities but as internally diverse collectives with overlapping and, at times, conflicting worldviews (Pretty et al. 2009).

The conservation values held by communities in Tegalmulyo and Sidorejo are deeply rooted in cultural identity, spiritual cosmology, and collective ethics. These values offer both a normative foundation and a practical framework for biodiversity protection. Recognizing, respecting, and working through these local belief systems is not only an ethical imperative but also a strategic pathway for building effective and enduring conservation partnerships in ethnobiologically rich regions such as Mount Merapi. These beliefs are also reflected in community practices and conservation symbols observed across the landscape, as illustrated in Figure 5.

Material sacrifice and incentive perception

Incentives—both material and non-material—play a central role in influencing participation in biodiversity conservation. However, in rural communities such as Tegalmulyo and Sidorejo, where subsistence livelihoods dominate, and market access is limited, the perception of material sacrifice in conservation takes on complex and often contradictory meanings. When asked whether conservation should involve a financial or material contribution, 62% of respondents disagreed, while only 28% agreed that such a sacrifice was necessary (see Table 3, item 6). These responses reveal a tension between moral imperatives and economic constraints that shape how conservation is interpreted and implemented at the local level.

Several respondents expressed the view that conservation should not be bought or paid for but rather understood as an intrinsic communal duty tied to cultural and religious values. In this sense, participation is framed not in terms of compensation but as a form of *ibadah* (worship) or *gotong royong* (mutual aid). This resonates with observations from other ethnobiological studies, where intrinsic motivations, such as spiritual fulfillment, social cohesion, and ancestral respect, frequently outweigh external incentives as drivers of environmental stewardship (Cetas and Yasué 2017). For many villagers, the act of planting trees or protecting forest borders is its own reward, tied to personal virtue and community reputation rather than financial gain.

However, economic realities cannot be completely separated from the dynamics of participation. Farming households in these villages often face seasonal income fluctuations, high dependence on natural inputs, and limited access to agricultural extension services. These conditions limit their ability to provide material support to conservation programs, even when they ideologically support them. For instance, respondents noted that while they were willing to donate time and labor, they could not afford seeds, tools, or transportation to participate in events located far from their homes. This insight highlights the need to distinguish between willingness and capacity—a distinction often overlooked in top-down conservation planning (Qodriyatun 2020).

The study also revealed variations in perception based on age, education, and exposure to formal conservation programs. Older respondents and those with strong ties to community institutions (such as religious groups or farmers' cooperatives) tended to view conservation as a shared moral responsibility. In contrast, a minority of younger respondents—especially those exposed to digital media or urban work migration—expressed more pragmatic views, suggesting that external support (funding, materials, or training) would increase participation. This indicates an emerging generational divergence in conservation motivation, which may require adaptive communication strategies and differentiated outreach by TNGM and partner organizations.

Interestingly, some villagers interpret material sacrifice not as a gift of money but as a release of potential income from extractive practices such as harvesting timber, hunting wildlife, or converting land to cash crops. From this perspective, conservation itself is already a form of economic sacrifice, as it requires self-restraint and long-term thinking in the face of immediate needs. This aligns with the broader ethnoecological understanding of conservation as a *disciplinary ethic*—a form of self-limitation rooted in ecological knowledge and cultural norms (Marhaento and Faida 2015; Berkes 2018).

Figure 5. Ethnoecological scenes from the buffer zone of Mount Merapi National Park, Indonesia. A. Local residents engage in reforestation activities; B. A home garden featuring valued plants cultivated for conservation and subsistence use; C. Signage indicating hunting prohibition and conservation zoning, reflecting the integration of formal regulations into community landscapes

To strengthen conservation engagement, several respondents suggested in-kind incentives that are non-monetary yet practically useful, such as access to seedlings, technical assistance for agroforestry, or recognition of community efforts through awards and social events. These suggestions reflect a preference for support that is relational and empowering rather than transactional. Furthermore, they align with best practices in community-based conservation, which emphasize trust-building, transparency, and mutual accountability over direct payments (Farley et al. 2010).

Perceptions of material sacrifice in Tegalmulyo and Sidorejo are shaped by a delicate balance of moral ideals, livelihood constraints, and evolving social values. While financial incentives are not entirely rejected, they are generally subordinated to notions of collective responsibility and cultural integrity. Conservation strategies in the TNGM buffer zone should, therefore, avoid framing participation solely in economic terms and instead recognize the full spectrum of motivations—including pride, duty, and spiritual reward—that underlie community commitment to biodiversity protection.

Community-based actions and institutional synergy

In biodiversity conservation, especially within high-risk landscapes such as the slopes of Mount Merapi, the success of long-term ecological protection hinges not only on individual awareness but also on the collective mobilization of local communities in synergy with formal institutions. In both Tegalmulyo and Sidorejo Villages, community-based actions have emerged as critical mechanisms through which conservation goals are localized, internalized, and operationalized.

One of the most prominent forms of community involvement is tree planting, which is carried out regularly through collaborative programs between residents and the TNGM management. Following the 2010 Merapi eruption, large-scale ecosystem restoration efforts involved local volunteers in planting endemic and ecologically functional species such as *puspa*, *tesek*, *sarangan*, *gondang*, and *ricen* (Marhaento and Faida 2015; Fadilah et al. 2024). These species not only restore forest structure and soil stability but also support local wildlife by providing food and shelter. In addition, villagers reported cultivating coffee (*Coffea arabica* var. yellow Caturra Bourbon) and native orchids (*Vanda* spp.) in home gardens and greenhouses, with the intention of reintroducing them into protected forest zones. Such initiatives demonstrate the integration of livelihood activities with conservation objectives, reflecting an ethnoecological model of sustainability that integrates cultural and ecological goals.

Volunteerism also plays a significant role in operationalizing conservation. Residents participate in Fire Care Community (MPA) and Forest Police Partner Community (MMP) groups, which conduct patrols, report violations, and support forest fire prevention efforts (Qodriyatun 2020). These community-based groups operate with limited resources but high local legitimacy, often filling institutional gaps left by understaffed or overstretched state agencies. Their effectiveness derives from local trust, embedded accountability, and the integration of customary norms, making them indispensable allies in protected area management.

Institutional synergy is further strengthened through the zoning system established by the Ministry of Environment and Forestry under Regulation No. P.76/Menlhk-Setjen/2015. However, while 97% of respondents acknowledged awareness of zone-based regulations, such as restrictions on harvesting in core and jungle zones, many expressed uncertainty about the precise boundaries or permitted activities within these zones (Wijayati and Rijanta 2020). This knowledge gap indicates the need for improved communication and participatory mapping, where local residents are involved in spatial planning and zone identification, enhancing both compliance and local ownership.

Another promising area of institutional collaboration lies in the involvement of local women's groups, such as PKK (Family Welfare Movement), in conservation-linked activities like home gardening, medicinal plant cultivation, and environmental education. These gender-inclusive initiatives recognize the differentiated knowledge systems and roles that women hold in managing biodiversity, especially within the domestic and peri-domestic spheres. By supporting these grassroots actors with training and access to native seedlings, conservation agencies can broaden their reach and strengthen the socio-cultural foundation of environmental stewardship (Fielding et al. 2023).

Despite these encouraging practices, institutional challenges remain. Several respondents pointed to the episodic and project-based nature of many conservation interventions, which often lack long-term follow-up or integration with village development plans. There is also a perceived disconnect between community contributions and recognition by authorities, leading to diminished motivation over time. This highlights the importance of reciprocity and visibility in institutional partnerships, where local actors are not merely beneficiaries or implementers but co-owners of conservation outcomes (Brosius et al. 2005).

To address these issues, conservation strategies must move beyond compliance and participation metrics toward models of co-management that integrate indigenous knowledge, local governance structures, and scientific expertise. This includes facilitating dialogues between village leaders, customary elders, and TNGM officials creating feedback loops that enable adaptive learning and responsive policy-making. Moreover, linking conservation actions to tangible co-benefits—such as ecotourism revenue, seedling exchange, or food security—can help sustain local engagement without eroding intrinsic motivations (Setiawan 2024).

Community-based conservation in the buffer zones of TNGM is active, multifaceted, and deeply embedded in local knowledge and practice. While institutional synergy is present, it remains fragile and uneven, requiring continuous investment in relationship-building, capacity development, and mutual accountability. Recognizing the full value of local action, not as a supplement to state conservation but as its foundation, is key to achieving long-term resilience in socially and ecologically dynamic landscapes such as Mount Merapi.

In conclusion, biodiversity conservation in Mount Merapi's buffer zone is driven by traditional ecological knowledge, cultural values, and selective interaction with formal regulations. Communities in Tegalmulyo and Sidorejo show strong environmental awareness rooted in spiritual beliefs, ancestral ethics, and communal practices like *gotong royong*. Their participation is mainly expressed through restraint, rituals, and voluntary actions, with minimal reliance on formal programs. Informal groups and local initiatives sustain conservation despite limited resources. This study highlights the importance of internalized values and relational incentives in shaping conservation, contrasting with top-down, regulation-based approaches. It emphasizes that effective strategies must align with local knowledge and social contexts, particularly in ecologically fragile and disaster-prone regions. To enhance long-term impact, authorities should integrate these ethnoecological insights into participatory and co-management policies that empower local communities and foster resilience.

ACKNOWLEDGEMENTS

The authors wish to express their sincere gratitude to the communities of Tegalmulyo and Sidorejo Villages for their warm cooperation and invaluable contributions during the research process. We are especially thankful to local leaders, members of the Fire Care Community (MPA), Forest Police Partner Community (MMP), and the staff of Mount Merapi National Park (TNGM), Indonesia, for facilitating access and supporting field activities. We also acknowledge the enumerators and local facilitators whose cultural insight and dedication were essential to the success of the study. All interpretations and conclusions expressed herein remain the sole responsibility of the authors.

REFERENCES

Aji T, Sutriyono, Qudratullah MF, Gunawan WI. 2022. *Ficus* sp. lokal untuk konservasi air pada kawasan wisata Merapi di Desa Wisata Jaka Garong, Wonokerto, Turi, Sleman. Jurnal Bakti Saintek: Jurnal Pengabdian Masyarakat Bidang Sains dan Teknologi 6 (2): 59-65. DOI: 10.14421/Jbs.3973. [Indonesian]

Ajzen I, Fishbein M. 1980. Understanding Attitudes and Predicting Social Behavior. Prentice-Hall, Englewood Cliffs.

Badan Penanggulangan Bencana Daerah Klaten (BPBD Klaten). 2023. Kawasan Rawan Bencana. https://bpbd.klaten.go.id/. [Indonesian]

Berkes F. 2018. Sacred ecology. Routledge, London.

Brosius PJ, Tsing AL, Zerner C. 2005. Communities and conservation: histories and politics of community-based natural resource management. Rowman Altamira, Walnut Creek.

Cetas ER, Yasué M. 2017. A systematic review of motivational values and conservation success in and around protected areas. Conserv Biol 31 (1): 203-212. DOI: 10.1111/cobi.12770.

Cunningham AB. 2001. Applied Ethnobotany. People Wild Plant Use and Conservation. Earthscan Publications Ltd, London.

Dako S, Laya NK, Ischak NI, Fathan S, Datau F. 2021. Pengelolaan konservasi kelelawar dimasa pandemi Covid 19. Jurnal Abdi Insani 8 (2): 216-222. DOI: 10.29303/Abdiinsani.V8i2.401. [Indonesian]

Dewi PP, Prayitno G, Dinanti D. 2021. Karakteristik responden modal sosial masyarakat desa wisata Pujon Kidul. Plan Urban Reg Environ J 10 (4): 13-20. [Indonesian]

Djuwantoko, Purnomo DW, Laksono FY. 2005. Taman Nasional Gunung Merapi: Peluang dan tantangan realisasi taman nasional di Pulau Jawa bagian tengah. Seminar Nasional: Menuju Taman Nasional Gunung Lawu. [Indonesian]

Ernawati E, Azrai EP, Wibowo SS. 2018. Hubungan persepsi kearifan lokal dengan sikap konservasi masyarakat Desa Lencoh Kecamatan Selo di Taman Nasional Gunung Merapi Biosfer: Jurnal Pendidikan Biologi 9 (1) : 65-69. DOI: 10.21009/Biosferjpb.9-1.10. [Indonesian]

Fadilah A, Sulistijorini, Ariyanti NS. 2024. Potensi cadangan biji tumbuhan bawah pasca erupsi Merapi di Taman Nasional Gunung Merapi. Jurnal Sumberdaya Hayati 10 (1): 15-24. DOI: 10.29244/Jsdh.10.1.15-24. [Indonesian]

Farley J, Batker D, De la Torre I, Hudspeth T. 2010. Conserving mangrove ecosystems in the Philippines: transcending disciplinary and institutional borders. Environ Manag 45: 39-51. DOI: 10.1007/s00267-009-9379-4.

Fielding KS, Prober SM, Williams KJ, Dean AJ. 2023. Developing an indicator of community appreciation of biodiversity. Environ Sustain Indic 19: 100278. DOI: 10.1016/J.Indic.2023.100278.

Firnanda E, Harianto SP, Winarno GD, Wulandari C, Dewi BS, Fitriana YR. 2024. Persepsi masyarakat daerah penyangga terhadap fungsi ekologi Taman Nasional Bukit Barisan Selatan. Jurnal Hutan Tropis 12 (3): 422-436. DOI: 10.20527/jht.v12i3.20561. [Indonesian]

García-Roselló E, González-Dacosta J, Lobo JM. 2023. The biased distribution of existing information on biodiversity hinders its use in conservation, and we need an integrative approach to act urgently. Biol Conserv 283: 110118. DOI: 10.1016/j.biocon.2023.110118.

Gavin MC, McCarter J, Mead A, Berkes F, Stepp JR, Peterson D, Tang R. 2015. Defining biocultural approaches to conservation. Trends Ecol Evol 30 (3): 140-145. DOI: 10.1016/j.tree.2014.12.005.

Indah N, Ranteallo R, Nurul N, Abadi MAD, Nizam M. 2021. Analisa karakteristik responden terhadap pemahaman akan mitigasi bencana tsunami di Desa Maloku Pantai Losari. Riset Sains dan Teknologi

Kelautan 4 (1): 31-36. DOI: 10.62012/sensistek.v4i1.19394. [Indonesian]

International Society of Ethnobiology (ISE). 2006. International Society of Ethnobiology Code of Ethics (with 2008 additions). https://www.ethnobiology.net/code-of-ethics/.

Marhaento H, Faida LRW. 2015. Risiko kepunahan keanekaragaman hayati di taman nasional Gunung Merapi: Tinjauan spasial. Jurnal Ilmu Kehutanan 9 (2): 75-84. DOI: 10.22146/Jik.10189. [Indonesian]

McPhearson T, Raymond CM, Gulsrud N, Albert C, Coles N, Fagerholm N, Nagatsu M, Olafsson AS, Soininen N, Vierikko K. 2021. Radical changes are needed for transformations to a good anthropocene. Npj Urban Sustain 1: 5. DOI: 10.1038/s42949-021-00017-x.

Mulyaningsih T, Aryanti E, Muspiah A, Zamroni Y. 2020. Pemdampingan wanatani dalam konservasi ex-situ dua varietas *Gyrinops versteegii* di Desa Pusuk Lestari, Lombok Barat. Jurnal Abdi Insani 7 (2): 159-165. DOI: 10.29303/Abdiinsani.V7i2.321. [Indonesian]

Pretty J, Adams B, Berkes F, de Athayde SF, Dudley N, Hunn E, Maffi L, Milton K, Rapport D, Robbins P, Sterling E, Stolton S, Tsing A, Vintinner E, Pilgrim S. 2009. The intersections of biological diversity and cultural diversity: towards integration. Conserv Soc 7 (2): 100-112. DOI: 10.4103/0972-4923.58642.

Purwatiningsih SD. 2022. Pemahaman masyarakat sekitar hutan pada informasi konservasi hutan dalam memanfaatkan dan melestarikan hutan Taman Nasional Gunung Halimun Salak. IKRA-ITH HUMANIORA: Jurnal Sosial dan Humaniora 6 (1): 110-120. [Indonesian]

Qodriyatun SN. 2020. Peran dan partisipasi masyarakat dalam pengelolaan kawasan konservasi secara kolaboratif. Kajian 24 (1): 41-54. DOI: 10.22212/kajian.v24i1.1858. [Indonesian]

Setiawan A. 2022. Keanekaragaman hayati Indonesia: Masalah dan upaya konservasinya. Indones J Conserv 11 (1): 13-21. DOI: 10.15294/Ijc.V11i1.34532.

Setiawan E. 2024. Perlindungan hukum terhadap satwa burung di Taman Nasional Alas Purwo. Jurnal For Island 2 (1): 1-9. DOI: 10.33387/foris.v2i1.82. [Indonesian]

Susandi LA, Purnomo EP, Ridho A. 2021. Perlindungan Ekosistem Melalui Pemberdayaan Masyarakat Sekitar Taman Nasional Gunung Merapi Daerah Istimewa Yogyakarta. Jurnal Ilmiah Pariwisata 26 (1): 111-122. DOI: 10.30647/jip.v26i1.1376. [Indonesian]

Torimbanu AR, Saputra AF, Aulia AA, Utomo AN, Safira RN, Yasa A, Saensouk S, Setyawan AD. 2024. Ethnobotany of medicinal plants used by the Javanese community of Mount Merapi National Park, Central Java, Indonesia. Asian J Ethnobiol 7 (2): 130-143. DOI: 10.13057/asianjethnobiol/y070206.

Truong DD. 2022. Community awareness and participation in biodiversity conservation at Phong Nha-Ke Bang National Park, Vietnam. Biodiversitas 23 (1): 583-594. DOI: 10.13057/biodiv/d230163.

Turo DF, Medeghini L. 2021. How green possibilities can help in a future sustainable conservation of cultural heritage in Europe. Sustainability 13 (7): 3609. DOI: 10.3390/Su13073609.

Whittington D, Pagiola S. 2012. Using contingent valuation in the design of payments for environmental services mechanisms: A review and assessment. World Bank Res Observ 27 (2): 261-287. DOI: 10.1093/wbro/lks004.

Wijayati D, Rijanta R. 2020. Evaluasi zonasi Taman Nasional Gunung Merapi. Jurnal Litbang Sukowati: Media Penelitian dan Pengembangan 3 (2): 92-106. DOI: 10.32630/sukowati.v3i2.93. [Indonesian]

Yunita RR, Suryanti S, Latifah N. 2020. Biodiversitas Echinodermata pada ekosistem lamun di perairan Pulau Karimunjawa, Jepara. Jurnal Kelautan Tropis 23 (1): 47-56. DOI: 10.14710/jkt.v23i1.3384. [Indonesian]

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 8, Number 1, May 2025
Pages: 116-139

E-ISSN: 2580-4510
DOI: 10.13057/asianjethnobiol/y080110

Ethnobotanical assessment of edible plant diversity in homegarden of Semarang District, Central Java, Indonesia

LATHIFAH ANINDA KUSUMA[1], SAKINA ENOVA RAHMADHANI[1], ZAKA KHOIRUL ANAM[1], SUNNIA NADHIRA[2], AHMAD YASA[3], SURAPON SAENSOUK[4], AHMAD DWI SETYAWAN[1,5,♥]

[1]Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-663-375, ♥email: volatileoils@gmail.com
[2]Department of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia
[3]Faculty of Medicine, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia
[4]Plant and Invertebrate Taxonomy and Its Applications Unit Group, Walai Rukhavej Botanical Research Institute, Mahasarakham University. Kantarawichai District, Maha Sarakham, 44150, Thailand
[5]Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

Manuscript received: 26 November 2024. Revision accepted: 30 May 2025.

Abstract. *Kusuma LA, Rahmadhani SE, Anam ZK, Nadhira S, Yasa A, Saensouk S, Setyawan AD. 2025. Ethnobotanical assessment of edible plant diversity in homegarden of Semarang District, Central Java, Indonesia. Asian J Ethnobiol 8: 116-139.* This study aims to document and analyze the diversity, utilization patterns, and cultural importance of edible plants maintained in home gardens as a foundation for preserving local knowledge and supporting community-based biodiversity conservation. The research was conducted across three villages in Semarang District, Central Java, Indonesia, using semi-structured interviews with 120 respondents. A total of 64 plant species from 34 families were recorded. The findings reveal a dominance of herbs (46.88%) and shrubs (35.94%), with Zingiberaceae as the most represented family (12.5%). Plants were grouped into six main utilization categories: fruits (32.8%), spices (25%), vegetables and beverages (each 12.5%), medicines (12.5%), and staple foods (4.7%). The most frequently used parts were fruits (51.6%) and leaves (21.9%), followed by tubers, stems, seeds, flowers, and rhizomes. Key species such as *Zingiber officinale*, *Syzygium polyanthum*, and *Aloe barbadensis* showed high cultural significance, indicated by their Use Value (UV) of 0.03 each, Relative Frequency of Citation (RFC) values of 0.15, 0.14, and 0.13 respectively, and Index of Cultural Significance (ICS) scores of 112, 66, and 33. The Informant Consensus Factor (ICF) values were highest in the spice (0.71) and medicinal (0.65) categories, reflecting strong agreement among respondents regarding their ethnobotanical roles. Women, particularly housewives (35.83%), played a central role in selecting, using, and transmitting knowledge about plants. Preparation methods such as raw consumption (46.9%) and boiling (18.8%) reflected traditional practices, while most plants were intentionally cultivated (89.1%), highlighting a strong culture of home-based plant management. Despite pressures from modernization and land-use change, the integration of traditional knowledge into daily household practices continues to support food security, health resilience, and cultural continuity. The study emphasizes the need for revitalization efforts and community-based conservation strategies to sustain this living ethnobotanical heritage. These findings highlight the importance of integrating traditional plant knowledge into local development and biodiversity policies to enhance food security, public health, and community resilience.

Keywords: Biodiversity, cultural significance, edible plants, home gardens, medicinal plants, traditional knowledge

INTRODUCTION

Indonesia, recognized as one of the world's biodiversity hotspots, is home to more than 7,000 species of medicinal plants, emphasizing the critical role of biodiversity in fulfilling human health and subsistence needs. Historically, Indonesian communities have relied on wild and semi-cultivated plants for both nutritional and therapeutic purposes, showcasing a deep-rooted ethnobotanical tradition (Hamiyati et al. 2019). Among these are edible plants commonly found in or around residential areas, such as fruits, roots, and leaves, which contribute not only to daily diets but also to local healthcare practices (Ojelel et al. 2019; Nasution et al. 2023).

In recent decades, home gardens have emerged as multifunctional agroecosystems that integrate cultural practices, food production, and ecological sustainability. Defined as cultivated land surrounding residences (Sukenti et al. 2019), home gardens typically combine ornamental, culinary, and medicinal plant species, forming an integral part of household livelihoods. These gardens are often modest in size but rich in biodiversity, and may include decorative plots, herbal sections, or vertical planting systems (Novita et al. 2023).

The significance of home gardens transcends aesthetics and nutrition—they also serve as centers of cultural knowledge and informal conservation. Their composition reflects sociocultural factors, local preferences, education levels, and environmental conditions (Afon and Adebara 2022). Plants cultivated in these gardens fulfill multiple roles, including sources of food, medicine, fuel, dyes, construction materials, and even income through local market sales (Yang et al. 2020). What were once considered 'subsistence-only' plants are now gaining commercial and medicinal value, particularly due to their rich micronutrient profiles and recognized health benefits (Duguma 2020; Radha et al. 2021).

Globally, the World Health Organization (WHO) reports that 80% of rural populations in developing countries rely on traditional herbal medicine as their primary healthcare source (Hu et al. 2020). However, this increasing dependence—combined with urban expansion and shifting land use—has contributed to a loss of biodiversity, threatening many indigenous plant species (Yeşil et al. 2019). Thus, sustainable management of local plant resources is now a pressing need, especially within rapidly changing socioecological landscapes.

Central Java, Indonesia, represents a compelling case for homegarden ethnobotany. Despite ranking second nationally in food security with an index of 82.95% (Badan Pusat Pangan 2022), certain regions such as Semarang District face unequal distribution of food availability, which remains at 80.95%, slightly lower than affordability (89.50%) and utilization (87.93%) rates (Tono et al. 2022). These disparities highlight persistent vulnerabilities, particularly in rural and peri-urban communities. Moreover, the poverty rate in Central Java remains significant at 10.46%, affecting approximately 3.7 million people, although recent data shows slight improvement (BPS 2024). In this context, home gardens provide an accessible and low-cost strategy to improve household food security, diversify diets, and reinforce traditional knowledge systems. The presence of diverse edible plants—ranging from vegetables to spices and medicinal herbs—demonstrates their vital contribution to local resilience.

Traditional herbal practices such as the use of jamu (a blend of boiled plant ingredients) remain prevalent among Central Java's rural populations (Surya et al. 2023). This not only supports public health but also preserves cultural heritage. The integration of local ecological knowledge into dietary and healthcare systems aligns with Sustainable Development Goal 2: Zero Hunger, which emphasizes improved access to safe, nutritious food and enhanced sustainability in food production systems (Li and Siddique 2020; UNDP 2022).

Despite a growing number of ethnobotanical studies in Indonesia, there remains a notable gap in understanding how homegarden plant diversity supports both food sovereignty and health outcomes at the village level. In particular, few studies quantitatively analyze the cultural significance, frequency of use, and preparation methods of homegrown species. Moreover, existing literature often overlooks the nuanced interactions between socio-demographic factors, plant management strategies, and ecological variation across different rural communities.

This study addresses those gaps by exploring the diversity and use of edible and medicinal plants in home gardens across three villages in Semarang District—Karangjati, Lerep, and Susukan. These locations were selected for their contrasting ecological and sociocultural profiles. By employing ethnobotanical indices, this research aims to assess both the importance of individual plant species and the collective ethnobotanical knowledge of local communities. Ultimately, this study contributes to the broader discourse on sustainable food systems, biodiversity conservation, and community-based healthcare, providing evidence-based insights to inform policy and community engagement in rural Indonesia.

MATERIALS AND METHODS

Study area

This study was conducted in September 2024, in three selected villages within Semarang District, Central Java, Indonesia, i.e.: Karangjati (Bergas Sub-district), Lerep (West Ungaran Sub-district), and Susukan (East Ungaran Sub-district) (Figure 1). These villages were purposively chosen based on preliminary assessments indicating high homegarden activity and diverse plant utilization (Figure 2). Karangjati Village, is known for cultivating vegetables and fruits in compact residential plots. Lerep Village presents a more ornamental and multifunctional garden composition, while Susukan Village emphasizes edible and medicinal plants within a greener agroecological matrix.

These three locations exhibit a representative profile of rural homegarden management in Java, reflecting varying ecological conditions, cultural practices, and socio-economic characteristics. Such diversity allows for a comparative understanding of plant use patterns in different community settings. The local population is predominantly Javanese, renowned for its deep-rooted traditions in utilizing herbal remedies and edible plants for everyday health and nutritional needs.

Local ethnobotanical knowledge in the study area is influenced by geographic proximity to plant-rich ecosystems such as Mount Ungaran and Mount Merbabu, as well as cultural familiarity with jamu (traditional medicine) derived from locally available flora. Semarang District spans approximately 95,020 hectares, accounting for 2.92% of Central Java Province, and features altitudes ranging from 100 to 2,000 meters above sea level. This elevation gradient supports a wide range of plant biodiversity that is directly accessible to rural households.

Data collection procedures

This research employed a mixed-method approach combining qualitative and quantitative techniques, with data obtained through direct observation and structured interviews. A total of 120 respondents were purposively sampled across the three villages (40 from each location), ensuring representation of local knowledge holders, primarily women and elderly individuals who are often responsible for homegarden management.

Structured interviews focused on a comprehensive set of ethnobotanical parameters, including local plant names, categories of utilization (such as food, medicine, spices, beverages, staple foods, and ornamentals), parts of the plant used (e.g., leaves, roots, stems, fruits, flowers, seeds, rhizomes), methods of preparation (such as raw consumption, boiling, cooking, drying, juicing, or topical application), perceived efficacy based on traditional knowledge, frequency of use in daily or seasonal contexts, exclusivity of use within the household or community, cultivation status (cultivated vs. wild), sources of planting material, and transmission of knowledge across generations. Data collection was supported by visual documentation, field notes, and GPS mapping of garden locations. The researchers carried out all observations directly in the field, allowing for contextual understanding and firsthand data validation.

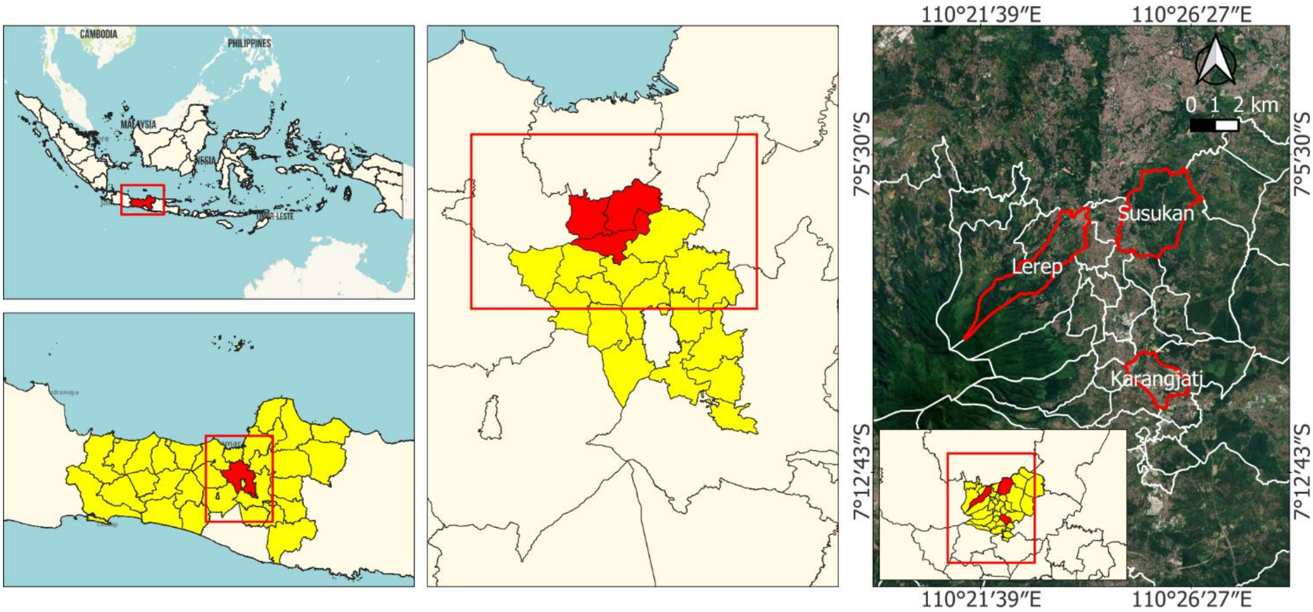


Figure 1. The study areas in Karangjati Village, Bergas Sub-district, Lerep Village, West Ungaran Sub-district, and Susukan Village, East Ungaran Sub-district, Semarang District, Central Java, Indonesia

Figure 2. Utilization of home gardens for cultivating edible plants in Semarang District, Central Java, Indonesia

To complement interview data, respondents were also asked to point out and describe the plant species currently cultivated or utilized in their home gardens. These in situ observations enabled the researchers to directly record species characteristics and usage contexts, while simultaneously verifying reported uses and terminologies. This integration of visual observation with respondent input strengthened the reliability of the data and ensured consistency between claimed practices and actual garden composition.

Plant identification was conducted through a combination of field-based morphological observation and vernacular knowledge obtained from key informants. Species were initially recognized by observing distinctive morphological traits such as leaf shape, stem and bark characteristics, flower and fruit structures, and growth habit. Local names provided by informants were carefully recorded and cross-checked to ensure consistency across villages. To validate scientific names and resolve synonymy, multiple botanical references were consulted, including Backer and van den Brink (1965) and Heyne (1987). When necessary, species identities were further verified through online taxonomic databases such as Plants of the World Online (https://powo.science.kew.org), The Plant List (http://www.theplantlist.org), and Tropicos (https://www.tropicos.org). This triangulated approach ensured that plant identifications were accurate, culturally contextualized, and taxonomically valid.

Table 1. Summary of ethnobotanical indices used in this study

Index	Formula	Purpose	Source
Relative Frequency Citation (RFC)	RFC = FC / N	Measures how frequently a species is mentioned by informants, indicating its familiarity or popularity.	Bano et al. (2014)
Use Value (UV)	UV = ∑Ui / N	Assesses the relative importance of a species based on the number of different uses cited by informants.	Zenderland et al. (2019)
Informant Consensus Factor (ICF)	ICF = (Nur – Nt) / (Nur – 1)	Evaluates the agreement among informants on plant use within specific categories (e.g., medicinal, food).	Pujinisa et al. (2023)
Index of Cultural Significance (ICS)	ICS = q × i × e	Integrates frequency, quality, and exclusivity of use to assess a plant's cultural relevance.	Helida et al. (2015)

Note: FC: number of informants citing a species, N: total number of informants, Ui: number of use-reports per species, Nur: total use-reports in a category, Nt: number of species used in that category, q, i, e: assigned scores for quality, intensity, and exclusivity of use

Quantitative ethnobotanical indices

To evaluate the cultural and practical relevance of each plant species, four ethnobotanical indices were used: Relative Frequency Citation (RFC), Use Value (UV), Informant Consensus Factor (ICF), and Index of Cultural Significance (ICS) (Table 1). These indices offer standardized methods to quantify traditional knowledge and plant importance within local communities. These indices were calculated to support comparative analysis and provide quantitative insights into plant use patterns and cultural values across the study sites.

Data analysis

Data analysis was conducted in two stages: classification and index computation. First, species data were categorized by family, growth habit, use category, parts used, and preparation methods. Next, each species was scored using the four ethnobotanical indices described above (RFC, UV, ICS, and ICF) to determine their prominence within the communities. Quantitative analysis was performed using Excel and SPSS for cross-tabulation, frequency analysis, and basic descriptive statistics.

To enhance interpretability of the index results, selected species were further visualized using heatmaps and radar (spider) charts. These graphical tools were used to depict the relative importance and multidimensional relevance of key species across use frequency, cultural significance, and versatility dimensions. Normalized index values were used in radar charts to facilitate comparison, while heatmaps highlighted prominent species patterns. Visualizations were generated using Python (v3.x) with Matplotlib and Seaborn libraries to ensure clarity and publication-ready quality.

In addition to quantitative analysis, qualitative insights were coded thematically based on field notes and open-ended interview responses. By integrating statistical metrics with ethnographic depth and visual exploration, this approach provided a nuanced understanding of how and why certain species are more culturally embedded and ecologically favored. The methodology offers a replicable framework for future community-based ethnobotanical research.

RESULTS AND DISCUSSION

Socio-demographic characteristics of respondents

The study involved 120 respondents equally distributed across Karangjati, Lerep, and Susukan Villages. The majority of respondents were women (53.33%), which can be attributed to their presence at home during the data collection period. Many of these women were housewives (35.83%), a group traditionally responsible for managing household resources, including home gardens. The availability of women and their active participation in garden-related activities position them as key holders and transmitters of local ethnobotanical knowledge. Their daily engagement with edible and medicinal plants enables them to maintain, apply, and pass on traditional practices to the next generation.

In terms of age, the dominant group was between 41-50 years old (35%), followed by 51-60 years (23.33%). These age groups represent a mature demographic, often serving as custodians of cultural traditions and having long-established experience in gardening and plant-based remedies. Meanwhile, only 2.5% of respondents were under 20, reflecting limited engagement among younger individuals in homegarden activities, which may signal the need for youth-focused education and awareness programs to sustain ethnobotanical heritage in the long term.

The educational background of respondents varied, with the largest proportion having completed senior high school (60%). This level of education suggests that the majority of participants had sufficient literacy to understand and apply basic agricultural, health, and ecological knowledge. Moreover, 10.83% had tertiary education, while a small percentage (2.5%) had no formal education at all. The combination of formal education and traditional experience contributes to a community-based knowledge system that blends scientific understanding with indigenous wisdom. Such integration is particularly valuable in the sustainable management and use of edible and medicinal plants.

Occupationally, besides housewives, the respondents included private employees (19.17%), traders (15%), farmers (8.33%), and a mix of civil servants, retirees, and others. While farmers directly engage in cultivation and plant care, housewives play a more holistic role in the daily application and preparation of plant-based resources. The occupational diversity suggests that ethnobotanical knowledge is not limited to agricultural professions but is shared across various segments of society. This finding aligns with research by Kujawska and Łuczaj (2015), which emphasizes the role of non-farming occupations, especially women in domestic roles, in maintaining and transmitting ecological knowledge.

The socio-demographic composition of the respondents reflects a community that is deeply embedded in plant-based practices, shaped by gender roles, age distribution, education levels, and livelihoods. These factors significantly influence the diversity of plant species found in home gardens, the methods of their use, and the sustainability of traditional practices in Semarang District (Table 2).

Diversity of edible plant species

This study recorded a total of 64 edible plant species, belonging to 52 genera and 34 families, indicating substantial biodiversity within home gardens in Semarang District. Among these, the Zingiberaceae family was the most represented with 8 species (12.5%), highlighting its central role in both culinary and traditional medicinal practices. Species such as *Z. officinale* (ginger), *Curcuma longa* (turmeric), and *Alpinia galanga* (galangal) are well known for their aromatic qualities and pharmacological benefits (Cao et al. 2020). Other highly represented families included Rutaceae with 6 species (9.4%), Myrtaceae with 5 species (7.8%), and Fabaceae with 4 species (6.3%) (Figure 3). These families are notable for their contributions to fruit, spice, and medicinal plant categories—such as *Citrus* spp. (Rutaceae), *Syzygium* spp. (Myrtaceae), and *Vigna unguiculata* (Fabaceae), which are commonly found in home gardens across all three study villages. Beyond these dominant families, most other families were represented by only one or two species, indicating a more selective or specialized use. This pattern suggests that while a few plant families provide multiple versatile species, the majority contribute unique or niche species that fulfill specific household needs, whether for nutrition, medicine, or beverages.

The most cited species across all sites was *Capsicum frutescens* (cayenne pepper), as reflected by its highest RFC value (0.20), highlighting its indispensable role in Javanese cooking and medicinal applications. Similarly, *Carica papaya* (RFC = 0.17) and *Aloe barbadensis* (aloe vera)(RFC = 0.13) were frequently encountered, valued not only for their edible parts but also for their therapeutic uses, such as digestive remedies and skin treatments (Table 3; Figure 4). These commonly found species across the three villages underscore their staple role in household diets and healthcare routines. Furthermore, the presence of multifunctional species such as *S. polyanthum* (Indonesian bay leaf) and *Z. officinale* illustrates the strong integration of food and health systems at the household level. These plants are consumed daily and simultaneously used to treat ailments like coughs, colds, and indigestion.

From an ecological perspective, the structural composition of these gardens—comprising herbs, shrubs, trees, lianas, and grasses—supports agroecosystem resilience. As described by Yang et al. (2020), such vertical layering not only optimizes space but also improves microclimatic conditions, enhances biodiversity, and contributes to pest regulation and soil stability.

Table 2. Socio-demographics of respondents

Variable		Total	Percentage (%)
Gender	Man	56	46.67
	Woman	64	53.33
Age	<20	3	2.50
	21-30	12	15.00
	31-40	19	15.83
	41-50	42	35.00
	51-60	28	23.33
	>60	16	13.33
Education	No education	3	2.50
	Elementary school	11	9.17
	Junior high school	21	17.50
	Senior high school	72	60.00
	University	13	10.83
Occupation	Private employee	23	19.17
	Trader	18	15.00
	Housewife	43	35.83
	Driver	1	0.83
	Farmer	10	8.33
	Retiree	2	1.67
	Self-employed	6	5.00
	Teacher	4	3.33
	Police officer	2	1.67
	Civil servant	4	3.33
	Student	5	4.17
	Not currently employed	2	1.67

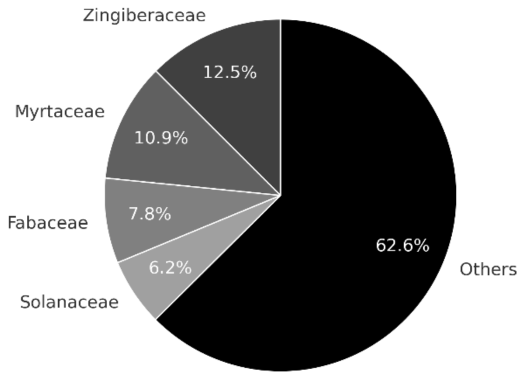


Figure 3. Distribution of major plant families contributing to total recorded species, with Zingiberaceae as the most represented

Table 3. List of edible plants in Semarang District, Central Java, Indonesia

Family & scientific name	Local name	Plant habits	Utilization categories	Parts used	Preparation	Growth status	Village			UV	RFC	ICS
							Karangjati	Lerep	Susukan			
Acanthaceae												
Strobilanthes crispa (L.) Blume	*Kejibeling*	Shrubs	Medicines	Leaf	Boiled	Planted			●	0.01	0.01	9
Acoraceae												
Acorus calamus L.	*Dlingo bengle*	Herbs	Medicines	Fruit	Pounded	Planted	●			0.01	0.01	12
Amaranthaceae												
Amaranthus caudatus L.	*Bayam*	Shrubs	Vegetables	Leaf	Cooked	Wild	●			0.01	0.03	8
Allium cepa L.	*Bawang merah*	Herbs	Spices	Tuber	Cooked	Planted	●		●	0.02	0.08	80
Mangifera foetida Lour.	*Bacang*	Tree	Fruits	Fruit	Raw	Planted			●	0.01	0.01	40
Mangifera indica L.	*Mangga*	Tree	Fruits	Fruit	Raw	Planted	●	●	●	0.01	0.13	24
Annonaceae												
Annona muricata L.	*Sirsak*	Tree	Fruits	Fruit	Raw	Wild	●	●	●	0.02	0.04	17
Araceae												
Colocasia esculenta (L.) Schott	*Talas*	Tree	Staple Foods	Tuber	Boiled	Planted			●	0.01	0.01	6
Arecaceae												
Cocos nucifera L.	*Kelapa*	Tree	Drinks	Fruit	Raw	Planted	●		●	0.02	0.03	40
Livistona R.Br.	*Palem livistona*	Tree	Fruits	Fruit	Raw	Planted	●			0.01	0.01	0,25
Asphodelaceae												
Aloe barbadensis	*Lidah buaya*	Herbs	Medicines	Trunk	Raw	Planted	●	●	●	0.03	0.13	9,25
Basellaceae												
Anredera cordifolia (Ten.) Steenis	*Binahong*	Liana	Medicines	Leaf	Raw	Planted		●		0.01	0.01	1,5
Cactaceae												
Hylocereus undatus	*Buah naga*	Liana	Fruits	Leaf	Raw	Planted	●			0.01	0.01	8
Caricaceae												
Carica papaya L.	*Pepaya*	Tree	Fruits	Fruit	Raw	Planted	●	●	●	0.02	0.17	56
Convolvulaceace												
Ipomoea batatas (L.) Lam.	*Ubi jalar ungu*	Tree	Staple Foods	Tuber	Boiled	Planted	●		●	0.01	0.02	50
Cucurbitaceae												
Cucurbita ficifolia	*Labu*	Herbs	Vegetables	Fruit	Cooked	Planted		●		0.01	0.02	16
Momordica charantia L.	*Pare*	Liana	Vegetables	Fruit	Cooked	Planted		●		0.01	0.03	24
Euphorbiaceae												
Manihot esculenta Crantz	*Singkong*	Tree	Staple Foods	Tuber	Boiled	Planted	●		●	0.01	0.06	20
Fabaceae												
Tamarindus indica L.	*Asam jawa*	Tree	Spices	Fruit	Raw	Planted			●	0.01	0.02	30
Vigna unguiculata (L.) Walp.	*Kacang panjang*	Shrubs	Fruits	Fruit	Cooked	Planted	●	●		0.01	0.03	32
Parkia speciosa Hassk.	*Petai*	Tree	Vegetables	Seed	Cooked	Planted	●			0.01	0.01	8
Clitoria ternatea	*Telang*	Shrubs	Drinks	Flower	Boiled	Planted			●	0.01	0.03	24

Iridaceae												
Eleutherine bulbosa (Mill.) Urb.	*Bawang dayak*	Herbs	Spices	Tuber	Cooked	Planted			●	0.01	0.01	24
Lamiaceae												
Ocimum basilicum L.	*Kemangi*	Herbs	Vegetables	Leaf	Raw	Planted		●	●	0.01	0,03	72
Orthosiphon aristatus (Blume) Miq.	*Kumis kucing*	Shrubs	Medicines	Leaf	Boiled	Planted			●	0.01	0.01	9
Lauraceae												
Persea americana Mill.	*Alpukat*	Tree	Fruits	Fruit	Raw	Planted	●	●	●	0.02	0.15	32
Lythraceae												
Punica granatum L.	*Delima*	Tree	Fruits	Fruit	Raw	Planted		●		0.01	0.03	8
Malvaceae												
Durio zibethinus Murray	*Durian*	Tree	Fruits	Fruit	Raw	Planted	●	●	●	0.01	0.09	8
Moraceae												
Artocarpus heterophyllus Lam.	*Nangka*	Tree	Fruits	Fruit	Raw	Planted	●	●	●	0.01	0.08	32
Moringaceae												
Moringa oleifera Lam.	*Kelor*	Tree	Drinks	Leaf	Boiled	Planted	●		●	0.01	0.02	12
Muntingiaceae												
Muntingia calabura L.	*Kersen*	Tree	Fruits	Fruit	Raw	Planted		●		0.01	0.02	8
Musaceae												
Musa ×paradisiaca L.	*Pisang raja*	Tree	Fruits	Fruit	Raw	Wild	●	●	●	0.01	0.12	32
Myrtaceae												
Syzygium aromaticum (L.) Merr. & L.M.Perry	*Cengkeh*	Shrubs	Spices	Flower	Cooked	Planted			●	0.01	0.01	24
Eugenia uniflora L.	*Dewandaru*	Tree	Medicines	Leaf	Boiled	Planted		●		0.01	0.01	1,5
Syzygium aqueum (Burm.fil.) Alston	*Jambu air*	Tree	Fruits	Fruit	Raw	Planted	●		●	0.01	0.04	24
Psidium guajava L.	*Jambu biji*	Shrubs	Medicines	Leaf	Raw	Planted	●	●	●	0.02	0.11	12
Syzygium polyanthum (Wight) Walp.	*Salam*	Tree	Spices	Leaf	Cooked	Wild	●	●	●	0.03	0.12	66
Oxalidaceae												
Averrhoa carambola L.	*Belimbing*	Tree	Fruits	Fruit	Raw	Planted	●			0.01	0.01	8
Averrhoa bilimbi L.	*Belimbing wuluh*	Tree	Vegetables	Fruit	Raw	Planted			●	0.01	0.01	12
Pandanaceae												
Pandanus Parkinson	*Pandan*	Shrubs	Spices	Leaf	Boiled	Planted	●	●	●	0.03	0.07	66
Phyllanthaceae												
Sauropus androgynus (L.) Merr.	*Katuk*	Shrubs	Drinks	Leaf	Boiled	Planted	●			0.01	0.01	12
Piperaceae												
Piper ornatum N.E.Br.	*Sirih merah*	Liana	Drinks	Leaf	Boiled	Planted	●		●	0.01	0.02	9
Poaceae												
Cymbopogon citratus (DC.) Stapf	*Serai*	Herbs	Spices	Trunk	Cooked	Planted		●	●	0.02	0.11	39
Saccharum officinarum L.	*Tebu*	Tree	Drinks	Trunk	Raw	Planted			●	0.01	0.01	6

Rutaceae												
Citrus maxima (Burm.) Merr.	*Jeruk bali*	Tree	Fruits	Fruit	Raw	Planted			●	0.01	0.01	4
Citrus sinensis (Mill.) Pers., 1806	*Jeruk manis*	Tree	Fruits	Fruit	Raw	Planted			●	0.01	0.04	16
Citrus ×aurantiifolia (Christm.) Swingle	*Jeruk nipis*	Tree	Spices	Leaf	Burned	Planted		●	●	0.03	0.09	74
Citrus hystrix DC.	*Jeruk purut*	Shrubs	Fruits	Fruit	Raw	Planted	●			0.01	0.01	8
Murraya koenigii (L.) Spreng.	*Korokeling*	Tree	Medicines	Leaf	Boiled	Planted		●		0.01	0.01	1,5
Citrus ×limon (L.) Osbeck	*Lemon*	Shrubs	Drinks	Fruit	Raw	Planted		●		0.01	0.03	12
Sapindaceae												
Dimocarpus longan Lour.	*Kelengkeng*	Tree	Fruits	Fruit	Raw	Planted	●		●	0.01	0.10	8
Nephelium lappaceum L.	*Rambutan*	Tree	Fruits	Fruit	Raw	Planted	●	●	●	0.01	0.17	8
Sapotaceae												
Manilkara zapota (L.) P.Royen	*Sawo manila*	Tree	Fruits	Fruit	Raw	Planted		●		0.01	0.02	8
Solanaceae												
Capsicum frutescens L.	*Cabai rawit*	Shrubs	Spices	Fruit	Cooked	Planted	●	●	●	0.02	0.20	64
Solanum torvum Sw.	*Takokak*	Shrubs	Drinks	Fruit	Raw	Planted			●	0.01	0.01	15
Solanum melongena L.	*Terong*	Shrubs	Vegetables	Fruit	Cooked	Planted	●	●	●	0.01	0.08	84
Solanum lycopersicum L.	*Tomat*	Herbs	Vegetables	Fruit	Cooked	Planted	●		●	0.01	0.03	40
Zingiberaceae												
Zingiber officinale Roscoe	*Jahe*	Herbs	Spices	Rhizome	Cooked	Planted	●	●	●	0.02	0.13	112
Elettaria cardamomum (L.) Maton	*Kapulaga sejati*	Herbs	Spices	Seed	Cooked	Planted			●	0.01	0.01	30
Kaempferia galanga L.	*Kencur*	Herbs	Spices	Rhizome	Cooked	Planted		●	●	0.02	0.04	48
Alpina galanga (L.) Willd.	*Lengkuas*	Herbs	Spices	Rhizome	Cooked	Wild	●	●	●	0.01	0.13	89
Curcuma longa L.	*Kunyit*	Herbs	Spices	Rhizome	Cooked	Wild	●		●	0.02	0.04	84
Curcuma aeruginosa Roxb.	*Temu ireng*	Herbs	Spices	Rhizome	Cooked	Wild	●			0.01	0.01	12
Curcuma zanthorrhiza Roxb.	*Temulawak*	Herbs	Spices	Rhizome	Cooked	Planted		●	●	0.02	0.05	36

Note: Village: 1. Karangjati Village, 2. Lerep Village, 3. Susukan Village. ●: present

Figure 4. Several species of edible plants in the homegarden of Semarang District, Central Java, Indonesia. A. *Aloe barbadensis,* B. *Carica papaya,* C. *Capsicum frutescens*

Comparison among villages

Species diversity varied significantly across the study sites, influenced by ecological factors, yard size, and cultural practices. Susukan Village had the highest species richness, with 45 species (40.18%), which can be attributed to its more spacious yards and greener agroecological surroundings that support diverse plant cultivation. This village also retained strong traditions in medicinal plant use and self-sufficiency.

Karangjati Village followed with 36 species (32.14%), exhibiting a balanced mix of fruits, vegetables, and spices. The community in Karangjati actively manages compact residential plots, often using container gardening and intercropping strategies. In contrast, Lerep Village recorded the lowest diversity with 31 species (27.68%), though residents maintained multifunctional gardens that blend ornamental and edible plants—indicative of a peri-urban setting with aesthetic preferences.

As shown in Figure 5, the relative proportion of species per village highlights Susukan's biodiversity advantage. While some species were widely shared among sites—such as *C. papaya*, *A. barbadensis*, and *C. frutescens*—distinct patterns of species preference emerged. Karangjati respondents favored *Psidium guajava* (guava), known for both its vitamin-rich fruit and medicinal leaves. In Lerep, *C. frutescens* was especially dominant, likely reflecting a cultural preference for spicy foods and spice cultivation. Meanwhile, in Susukan, *A. galanga* was cited more frequently, signifying its importance in cooking and traditional medicine.

These differences demonstrate that plant selection is not random but is shaped by a combination of cultural preference, ecological suitability, and household priorities. Such patterns reinforce the value of home gardens as culturally responsive agroecosystems and suggest the need for localized conservation strategies that respect ecological and sociocultural diversity across villages.

Diversity of plant habits

The diversity of plant habits observed in the home gardens of Semarang District reflects the community's capacity to manage spatial, ecological, and cultural factors in the use of plant resources. Based on the inventory of 64 species presented in Table 3 and visualized in Figure 6, five main growth forms were identified: herbs (32.8%), trees (32.8%), shrubs (26.6%), lianas (6.3%), and grasses (1.6%). This distribution reveals a relatively balanced representation between herbs and trees, with shrubs following closely, suggesting that residents maintain a structurally and functionally diverse homegarden ecosystem.

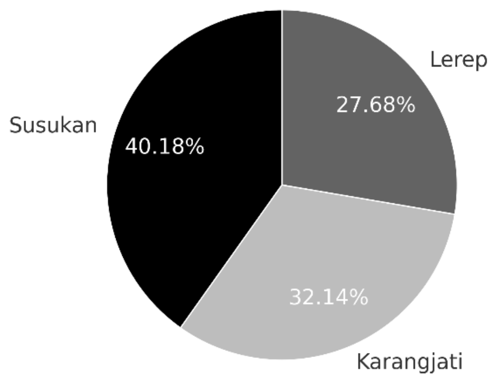


Figure 5. Species richness per village, showing the proportion of edible plant species found in Susukan, Karangjati, and Lerep

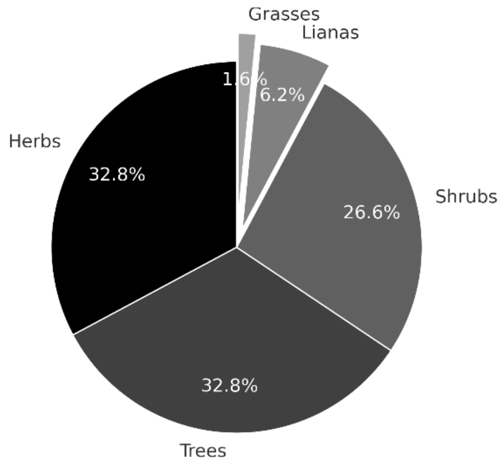


Figure 6. Habits of edible plants in Semarang District, Central Java, Indonesia

The prevalence of herbs in home gardens—accounting for approximately one-third of the recorded species—demonstrates their practicality and high cultural value. Herbs are favored due to their rapid growth, short life cycles, and versatility. Plants such as *Z. officinale*, *C. longa*, and *Kaempferia galanga* (aromatic ginger), all members of the Zingiberaceae family, are typically grown for their rhizomes, which serve culinary and medicinal purposes. Their small stature and ability to thrive in containers or narrow spaces make them ideal for intensive cultivation in limited landholdings, a feature common to semi-urban and peri-urban villages.

Trees, which also comprised 32.8% of the total, contribute to the vertical stratification of the garden and provide long-term benefits. Species like *Mangifera indica* (mango), *Persea americana* (avocado), and *C. papaya* are valued not only for their fruit yield but also for their role in creating microclimates, providing shade, and supporting soil conservation. While trees require more space and longer periods to mature, their inclusion signals a forward-looking gardening strategy aimed at sustainability and continual harvests.

Shrubs, contributing 26.6% of the total species, occupy an intermediate niche in both physical size and functional use. Examples include *P. guajava* (guava) and *C. frutescens* (cayenne pepper), which are commonly planted for their edible fruits and medicinal leaves. Shrubs are often preferred because they are relatively low-maintenance yet productive over several seasons. Their compact form allows them to coexist with other plant types, forming the mid-layer of garden vegetation.

Although less common, lianas such as *Momordica charantia* (bitter melon) and *Anredera cordifolia* (binahong) are functionally significant. These climbing plants are space-efficient because they utilize vertical structures like fences or stakes, thereby not competing for ground area. Lianas typically provide leafy vegetables or medicinal foliage, further enriching the garden's multifunctionality.

Grasses, represented minimally by species such as *C. citratus*, accounted for only 1.6% of the species documented. Despite their small number, grasses play specialized roles, such as acting as insect repellents or aromatic enhancers in traditional herbal teas and food.

The structural diversity of these plant habits reveals the ecological intelligence embedded in traditional homegarden design. Residents selectively cultivate species based on their practical value, ease of growth, and cultural relevance. Moreover, the habitus of each plant often correlates with the plant parts utilized (as shown in Figure 8), where herbs and shrubs dominate the categories of edible fruits, leaves, and rhizomes.

The distribution of plant habits in Semarang's home gardens is a reflection of local ecological adaptation and cultural preference. The coexistence of trees, shrubs, herbs, lianas, and grasses illustrates a multidimensional approach to land use that maximizes productivity, biodiversity, and household utility within the constraints of small-scale gardening.

Utilization categories

Edible plants identified in the home gardens were categorized into six major utilization groups: fruits (21 spp.; 32.8%), spices (16 spp.; 25%), vegetables (8 spp.; 12.5%), beverages (8 spp.; 12.5%), medicines (8 spp.; 12.5%), and staple foods (3 spp.; 4.7%), as illustrated in Figure 7. This classification helps to contextualize the multifunctional roles these plants play in household consumption and health maintenance.

Fruits were the most dominant category, reflecting their nutritional richness, economic value, and year-round demand. Species such as *C. papaya*, *M. indica*, and *P. guajava* are common due to their adaptability and high yield. These fruits not only serve as daily food sources but are also used in processed forms, such as juices and jams, contributing to household food security.

Spices came second in frequency, highlighting their central role in traditional cuisine. The Zingiberaceae family contributed significantly to this category, with widely cultivated species like *Z. officinale*, *C. longa*, and *K. galanga*. These spices are valued not only for flavor but also for their therapeutic benefits, such as anti-inflammatory and digestive properties.

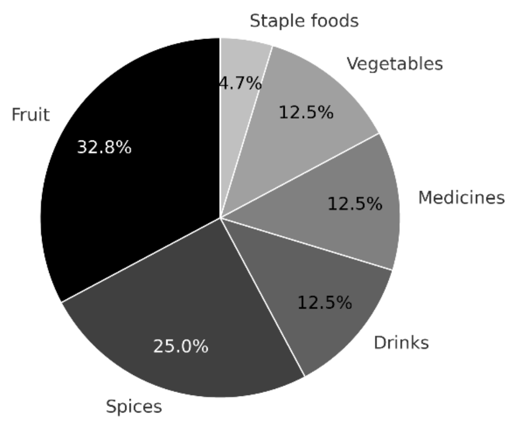


Figure 7. Utilization categories of edible plants in Semarang District, Central Java, Indonesia

The vegetables category included common leafy greens and fruit vegetables such as *Solanum melongena* (eggplant), *Amaranthus caudatus* (spinach), and *V. unguiculata* (long beans). These are essential daily food items and are often intercropped for efficient land use. Vegetables provide vitamins, minerals, and dietary fiber, contributing to the balanced nutrition of the household.

Beverage plants include *Clitoria ternatea* (butterfly pea), *Moringa oleifera*, and *C. citratus*. These species are commonly processed into herbal drinks or teas, providing refreshing and health-promoting beverages. For instance, butterfly pea flowers are known for their antioxidant properties and vibrant color, which is popular in traditional drinks.

The medicinal category comprised species like *P. guajava, A. barbadensis,* and *Strobilanthes crispa*, used to treat digestive issues, wounds, and infections. These plants underscore the community's reliance on traditional knowledge to address primary healthcare needs, especially in areas with limited access to modern medicine.

Lastly, staple foods, though few, included energy-rich crops like *Manihot esculenta* (cassava) and *Ipomoea batatas* (sweet potato). These are typically boiled or steamed and serve as carbohydrate sources, especially in food-insecure periods.

The categorization of edible plants by utilization highlights the diverse roles of homegarden species in meeting nutritional, cultural, and medicinal needs. The wide range of plant uses demonstrates not only ecological adaptability but also cultural richness and resilience in household food systems.

Parts used

The study revealed that the most frequently utilized plant part in the home gardens of Semarang District was the fruit (51.6%), followed by leaves (21.9%), and smaller percentages for tubers, stems, seeds, flowers, and rhizomes (Figure 8). This trend underscores the multifunctional role of plant species in daily life, reflecting their nutritional, medicinal, and cultural importance.

Fruits are highly favored due to their culinary versatility, immediate consumption, and nutritional value. Plants such as *C. papaya, M. indica* (mango), *C. frutescens* (cayenne pepper), and *P. guajava* (guava) are frequently consumed fresh, processed into beverages or jams, or used in traditional culinary preparations. Fruits often require minimal preparation and can be integrated into both main dishes and snacks, making them a practical and valuable part of the household diet.

Leaves, the second most utilized plant part, are often used in both food and medicine. For example, *P. guajava* leaves are widely used as a remedy for diarrhea due to their antibacterial properties. Similarly, *M. oleifera* leaves are rich in micronutrients and often prepared as herbal infusions or cooked as leafy greens. The frequent use of leaves indicates not only their availability but also the community's knowledge in processing and preserving them for health benefits.

Tubers from species like *M. esculenta* (cassava) and *I. batatas* (sweet potato) are essential carbohydrate sources. These are typically prepared by boiling or steaming and provide energy during food-scarce periods. Tubers have long storage durations, making them important for food security strategies.

Stems and rhizomes, particularly from aromatic and medicinal species such as *Z. officinale* and *C. longa*, are commonly used as both seasoning and herbal medicine. These parts are typically sliced, pounded, or boiled to extract their active compounds. The strong association of rhizomes with traditional remedies underscores the role of home gardens as a primary source of household healthcare.

Seeds, such as those from *Parkia speciosa* (petai) and *Elettaria cardamomum* (cardamom), are used either as vegetables or spices. Flowers, including those of *C. ternatea*, are prized for their antioxidant-rich pigments, often used in beverages and as natural food coloring.

The pattern of plant part utilization also correlates with the habitus of plants described in earlier sections. Herbs and shrubs dominate the gardens, and their parts—leaves, rhizomes, and fruits—are more accessible for daily use. Figure 8 visually presents this distribution and confirms the emphasis on parts that are easy to harvest and integrate into food or medicine, a reflection of both practicality and cultural knowledge.

The wide variety of plant parts utilized in the study area reflects a complex, adaptive knowledge system that maximizes the use of each plant. This diversity in use not only enhances nutritional and medicinal coverage but also reinforces the importance of biodiversity in supporting sustainable household resilience.

Preparation method

The preparation methods of edible plants in Semarang District demonstrate a strong relationship between traditional knowledge and practical household needs. Based on the findings illustrated in Figure 9, the most common method of preparation is raw consumption (46.9%), followed by cooking (31.3%), boiling (18.8%), and pounding and burning (1.6% each). These diverse methods reflect both the characteristics of the plants themselves and the embedded culinary and medicinal practices in the local culture.

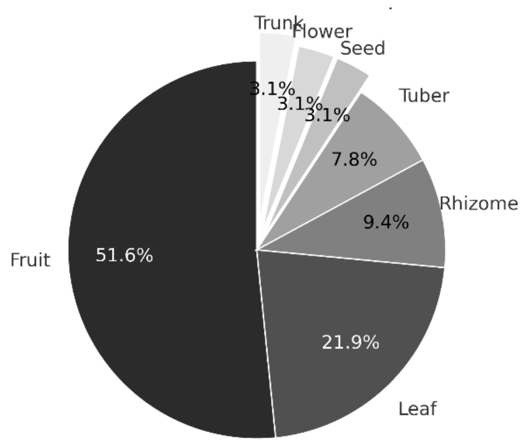


Figure 8. Plant part utilization of edible plants in Semarang District, Central Java, Indonesia

Raw consumption is predominantly associated with fruits, such as *C. papaya*, *P. guajava*, *Musa ×paradisiaca* (banana), and *Citrus* spp., which are often eaten fresh due to their palatable taste, high vitamin content, and minimal processing needs. Consuming fruits raw helps preserve heat-sensitive nutrients such as vitamin C, polyphenols, and antioxidants, contributing to the local diet's nutritional adequacy.

Cooking is the second most utilized preparation method, particularly for vegetables and spices. *C. frutescens* (cayenne pepper), *S. melongena*, *V. unguiculata* (long beans), and *A. caudatus.* are typically sautéed or stir-fried as part of daily meals. Cooking enhances flavor, softens texture, and in some cases improves the bioavailability of certain nutrients. Furthermore, cooking is a common method for spices like *Z. officinale* and *C. longa*, which are used as seasoning agents or in traditional dishes such as curries and herbal concoctions.

Boiling is a preferred method for medicinal and beverage plants. *Moringa oleifera* leaves, *P. guajava* leaves, and *S. crispa* are often boiled to extract their bioactive compounds. This method is common in preparing jamu—a traditional Indonesian herbal drink—and other decoctions. Boiling not only sterilizes the ingredients but also allows for the release of medicinal compounds into the water, increasing the therapeutic efficacy of the plants.

Less commonly used methods include pounding and burning (1.6% each). Pounding is primarily employed in preparing rhizomes and roots, such as *Curcuma* spp. and *K. galanga*, for cooking or topical application in traditional medicine. Burning is occasionally used for aromatic leaves or to soften tough plant parts, such as *Citrus ×aurantiifolia* (lime) leaves, prior to culinary use.

The variety of preparation techniques highlights the community's adaptive strategies to optimize plant utility. These methods are not only influenced by taste and usability but also by traditional medicinal practices passed down through generations. They form part of a functional ethnobotanical system that integrates health, nutrition, and cultural heritage.

The preparation methods reflect both pragmatism and cultural richness. As shown in Figure 9, the dominance of raw and cooked preparations underlines a preference for simplicity and efficiency, while the presence of boiling, pounding, and burning shows the depth of traditional processing methods used to enhance the benefits of local edible plants.

Source of plant material

The origin or source of plant material in Semarang District's home gardens reflects a strong culture of plant domestication and active management. Based on field data, 89.1% of the edible plant species were intentionally cultivated, while only 10.9% were sourced from the wild, as shown in Figure 10. This distribution highlights the central role of human agency in shaping plant diversity and sustaining ethnobotanical practices.

The dominance of cultivated species signifies a deliberate effort by the local communities to select, propagate, and manage plants that meet daily needs for food, health, and household economy. Cultivated plants such as *C. papaya*, *C. frutescens*, *Z. officinale*, and *P. guajava* are grown in designated plots or containers, often near kitchen areas or along home borders. These plants are easy to access and integrate into daily meals and remedies, which enhances their practical utility.

Cultivation practices observed include seed saving, vegetative propagation (e.g., rhizome division in *C. longa* or *K. galanga*), and selective planting based on household preferences. This indicates not only horticultural knowledge but also a deep cultural relationship with plant resources. Many families have developed their own varietal selections and plant arrangements, passed down through generations.

In contrast, the wild-sourced species (10.9%) play a more complementary role. These plants typically grow spontaneously in less-managed garden corners, along fences, or in nearby vacant land. Species like *S. crispa* and *A. cordifolia* are notable examples. These wild species are often collected as needed for specific medicinal uses or as emergency food sources, particularly in times of economic hardship or seasonal shortages.

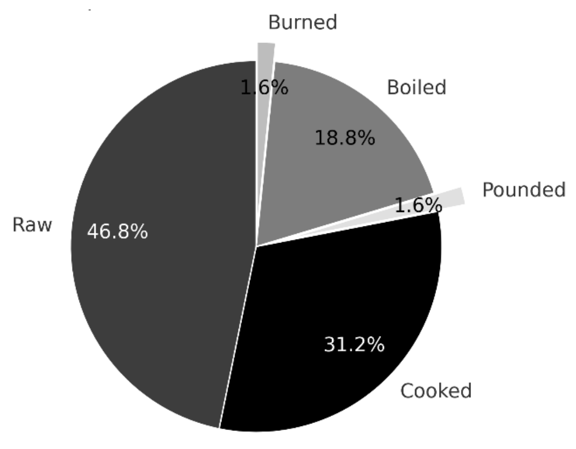


Figure 9. Preparation methods of edible plants in Semarang District, Central Java, Indonesia

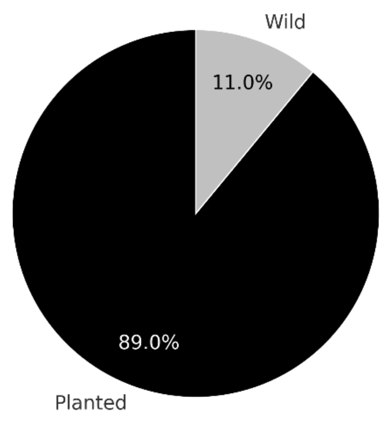


Figure 10. Source of edible plants in Semarang District, Central Java, Indonesia

The presence of both cultivated and wild plants points to a semi-domesticated agroecosystem, where biodiversity is maintained through a combination of intentional cultivation and ecological tolerance. It also suggests a continuum of human interaction, from actively grown crops to opportunistic harvesting of self-propagating species.

Figure 10 provides a visual representation of this proportion, emphasizing how cultivation is the predominant strategy for managing edible plant resources in the study area. The relatively small proportion of wild plants does not diminish their importance, as they contribute unique nutritional or medicinal properties not commonly found in cultivated species.

The pattern of plant sourcing in Semarang's home gardens underscores a well-established tradition of cultivation, supported by selective wild harvesting. This balance reflects a resilient ethnobotanical system that merges agricultural practice with ecological awareness and cultural continuity.

Quantitative ethnobotanical indices

Prior to the presentation of quantitative analyses, it is essential to recognize that the observed qualitative patterns—ranging from species diversity and parts utilized to preparation methods and plant sourcing—serve as a foundational context for assessing the functional integration of these species in everyday life. To reinforce and quantify their ethnobotanical relevance, this study employs three established indices: the Use Value (UV), Relative Frequency of Citation (RFC), and the Index of Cultural Significance (ICS). These analytical tools offer systematic insights into the degree of importance assigned to each plant species by the community, highlighting their roles in cultural practices, economic activities, and traditional healthcare systems. In Semarang's home gardens underscores a well-established tradition of cultivation, supported by selective wild harvesting. This balance reflects a resilient ethnobotanical system that merges agricultural practice with ecological awareness and cultural continuity.

Use Value (UV)

Use Value (UV) is a quantitative ethnobotanical index that reflects the relative importance of plant species based on the number of distinct uses reported by informants. A high UV indicates that a plant is not only well known but also utilized in multiple ways, underscoring its functional versatility and cultural integration within the community. In the present study, UV values derived from 64 plant species revealed considerable variation, ranging from 0.01 to 0.03 (Table 3).

Species with the highest UV scores include *Z. officinale*, *S. polyanthum*, and *A. barbadensis*, each with a UV of 0.03. These plants are widely employed across different contexts—culinary, medicinal, and even ritual—highlighting their multifunctionality. *Z. officinale,* for instance, is commonly used in cooking, as a base for herbal drinks (jamu), and in topical preparations for colds and muscle pain. Similarly, *S. polyanthum* is essential in Javanese cuisine and also cited for its antihypertensive properties. *A. barbadensis* (aloe vera) is another culturally salient species, widely cultivated for its use in skin treatment, digestion, and beverages.

Moderate UV values (0.02) were recorded for other frequently mentioned species such as *C. frutescens*, *C. papaya*, *C. longa*, *K. galanga*, and *C. citratus*. These plants are often cited for both culinary and medicinal uses, indicating their dual significance in food and health systems. Despite *C. frutescens* showing the highest RFC in the dataset, its UV was relatively lower than expected, suggesting its use is consistent but limited in variety—mainly as a spice.

At the lower end of the spectrum, species like *S. crispa*, *Colocasia esculenta* (taro), and *A. caudatus* had UVs of only 0.01. These plants may serve more specialized or occasional functions, or be known and used by fewer individuals. Their low UV values may also reflect a decline in traditional knowledge transmission or limited accessibility.

These findings demonstrate that UV is not necessarily correlated with popularity or frequency of mention (as captured by RFC), but rather with the diversity of applications. By identifying plants with both high and low UV scores, this analysis provides insights into which species are central to everyday life and which may be at risk of underutilization. Such information is vital for ethnobotanical conservation, local food security planning, and revitalization of culturally important plant species (Table 3).

Relative Frequency of Citation (RFC)

The Relative Frequency of Citation (RFC) is an ethnobotanical index used to determine the popularity or commonness of a species based on how often it is mentioned by informants, regardless of its number of uses. It is calculated by dividing the number of informants who cited a species by the total number of informants surveyed. In this study, RFC values ranged up to 0.20, with the highest RFC recorded for *C. frutescens*, followed closely by *C. papaya* (RFC = 0.17) and *Nephelium lappaceum* (RFC = 0.17) (Table 2).

The high RFC of *C. frutescens*, commonly known as cayenne pepper, indicates its ubiquity and essential role in daily culinary practices. This species is a staple ingredient in Indonesian cuisine and is used across various households regardless of socio-economic status. In addition to its flavor-enhancing properties, *C. frutescens* is also appreciated for its potential medicinal benefits, including promoting circulation and relieving congestion.

Carica papaya, another widely cited species, is valued for its nutritional and therapeutic benefits. Its ripe fruit is consumed fresh or processed, while the unripe fruit is used in traditional dishes such as *oseng-oseng* or *sayur asem*. Moreover, the latex and leaves are employed in traditional medicine to treat digestive issues and as natural dewormers, enhancing the species' utility and relevance in both food and health contexts.

Nephelium lappaceum (rambutan), a seasonal fruit tree, holds high cultural and economic importance. Although its harvest is limited to certain months of the year, its sweet and appealing flavor, combined with its role as a cash crop during harvest season, contributes to its frequent mention. Its RFC value underscores how even seasonal species can maintain high cultural significance when they are deeply embedded in community practices.

Species with lower RFC values may be underutilized or specialized in use, such as those used primarily for medicinal or ornamental purposes. The variation in RFC values provides insight into local familiarity and accessibility, offering a lens to assess which species are culturally ingrained and widely used across the population.

RFC analysis emphasizes the importance of certain species not only due to their multiplicity of uses but also due to their frequency of interaction with the community. High RFC values signal that these plants are indispensable in daily life, playing consistent roles in nutrition, health, and even economic livelihoods.

Index of Cultural Significance (ICS)

The Index of Cultural Significance (ICS) is a comprehensive ethnobotanical metric that combines three dimensions of a plant's role in society: frequency of use, variety of use, and exclusivity or uniqueness of use. This index goes beyond frequency alone and accounts for how deeply a plant is embedded in cultural traditions, rituals, and daily functions. The ICS values recorded in this study highlight the plants most central to the cultural identity and daily practices of households in Semarang District.

Among the species assessed, the highest ICS score was recorded for *Z. officinale* (ICS = 112), followed by *S. polyanthum* (ICS = 66) and *C. citratus* (ICS = 39) (Table 2). These three species reflect not only high use frequency but also diverse applications and a strong connection to cultural heritage.

Zingiber officinale stands out as a culturally vital plant, used extensively in cooking, traditional medicine, and ceremonial practices. It is a core component in many Javanese herbal drinks (*jamu*), valued for its warming and anti-inflammatory properties. Its role extends beyond the household to communal contexts such as family health traditions and festive food preparation, which justifies its exceptional ICS score. The inclusion of ginger in sacred rituals and its recognized efficacy in healing affirms its symbolic and functional significance.

Syzygium polyanthum is another plant with multifaceted cultural relevance. It is used almost daily in cooking, especially in traditional stews and curries, and has recognized health applications for lowering cholesterol and managing blood pressure. The widespread use of its leaves in domestic kitchens reflects its embeddedness in local dietary culture. Additionally, its cultivation near the house and ease of access further enhance its cultural presence.

Cymbopogon citratus also demonstrates strong cultural ties through its role in both culinary and medicinal traditions. It is commonly used in soups, teas, and aromatic preparations and is known for its calming and anti-microbial properties. Its scent and flavor contribute not only to food preparation but also to a sense of cultural identity associated with traditional home remedies.

Plants with high ICS scores are often those that serve multiple roles—nutritional, medicinal, and symbolic—and are frequently used in both ordinary and special occasions. The ICS thus helps distinguish plants that are not merely popular but are integral to the lived experiences and values of the community.

On the other hand, species with low ICS values may either be underrecognized or serve highly specialized purposes that are not widely known or practiced. These findings can inform conservation and education strategies, emphasizing the protection and promotion of culturally significant plants.

The ICS analysis provides a nuanced understanding of plant importance, highlighting not only what is frequently used but also what is most culturally embedded and symbolically meaningful. It reveals the depth of traditional knowledge systems and helps prioritize species that should be conserved, promoted, or reintroduced into community practices.

Visual Representation of UV, RFC, and ICS Values

To complement the numerical analysis of ethnobotanical indices, visual representations were created to highlight the comparative cultural importance of selected plant species. Figures 11 and 12 illustrate the distribution of *Use Value (UV)*, *Relative Frequency of Citation (RFC)*, and *Index of Cultural Significance (ICS)* for six dominant species frequently cited by respondents across the three study villages: *Z. officinale, S. polyanthum*, *A. barbadensis*, *C. frutescens*, *C. papaya*, and *N. lappaceum*.

As shown in Figure 11 (heatmap), *Z. officinale* stood out with the highest ICS value, signifying its exceptional cultural importance. This plant is widely used not only in daily cooking but also in traditional medicine and ritual practices, such as postpartum care and body warming therapies. Its consistently high UV and RFC values further confirm its functional and symbolic centrality in Javanese households. Similarly, *S. polyanthum*, a native bay leaf used in almost every savory dish, also scored well across all indices, reflecting its indispensable culinary and medicinal role.

Capsicum frutescens recorded the highest RFC, indicating its widespread and near-universal use, especially in spicy food preparation. However, its UV and ICS values were relatively moderate, suggesting that while it is frequently used, its perceived cultural or symbolic significance may be less than that of rhizomatous or ritual-associated plants. *A. barbadensis* (aloe vera) showed a balanced profile, used widely for skin care, burns, and herbal drinks, and often planted for both ornamental and medicinal purposes. *C. papaya* and *N. lappaceum* had lower UV and ICS values, possibly due to their limited medicinal applications or more seasonal availability.

Figure 12 (radar chart) presents these relationships more dynamically by plotting normalized values across the three indices. The chart reveals distinct functional profiles for each species. For example, *Z. officinale* forms a sharp peak in ICS, reflecting high symbolic and practical value, while *C. frutescens* spikes in RFC, emphasizing its prevalence in daily routines. Meanwhile, species like *A. barbadensis* and *S. polyanthum* demonstrate a well-rounded ethnobotanical profile, scoring relatively evenly across all metrics. This balanced pattern suggests multifunctionality and strong retention in household knowledge systems.

The combination of heatmap and radar visualization provides an intuitive understanding of how species are perceived and utilized in daily life. While numerical values alone may not capture cultural nuance, visualizations help reveal the multidimensional roles that certain species play—whether as staple flavoring agents, household remedies, or culturally symbolic plants. These tools also help identify priority species for further conservation or integration into community food and health programs. For instance, species with both high ICS and RFC scores, such as *Z. officinale* and *S. polyanthum*, represent ideal candidates for targeted propagation, policy support, and public health messaging due to their proven social and ecological value.

Overall, these visual summaries enrich the ethnobotanical analysis by bridging quantitative data with intuitive, comparative insights into plant significance across the study villages.

Informant Consensus Factor (ICF)

The Informant Consensus Factor (ICF) is a valuable ethnobotanical index used to evaluate the degree of agreement among informants regarding the use of plant species within specific categories. A high ICF value suggests strong cultural coherence and shared knowledge, whereas a low ICF indicates dispersed or individualized practices and possibly declining traditional relevance.

As shown in Table 4, the spices category exhibited the highest ICF value (0.71), reflecting strong consensus among respondents about the species commonly used for culinary and medicinal purposes. Key plants in this group include *Z. officinale*, *C. longa*, *S. polyanthum*, and *C. citratus*. These species are deeply embedded in daily cooking and traditional herbal preparations (*jamu*), making them culturally prominent and widely recognized across all study villages.

The medicinal category followed with an ICF value of 0.65, suggesting substantial agreement among respondents on the use of plants for health-related purposes. Species such as *A. barbadensis*, and *P. guajava*were frequently mentioned for treating digestive problems, wounds, fever, and general wellness. The strong consensus in this category affirms the continued reliance on plant-based healthcare, especially among older and female informants.

By contrast, fruits (0.52) and vegetables (0.48) showed moderate levels of informant agreement. These lower values likely stem from greater variability in household preferences, seasonal availability, and ecological differences between the villages. While species like *C. papaya* and *P. guajava* were consistently reported, other fruit trees and leafy greens showed more localized or idiosyncratic use, which reduced cross-community uniformity.

The beverages category had a lower ICF value of 0.41, indicating more individualized or experimental use of species such as *C. ternatea*, *C. citratus*, and *M. oleifera* in household herbal drinks. The variation in preparation styles, combinations, and consumption frequency suggests a blend of traditional knowledge and recent innovation, influenced by modern wellness trends.

Notably, the staple foods category had the lowest ICF value at 0.29, highlighting a weak consensus among respondents. This finding reflects a broader shift in consumption patterns and land-use priorities. Traditional staples such as *M. esculenta* (cassava), *I. batatas* (sweet potato), and *C. esculenta* were only sporadically cited. Several factors contribute to this trend: the widespread availability and preference for rice, reduced cultivation space in home gardens, and the labor-intensive nature of staple food production. Moreover, younger generations appear less familiar with traditional preparation techniques, relying instead on market-based or processed foods.

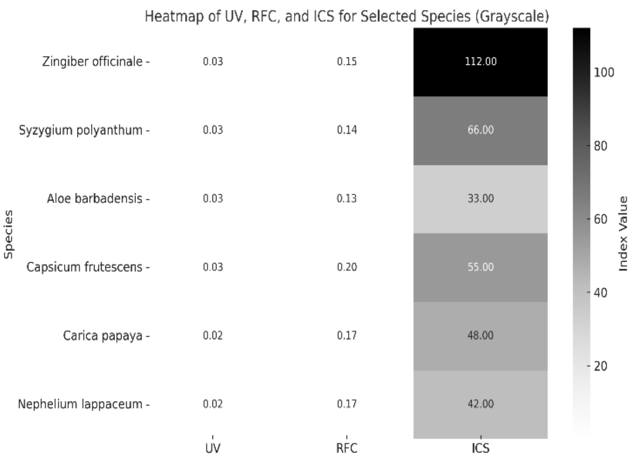


Figure 11. Heatmap of Use Value (UV), Relative Frequency of Citation (RFC), and Index of Cultural Significance (ICS) for six culturally important plant species recorded in home gardens of Semarang District. Higher values indicate greater local relevance or frequency of use

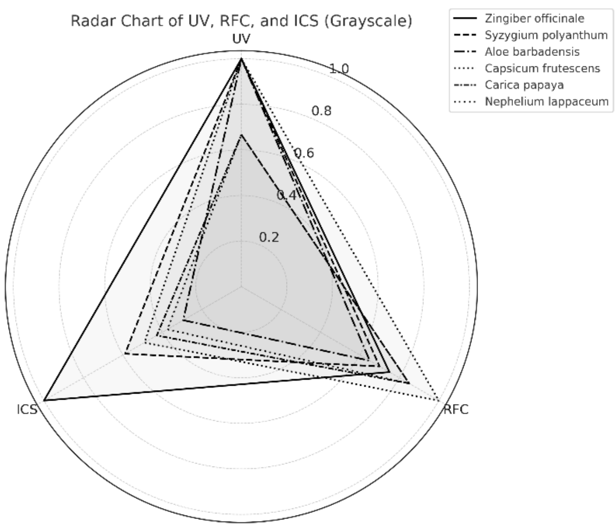


Figure 12. Radar chart displaying normalized UV, RFC, and ICS values for six dominant plant species. The diagram highlights the relative ethnobotanical prominence and functional versatility of each species across multiple cultural dimensions

The low ICF value in this category may thus represent not only fragmented ethnobotanical knowledge but also a gradual cultural and functional displacement of local carbohydrate sources. This is consistent with previous findings in rural Java, where food modernization and urbanization have led to the marginalization of indigenous staples (Cahyaningsih et al. 2021; Santoso et al. 2023).

In summary, ICF values reveal that shared knowledge is highest in categories that remain functionally relevant and culturally central, such as spices and medicinal plants. Meanwhile, staple food plants—once foundational to household resilience—are increasingly neglected. This underscores the need for targeted revitalization efforts, including educational programs, homegarden incentives, and seed-saving initiatives to restore the role of traditional staples in household food systems.

Discussion

Integration of ethnobotanical knowledge into household practices

The integration of ethnobotanical knowledge into daily household practices in Semarang District reveals a deeply rooted cultural system in which plants are more than just resources—they are essential elements of identity, sustenance, and wellbeing. The findings of this study demonstrate that edible and medicinal plants in home gardens are not passively grown or consumed, but are actively selected, maintained, and utilized based on generations of traditional ecological knowledge. This knowledge is embedded in routines such as food preparation, herbal medicine, and garden management, indicating that ethnobotanical practices are both dynamic and adaptive (Albuquerque et al. 2019; Novita et al. 2023).

The demographic profile of respondents—dominated by middle-aged women with senior high school education—plays a crucial role in the continuity of such practices. Women, particularly housewives, serve as the primary custodians of home gardens and traditional plant knowledge, responsible for selecting species, managing cultivation, and transmitting knowledge across generations. Similar observations have been made in other ethnobotanical studies, where women are regarded as key holders of ecological knowledge in domestic spaces (Kujawska and Łuczaj 2015; Duguma 2020). This aligns with the role of women in rural Indonesian communities who manage household health and nutrition through plant-based resources (Hamiyati et al. 2022).

The dominant plant species identified—*Z. officinale, S. polyanthum,* and *A. barbadensis*—are not only valued for their high utility (UV) and cultural significance (ICS), but also function as culturally embedded staples in both culinary and medicinal contexts. Their multifunctionality is evident in how they are incorporated into herbal remedies (*jamu*), traditional cuisine, and seasonal rituals. This confirms findings from studies in other regions of Southeast Asia, where multifunctional plants tend to be the most conserved and frequently used (Hu et al. 2020; Cahyaningsih et al. 2021a).

Table 4. Categories of disease in the study area and the Informant Consensus Factor (ICF)

Classification	Disease details	Species used	ICF
Infectious and certain parasites	Diarrhea, ringworm, worms, malaria, dysentery, leprosy	*Psidium guajava, Eugenia uniflora*	0.67
Circulatory	Hypertension	*Orthosiphon aristatus, Syzygium polyanthum, Annona muricata*	0.00
Digestion	Constipation, stomach ulcers, canker sores, stomach pain, toothache, indigestion, cholesterol	*Piper ornatum, Syzygium polyanthum, Annona muricata*	0.33
Eyes and adnexa	Inflammation of the eyes, eye pain	*Moringa oleifera*	1.00
Genitourinary	Menstrual pain, urination, nephrolithiasis	*Strobilanthes crispa, Carica papaya*	0.67
Respiratory	Asthma, influenza, sore throat	*Zingiber officinale*	1.00
Subcutaneous skin and tissue	Itching, swelling, ulcers, allergies	*Aloe barbadensis*	1.00
Endocrine, nutrients, and metabolism	Diabetes	*Piper ornatum, Cymbopogon citratus, Annona muricata*	0.33
Symptoms and signs involving the circulatory and respiratory systems	Cough, nosebleeds	*Piper ornatum, Zingiber officinale*	0.67
Clinical and laboratory disorders	Fever, runny nose, flatulence, acne, jaundice, headache, pain	*Acorus calamus, Zingiber officinale, Cymbopogon citratus, Curcuma longa*	0.00
Musculoskeletal and connective tissue	Gout arthritis, rheumatism	*Moringa oleifera, Annona muricata, Solanum torvum, Orthosiphon aristatus*	0.00
Symptoms and signs of subcutaneous skin and tissue	Burnt skin	*Aloe barbadensis*	1.00
Mental and behavioral	Appetite	*Curcuma zanthorrhiza*	1.00
Injuries, poisoning, and other consequences of external causes	Wounds, snack poisoning	*Aloe barbadensis, Anredera cordifolia*	0.67

Preparation methods—such as raw consumption, boiling, and cooking—also reflect culturally rooted practices that aim to preserve or enhance the efficacy and flavor of the plants (Andersen et al. 2017). As shown in Figure 9, raw and cooked forms dominate, which corresponds with traditional foodways documented in Java and other parts of Indonesia (Surya et al. 2023). These methods are often guided by empirical understanding of the plants' bioactive compounds, though such knowledge is largely transmitted orally and informally.

The dominance of cultivated plants (89.1%) over wild species (10.9%)—as shown in Figure 10—reflects a system of domesticated sustainability in which home gardens act as curated reservoirs of plant biodiversity (Feni et al. 2022). While wild harvesting still plays a role, particularly for medicinal uses, the strong preference for cultivated species suggests a deliberate effort to manage plant resources efficiently and sustainably, a pattern also reported by Cao et al. (2020) in rural China.

Visualizing plant importance and cultural roles

The inclusion of visual representations of ethnobotanical indices in this study (Figures 11 and 12) provides deeper analytical insight beyond numerical tabulation. The heatmap (Figure 11) reveals that *Z. officinale* stands out for its high ICS, supported by elevated UV and RFC values. This pattern aligns with its role as a culinary-medicinal keystone species in Javanese culture. Similarly, *S. polyanthum* and *A. barbadensis* exhibit strong balance across all three indices, highlighting their well-integrated utility and symbolic roles.

Radar charts (Figure 12) further illustrate the multidimensional relevance of species. While *C. frutescens* spikes in RFC due to its ubiquity in daily food preparation, its moderate ICS suggests more utilitarian than symbolic value. Meanwhile, *C. papaya* and *N. lappaceum* show lower scores, possibly due to seasonal limitations or reduced cultural embedding. This visual evidence supports prior interpretations and helps identify priority species for conservation and knowledge transmission based on both frequency and depth of use.

By presenting index values graphically, the study enables a more intuitive understanding of how plant importance varies along functional and cultural axes. These visual tools are especially valuable for engaging non-academic stakeholders—such as community leaders and policy-makers—in designing responsive and evidence-based strategies for biodiversity protection and ethnobotanical education.

Challenges and opportunities for revitalization

Despite the richness of traditional knowledge, this study also documents emerging challenges. Younger generations show decreasing familiarity with species, as well as reduced understanding of herbal preparations. This generational gap mirrors findings across Southeast Asia (Sujarwo and Caneva 2016; Santoso et al. 2023), and underscores the urgency of intergenerational learning programs and school-based interventions.

Urbanization and shrinking garden spaces—particularly in peri-urban Lerep—also reduce opportunities for maintaining diverse and multifunctional gardens. These pressures lead households to prioritize ornamental or high-yield plants, diminishing the cultivation of culturally significant species. At the same time, however, renewed interest in organic living and wellness post-pandemic creates momentum to reintegrate traditional knowledge into modern contexts (Hamiyati et al. 2022).

Programs such as community herbal gardens, seed banks, and inter-household plant exchanges can play a strategic role in revitalizing plant knowledge and practice. These initiatives should prioritize species with high ethnobotanical indices—as documented in this study—while also incorporating less-known but ecologically resilient wild species. Visual tools such as heatmaps and radar charts can support these efforts by communicating scientific findings in community-friendly formats.

The role of women remains central in this revitalization. As primary agents of household ethnobotany, their participation in knowledge transmission, community training, and decision-making must be foregrounded. Supporting their roles through policy, education, and economic incentives will be crucial for ensuring long-term ethnobotanical sustainability in Semarang and beyond.

Species richness and its socioecological implications

The identification of 64 edible plant species across 52 genera and 34 families in the home gardens of Semarang District demonstrates a remarkable level of species richness. This diversity is particularly significant when understood through the lens of socioecological resilience—highlighting how biodiversity at the household level contributes not only to ecological stability but also to cultural identity, health, and local food security (Albuquerque et al. 2019; Yang et al. 2020).

Among the three research locations, Susukan Village exhibited the highest species richness (45 species), followed by Karangjati (36 species) and Lerep (31 species) (Figure 5). These differences reflect varying degrees of land availability, agroecological conditions, household composition, and local ethnobotanical knowledge. High species richness, as observed in Susukan, often correlates with more extensive yards and a stronger dependence on self-sufficiency, as has been similarly documented in rural Ethiopia and Thailand (Duguma 2020; Hu et al. 2020). Meanwhile, lower species counts in Lerep may be attributed to spatial constraints or a higher emphasis on ornamental rather than functional planting, although ethnobotanical integration still remains strong.

Ecologically, such diversity supports important functions including pest regulation, pollinator attraction, nutrient cycling, and climate buffering within the microenvironment of the home garden. Structurally, the coexistence of herbs, shrubs, trees, and lianas in vertically layered arrangements mimics natural forest systems, enhancing ecosystem services even in anthropogenic landscapes (Cahyaningsih et al. 2021b; Feni et al. 2022). These findings reinforce the notion that home gardens, though often small in area, serve as critical reservoirs of agrobiodiversity and provide essential ecosystem functions at the local level.

Culturally and nutritionally, high species richness ensures greater dietary diversity, reduces dependence on market-based food systems, and enables households to cope with seasonal food shortages. Fruits, spices, vegetables, and medicinal plants are often used interchangeably, and many species serve multiple roles—e.g., *C. papaya* provides both fruit and medicinal latex, while *P. guajava* is valued for both its edible fruit and therapeutic leaves. This multifunctionality is a hallmark of traditional agroecological systems (Ojelel et al. 2019; Cao et al. 2020), where the boundaries between food and medicine are fluid and overlapping.

Importantly, species richness is not merely a measure of ecological value, but also reflects social dynamics such as knowledge sharing, gender roles, and community cohesion. In many cases, the cultivation and exchange of specific plant varieties among neighbors or relatives strengthens social ties and reinforces cultural continuity (Novita et al. 2023). Such informal seed exchange networks are especially relevant in rural Java, where traditional knowledge still guides planting decisions despite increasing market influence.

On the other hand, there is a risk that species richness could decline due to shifting dietary patterns, land conversion, and the undervaluation of traditional species. Studies in other parts of Indonesia have shown that younger generations are less familiar with lesser-known plants, leading to the gradual loss of cultural and biological diversity (Santoso et al. 2023). This underscores the urgency of documenting local plant knowledge and integrating it into formal and informal education systems.

Species richness in home gardens is a vital indicator of both ecological and cultural sustainability. It serves as a buffer against environmental and economic shocks, enhances local nutrition and health, and sustains a living connection to ancestral practices. Supporting this richness through policy, education, and participatory conservation efforts is essential for building resilient and self-reliant rural communities in Central Java and beyond (Li and Siddique 2020; UNDP 2022).

The role of women and household structure in knowledge transmission

The role of women in the transmission of ethnobotanical knowledge is fundamental and deeply embedded within the household structure, especially in rural communities such as those in Semarang District. As the majority of respondents in this study were women—specifically housewives aged 41–60 years—the findings affirm a widely observed pattern in ethnobotany: women are the primary stewards of home gardens and custodians of traditional ecological knowledge (Kujawska and Łuczaj 2015; Hamiyati et al. 2022). Women in the study area play a pivotal role in the cultivation and management of Family Medicinal Plants (TOGA), functioning as primary agents in knowledge exchange and in strengthening social cohesion among community members (Figure 13).

Women's responsibilities in managing food preparation, health care, and domestic spaces naturally position them as the central figures in the cultivation and utilization of edible plants. These responsibilities are not limited to routine tasks but involve complex knowledge systems, including understanding plant cycles, seasonal availability, preparation techniques, and medicinal uses. As observed in this study, women were often able to name specific species, describe their uses in detail, and explain how plants should be prepared depending on the intended function—culinary, medicinal, or ceremonial.

Figure 13. Family Medicinal Plants (TOGA) management in Lerep Village, Semarang District, Central Java, Indonesia

This dynamic of female-led knowledge is reinforced by the social structure of many Javanese households, where multigenerational living arrangements are common. Older women, such as grandmothers or senior housewives, often serve as knowledge brokers, passing information about plant use and cultivation to daughters and grandchildren through daily interaction and practice. Such informal learning is both experiential and oral, relying on repeated participation rather than formal instruction (Feni et al. 2022; Novita et al. 2023). This mode of transmission ensures that ethnobotanical knowledge remains resilient and context-specific, although it is also vulnerable to disruption in the face of modernization.

Studies in other regions of Southeast Asia and Sub-Saharan Africa have echoed similar patterns, where women's plant-related knowledge surpasses that of men in both breadth and depth, especially regarding food, health, and childcare (Duguma 2020; Hu et al. 2020). This reflects a gendered division of knowledge that, rather than being restrictive, allows for the development of rich, localized expertise in plant-based systems. In the context of Semarang District, this gendered role appears to be not only accepted but foundational to household sustainability.

Women's responsibilities in managing food preparation, health care, and domestic spaces naturally position them as the central figures in the cultivation and utilization of edible plants. These responsibilities are not limited to routine tasks but involve complex knowledge systems, including understanding plant cycles, seasonal availability, preparation techniques, and medicinal uses. As observed in this study, women were often able to name specific species, describe their uses in detail, and explain how plants should be prepared depending on the intended function—culinary, medicinal, or ceremonial.

This dynamic of female-led knowledge is reinforced by the social structure of many Javanese households, where multigenerational living arrangements are common. Older women, such as grandmothers or senior housewives, often serve as knowledge brokers, passing information about plant use and cultivation to daughters and grandchildren through daily interaction and practice. Such informal learning is both experiential and oral, relying on repeated participation rather than formal instruction (Feni et al. 2022; Novita et al. 2023). This mode of transmission ensures that ethnobotanical knowledge remains resilient and context-specific, although it is also vulnerable to disruption in the face of modernization.

Studies in other regions of Southeast Asia and Sub-Saharan Africa have echoed similar patterns, where women's plant-related knowledge surpasses that of men in both breadth and depth, especially regarding food, health, and childcare (Duguma 2020; Hu et al. 2020). This reflects a gendered division of knowledge that, rather than being restrictive, allows for the development of rich, localized expertise in plant-based systems. In the context of Semarang District, this gendered role appears to be not only accepted but foundational to household sustainability.

However, the persistence of this knowledge is increasingly challenged by external pressures such as urbanization, migration of younger family members, and the declining interest of youth in traditional practices. Formal education systems rarely integrate ethnobotanical knowledge, and as younger generations become more detached from agricultural life, the potential for intergenerational knowledge loss increases (Cahyaningsih et al. 2021c; Santoso et al. 2023). Some younger respondents in this study expressed limited familiarity with traditional medicinal uses or local plant names, relying instead on market-purchased food and pharmaceuticals.

To address this, the preservation and revitalization of women-led knowledge systems must be prioritized through community-based programs, integration into school curricula, and recognition in policy frameworks. Programs that promote seed exchange, homegarden training, and documentation of oral histories can strengthen the role of women not only as caregivers but also as agents of biodiversity conservation and cultural continuity (Li and Siddique 2020; UNDP 2022).

Women in Semarang's rural households are not passive recipients but active agents in maintaining and transmitting ethnobotanical knowledge. Their roles are vital for sustaining the cultural and ecological integrity of home gardens. Supporting this structure through inclusive, gender-aware strategies is essential for long-term resilience in food and health systems.

Multifunctionality and cultural embeddedness of key species

One of the most prominent findings of this study is the multifunctionality of several plant species that serve a variety of roles in the daily lives of the Semarang District community. These roles are not only limited to practical functions such as food and medicine but are also tightly interwoven with cultural identity, rituals, and symbolic meaning. The multifunctionality of plants such as *Z. officinale*, *S. polyanthum*, and *A. barbadensis* (aloe vera) confirms a well-documented pattern in ethnobotanical literature: culturally important plants often fulfill overlapping utilitarian and symbolic roles, making them deeply embedded in local traditions (Sujarwo and Caneva 2016; Albuquerque et al. 2019).

In Semarang District, *Z. officinale* holds the highest Index of Cultural Significance (ICS = 112), reflecting its centrality in both daily and ritual use. It is a staple in traditional Javanese herbal tonics (*jamu*), cooking, and ceremonial offerings. Its known warming and anti-inflammatory properties make it indispensable in household healthcare, while its strong flavor contributes to the sensory identity of local cuisine (Baenas et al. 2019; Surya et al. 2023). The same plant is often planted in easy-to-access locations near kitchens, symbolizing its vital function in daily life.

Syzygium polyanthum also exemplifies cultural embeddedness through its near-universal use in Javanese cooking. Its inclusion in staple dishes such as *rendang* and *opor ayam* elevates it from a mere spice to a culturally significant plant that defines regional flavor profiles. Beyond its culinary use, this species is recognized for its medicinal effects, including lowering blood pressure and improving digestion (Cahyaningsih et al. 2021a). Its high

UV and ICS scores in this study further indicate widespread familiarity, use, and respect for its properties.

Meanwhile, *A. barbadensis* serves as a bridge between traditional and modern applications. While it has long been used to treat skin conditions and internal ailments, it is also increasingly incorporated into contemporary herbal products and cosmetics, reflecting an evolving cultural valuation. Its versatility in raw and processed forms, and its relevance in both folk and commercial domains, exemplifies how multifunctional species can adapt across time and use contexts (Nimma et al. 2017; Sánchez et al. 2020).

These multifunctional species are more likely to be cultivated, shared, and preserved within families. Their embeddedness is not only practical but symbolic—serving as representations of health, nourishment, and continuity with ancestral practices. Their presence in multiple domains (kitchen, medicine cabinet, ceremonial space) underscores the layered meanings they hold within households (Novita et al. 2023).

Comparative studies in other tropical regions have similarly shown that multifunctional plants—particularly those used in both food and healing—are among the most valued and preserved across generations (Kayani et al. 2015; Cao et al. 2020). This multifunctionality is thus a crucial criterion for identifying priority species in biodiversity conservation and cultural revitalization efforts.

The multifunctionality of key species in Semarang's home gardens highlights their pivotal role in maintaining cultural practices, sustaining family health, and securing food needs. These plants form the backbone of a living ethnobotanical system where utility and meaning converge. Efforts to protect and promote these species must therefore go beyond agronomic value, encompassing their roles as cultural and symbolic assets.

Plant habit and garden structure: Reflections of practical ecology

The dominance of herbaceous and shrubby plants in Semarang's home gardens reflects not only ecological pragmatism but also sociocultural adaptation to space, time, and labor constraints. As the data show, most cultivated species fall into the categories of herbs and shrubs, which are easier to plant, harvest, and regenerate, especially in small-scale homegarden settings. This finding aligns with previous studies emphasizing that plant habitus is a decisive factor in household plant selection, particularly in densely inhabited rural and peri-urban areas (Albuquerque et al. 2019; Novita et al. 2023).

Short-lived and fast-growing species such as *Ocimum basilicum* (basil), *C. frutescens* (cayenne pepper), and *C. longa* are common in these gardens due to their relatively quick yield cycles, low maintenance, and continuous household utility. These characteristics make herbaceous plants well-suited for daily needs and dynamic domestic environments, where plant turnover must meet fast-paced consumption patterns. The preference for such forms indicates an agroecological logic that maximizes return while minimizing inputs—a feature consistent with subsistence-based systems globally (Yang et al. 2020).

In contrast, tree species, though less frequent, are carefully integrated into the vertical structure of the garden. Fruit trees like *C. papaya*, *P. guajava*, and *M. indica* are typically planted in corners or along the periphery of the yard to avoid shading smaller crops, reflecting a deliberate spatial strategy that balances canopy cover with understorey production. This vertical stratification mimics forest-like architecture, optimizing space and microclimate conditions (Feni et al. 2022). Such structural complexity not only improves light use efficiency and pest management but also enhances biodiversity at the plot level (Cahyaningsih et al. 2021b).

Additionally, the presence of lianas such as *M. charantia* (bitter gourd) and *A. cordifolia* (binahong) adds another vertical layer, often trained along fences or trellises. These species demonstrate how vertical gardening techniques are employed as adaptive responses to limited land area, allowing households to expand productivity without increasing land use footprint—a trend also seen in other parts of Southeast Asia (Cao et al. 2020).

The overall garden layout observed during field visits supports the idea of a multifunctional and layered system where aesthetics, productivity, and ecological function coexist. Certain plants such as *C. ternatea*, which produce vibrant flowers used for both decoration and drinks, blur the line between ornamental and functional roles. This blurring reflects a local understanding that beauty and utility are not mutually exclusive—a notion reinforced by traditional Javanese philosophies of harmony between nature and household life.

Moreover, the composition of plant habits also mirrors cultural and gendered labor divisions. Herbaceous plants, often grown close to the kitchen or main house, are frequently tended by women, whereas tree planting and maintenance may involve male household members or shared labor during community planting days. This spatial-labor alignment adds another layer of meaning to the physical structure of the garden, embedding social norms into ecological practice (Kujawska and Łuczaj 2015).

The habitus composition and structural arrangement of home gardens in Semarang District reflect a form of practical ecology—a lived, learned system of environmental management shaped by cultural knowledge, labor patterns, and ecological constraints. It illustrates that decisions about what and how to plant are not only agronomic but deeply social, spatial, and ecological. Promoting this integrated model through local policy and educational outreach could enhance agroecological resilience and biodiversity conservation across rural and peri-urban Java.

Domesticated vs. wild plants: Management and resilience

The overwhelming predominance of domesticated species in Semarang's home gardens—89.1% compared to only 10.9% of wild plants (Figure 10)—reflects a conscious strategy of plant management that prioritizes reliability, ease of access, and familiarity. This pattern underscores a system where households intentionally cultivate species with known utility, growth patterns, and cultural relevance, thereby reducing dependency on external or unpredictable sources. Similar findings have been reported in other parts of Indonesia and Southeast Asia, where cultivated species dominate home gardens due to their adaptability to small-scale settings and daily household demands (Cahyaningsih et al. 2021a; Sujarwo and Caneva 2016).

Domesticated species, particularly annual and perennial herbs like *Ocimum basilicum*, *Z. officinale,* and *C. frutescens*, are managed intensively in terms of watering, pruning, and propagation. These plants often occupy the most accessible parts of the garden, near kitchens or water sources, highlighting their functional centrality. Their continued presence in gardens also reflects cultural continuity, as many are inherited knowledge selections passed down through generations. This mirrors what Albuquerque et al. (2019) term "cultural keystone species"—plants so integral to a community's way of life that they shape both landscape and identity.

However, the presence—albeit limited—of wild species in home gardens suggests a different form of ecological resilience. Plants such as *A. cordifolia* (*binahong*) may emerge spontaneously or be transplanted from nearby forests or roadsides. Their survival without constant care highlights their ecological hardiness, while their continued use reflects retained ethnobotanical knowledge. In some cases, these species are considered medicinally potent and are harvested selectively as needed, thus maintaining a link between cultivated gardens and the surrounding natural environment (Kayani et al. 2015; Duguma 2020).

This cultivated-wild dynamic is not simply dichotomous but rather complementary. Many households employ a "semi-wild" strategy in which wild species are tolerated or semi-managed within the garden, blending management with opportunism. This approach enhances functional redundancy—a key trait of resilient systems—where different species can fulfill similar roles, such as treating fever or aiding digestion (Li and Siddique 2020).

Moreover, the limited but strategic inclusion of wild plants may serve as a form of ecological insurance, preserving genetic diversity and local varieties that could otherwise be lost due to market-driven homogenization. Such species may also carry spiritual or symbolic meanings not fully replaced by cultivated alternatives. For instance, *Pandanus* spp. and *C. citratus*, though cultivated, retain strong ritual associations that originated from their wild use in traditional settings (Sánchez et al. 2020).

From a conservation standpoint, the integration of wild plants in home gardens offers an opportunity for in situ conservation, where biodiversity is preserved in the context of daily use rather than isolated in protected areas. This aligns with global calls for participatory conservation approaches that recognize local communities as active agents of biodiversity stewardship (UNDP 2022).

While cultivated species dominate Semarang's home gardens, the continued presence and management of wild plants—however modest—plays a crucial role in maintaining ecological diversity, cultural memory, and household adaptability. Strengthening both domains through documentation, seed exchange programs, and education will be vital in sustaining this hybrid ethnobotanical system amidst changing socioecological landscapes.

Traditional knowledge as a pillar of household health security

Traditional knowledge plays a foundational role in shaping household health strategies in rural communities, and this is clearly reflected in the ethnobotanical practices observed in Semarang District. The use of homegarden plants for medicinal purposes—whether for treating common ailments such as colds, digestive issues, or wounds—illustrates the importance of inherited, experience-based knowledge systems in maintaining family wellbeing. As shown in this study, 12.5% of the recorded species were used primarily as medicinal plants, and many others served dual roles as food and medicine, emphasizing the blurred line between nourishment and healing in traditional contexts (Sujarwo and Caneva 2016; Andersen et al. 2017).

The most commonly cited medicinal species, including *Z. officinale*, *A. barbadensis*, and *P. guajava*, were widely known across respondents and typically used in accessible forms such as decoctions, infusions, and topical applications. These preparation methods, which rely on boiling, pounding, or using the plant raw (Figure 9), reflect long-standing traditions that are passed down orally—especially by women within the household. As previous studies have shown, such practices often exhibit a high degree of internal consistency, built upon generational trial and observation (Kujawska and Łuczaj 2015; Duguma 2020).

The central role of plants in household health care is especially important in contexts where access to formal health services may be limited, expensive, or culturally unfamiliar. In this way, traditional plant knowledge serves as a first line of defense—providing affordable, familiar, and trusted remedies within the domestic sphere. Similar patterns have been reported across Southeast Asia, where ethnomedicine continues to complement modern healthcare, especially among older generations and in lower-income households (Hu et al. 2020; Hamiyati et al. 2022).

Moreover, traditional medicine in Java is not only utilitarian but deeply embedded in cosmological and spiritual frameworks. Plants are used not just to heal the body, but to restore balance, protect from misfortune, or purify the household. For instance, *C. citratus* is often burned as an aromatic to cleanse indoor spaces, while *Pandanus* spp. is used in both ritual offerings and food as a symbol of protection and harmony. These symbolic uses indicate that plant-based health practices operate at the intersection of physical and metaphysical wellbeing (Sánchez et al. 2020; Cahyaningsih et al. 2021c).

However, this rich body of knowledge is at risk. As younger generations become increasingly detached from agricultural practices and more reliant on pharmaceutical products, the transmission of traditional medicinal knowledge is weakening. In this study, some younger participants expressed uncertainty about the preparation and dosage of herbal remedies, relying more on packaged herbal drinks or over-the-counter medications. This mirrors broader trends in Indonesia and other countries where traditional health systems face marginalization in favor of biomedical approaches (UNDP 2022; Santoso et al. 2023).

To address this erosion, it is critical to document and revitalize traditional knowledge as part of public health strategies. Integrating ethnobotanical education into school curricula, promoting intergenerational learning spaces, and supporting home-based herbal gardens can help safeguard this knowledge. Such approaches not only preserve cultural identity but also enhance community resilience by providing sustainable and locally adapted healthcare options (Albuquerque et al. 2019; Li and Siddique 2020).

Traditional plant knowledge remains a pillar of household health security in Semarang's villages. It offers a culturally relevant, economically accessible, and ecologically sustainable approach to everyday healthcare. Recognizing and supporting this knowledge system is essential for building resilient, inclusive, and self-reliant rural health infrastructures.

Challenges and opportunities for conservation and knowledge revitalization

While the ethnobotanical richness documented in Semarang District's home gardens reflects a vibrant and functional knowledge system, it is increasingly threatened by social, economic, and environmental changes. A major challenge is the erosion of traditional knowledge, particularly among younger generations, who show declining interest in plant-based practices and greater dependence on commercial food and health products. This generational shift, commonly observed in rural Southeast Asia, leads to the gradual disappearance of local terminologies, preparation techniques, and even plant varieties (Sujarwo and Caneva 2016; Santoso et al. 2023).

Field observations during this study revealed that many less-utilized species, and certain local landraces of *Pandanus*, are no longer commonly known or used by younger household members. This suggests an underutilization of local biodiversity, not due to ecological constraints, but because of weakening cultural transmission. As Li and Siddique (2020) argue, without active intergenerational transfer, knowledge systems can become "intangible heritage at risk," with functional loss often preceding ecological loss.

Another challenge is land-use change. Urbanization, reduction in yard size, and the shift toward ornamental landscaping have contributed to declining species richness in some areas, particularly in peri-urban villages such as Lerep. Limited space leads to prioritization of fast-growing or economically profitable species, reducing the diversity and multifunctionality traditionally associated with home gardens (Cahyaningsih et al. 2021b; UNDP 2022). Market pressures also contribute to the replacement of indigenous species with hybrid or imported varieties, further undermining local agro-biodiversity.

Despite these challenges, several opportunities exist for conservation and revitalization. First, the documented data on species with high UV, RFC, and ICS scores can inform community-led prioritization of key plants for protection and propagation. Plants like *Z. officinale*, *S. polyanthum*, and *C. citratus* serve as entry points for education and conservation programs, given their cultural familiarity and continued relevance (Albuquerque et al. 2019).

Second, the momentum of interest in herbal medicine, organic gardening, and wellness—particularly post-pandemic—offers a timely opportunity to reintroduce traditional plant knowledge into public discourse. Community herbal gardens, "green schools," and home-based training programs have shown success in other Indonesian regions and could be adapted to the Semarang context (Hamiyati et al. 2022; Novita et al. 2023).

Documentation efforts—such as the current study—also contribute to conservation by providing a baseline for species inventory, usage patterns, and cultural significance. Such data can support local governments and NGOs in designing culturally appropriate biodiversity programs, including seed exchange networks, native species festivals, and oral history archives. Moreover, engaging women and elders as knowledge keepers and facilitators can ensure authenticity and sustainability of revitalization initiatives (Kujawska and Łuczaj 2015; Duguma 2020).

Finally, integrating traditional knowledge into formal education and local policy can institutionalize its value. Ethnobotanical curricula, school gardens, and participatory documentation projects involving youth have been effective in other cultural contexts for strengthening biocultural heritage (Yang et al. 2020). Local policy support—through village regulations or incentives for maintaining biodiversity-rich gardens—can complement grassroots efforts and offer long-term protection to cultural plant landscapes. While traditional plant knowledge in Semarang's home gardens faces significant challenges, the foundation for its revitalization is strong. By bridging generations, integrating policy and practice, and aligning conservation with local values, communities can sustain and even strengthen their ethnobotanical heritage for the future.

In conclusion, homegardens in Semarang District serve as vital spaces where biodiversity, cultural tradition, and household needs intersect. The diversity of edible plant species, dominated by herbs and shrubs, reflects practical and ecological considerations, while the high cultural value of multifunctional species like *Z. officinale* and *S. polyanthum* underscores their embeddedness in daily life. Women play a central role in managing and transmitting ethnobotanical knowledge, which remains essential for food security and household health. However, generational knowledge erosion and land-use change pose significant threats. Despite these challenges, opportunities exist to revitalize traditional plant knowledge through education, community initiatives, and inclusive conservation strategies that affirm its role in sustaining resilient and culturally rooted homegarden systems.

ACKNOWLEDGEMENTS

The authors would like to thank all formal leaders, informal leaders, respondents, and community informants from the three research sites in Semarang District, Central Java, who assisted and supported this research.

REFERENCES

Afon AO, Adebara TM. 2022. Socio-cultural utilization of open spaces in the traditional residential neighborhood of Ile-Ife, Nigeria. Space Cult 25 (1): 33-51. DOI: 10.1177/1206331219874698.

Albuquerque UP, Lucena RFP, Macía MJ. 2019. Methods and Techniques in Ethnobiology and Ethnoecology. Springer. DOI: 10.1007/978-1-4939-8919-5.

Ananta IGBT, Anjasmara DGA. 2022. Antioxidant and antibacterial potency of red chillies extract (*Capsicum annum* var. Longum). Jurnal Ilmiah Medicamento 8 (1): 48-55. DOI: 10.36733/medicamento.v8i1.3170. [Indonesian]

Andersen BV, Byrne DV, Bredie WLP, Møller P. 2017. Cayenne pepper in a meal: Effect of oral heat on feelings of appetite, sensory specific desires and well-being. Food Qual Prefer 60: 1-8. DOI: 10.1016/j.foodqual.2017.03.007.

Arumingtyas EL, Kusnadi J, Mastuti R, Faradise NS. 2018. The effect of ethyl methane sulfonate on the antioxidant content of chili pepper (*Capsicum frutescens* L.). AIP Conf Proc 2019 (1): 020010. DOI: 10.1063/1.5061846.

Badan Pusat Pangan (BPP). 2022. Peta Ketahanan dan Kerentanan Pangan Indonesia Tahun 2022. Badan Pangan Nasional, Jakarta. [Indonesian]

Badan Pusat Statistik (BPS). 2024. Kemiskinan di Indonesia Maret 2024. Badan Pusat Statistik. Retrieved from https://www.bps.go.id. [Indonesian]

Badan Pusat Statistik (BPS). 2024. Statistik Daerah Kabupaten Semarang 2024. BPS Kabupaten Semarang. Retrieved from https://semarangkab.bps.go.id. [Indonesian]

Baenas N, Belović M, Ilic N, Moreno DA, García-Viguera C. 2019. Industrial use of pepper (*Capsicum annum* L.) derived products: Technological benefits and biological advantages. Food Chem 274: 872-885. DOI: 10.1016/j.foodchem.2018.09.047.

Bano A, Ahmad M, Hadda TB, Saboor A, Sultana S, Zafar M, Khan MPZ, Arshad M, Ashraf MA. 2014. Quantitative ethnomedicinal study of plants used in the skardu valley at high altitude of Karakoram-Himalayan range, Pakistan. J Ethnobiol Ethnomed 10: 43. DOI: 10.1186/1746-4269-10-43.

Cahyaningsih R, Magos Brehm J, Maxted N. 2021. Setting the priority medicinal plants for conservation in Indonesia. Genet Resour Crop Evol 68: 2019-2050. DOI: 10.1007/s10722-021-01115-6.

Cahyaningsih R, Brehm JM, Maxted N. 2021. Gap analysis of Indonesian priority medicinal plant species as part of their conservation planning. Glob Ecol Conserv 26: e01459. DOI: 10.1016/j.gecco.2021.e01459.

Cahyaningsih R, Phillips J, Brehm JM, Gaisberger H, Maxted N. 2021. Climate change impact on medicinal plants in Indonesia. Glob Ecol Conserv 30: e01752. DOI: 10.1016/j.gecco.2021.e01752.

Cao Y, Li R, Zhou S, Song L, Quan R, Hu H. 2020. Ethnobotanical study on wild edible plants used by three trans-boundary ethnic groups in Jiangcheng County, Pu'er, Southwest China. J Ethnobiol Ethnomed 16 (1): 66. DOI: 10.1186/s13002-020-00420-1.

Das S, Maulik SR. 2024. Recent Approaches and Advancements in Natural Dyes. In: Muthu SS (eds.). Natural Dyes and Sustainability. Sustainable Textiles: Production, Processing, Manufacturing & Chemistry. Springer, Cham. DOI: 10.1007/978-3-031-47471-2_4.

Duguma HT. 2020. Wild edible plant nutritional contribution and consumer perception in Ethiopia. Intl J Food Sci 2020: 2958623. DOI: 10.1155/2020/2958623.

FAO. 2021. The State of Food Security and Nutrition in the Word Transforming Food Systemsfor Food Security, Improved Nutrition and Affordable Healthy Diets For All, FAO. FAO, Rome.

Feni R, Marwan E, Kusumawati N. 2022. Live pharmacy plants for yard land utilization in Kepahiang Sub-district, Kepahiang District. SINAR SANG SURYA: Jurnal Pusat Pengabdian Kepada Masyarakat 6 (1): 168-175. DOI: 10.24127/sss.v6i1.1887. [Indonesian]

Goyal MR, Chauhan A. 2024. Holistic approach of nutrients and traditional natural medicines for human health: A review. Future Integr Med 3 (3): 197-208. DOI: 10.14218/FIM.2023.00089.

Hamiyati H, Doriza S, Rahmawaty D. 2022. Training on making herbal plant gardens in home yards to maintain family immunity in the Mekar Village Community, Muara Gembong Sub-district, Bekasi District. Jurnal Pengabdian Masyarakat 3 (3): 1911-1915. DOI: 10.31004/cdj.v3i3.9343. [Indonesian]

Helida A, Zuhud EAM, Hardjanto H, Purwanto Y, Hikmat A. 2015. Index of cultural significance as a potential tool for conservation of plants diversity by communities in the Kerinci Seblat National Park. Jurnal Manajemen Hutan Tropika 21 (3): 192-201. DOI: 10.7226/jtfm.21.3.192.

Hu R, Lin C, Xu W, Liu Y, Long C. 2020. Ethnobotanical study on medicinal plants used by Mulam people in Guangxi, China. J Ethnobiol Ethnomed 16 (1): 40. DOI: 10.1186/s13002-020-00387-z.

Kayani S, Ahmad M, Sultana S, Shinwari ZK, Zafar M, Yaseen G, Hussain M, Bibi T. 2015. Ethnobotany of medicinal plants among the communities of Alpine and Sub-alpine regions of Pakistan. J Ethnopharmacol 164: 186-202. DOI: 10.1016/j.jep.2015.02.004.

Kujawska M, Łuczaj Ł. 2015. Wild food plants used by the Polish community in Misiones, Argentina. Hum Ecol 43(6): 855–869. DOI: 10.1007/s10745-015-9790-9.

Kumoro AC, Wardhani DH, Retnowati DS, Haryani K. 2021. A brief review on the characteristics, extraction and potential industrial applications of citronella grass (*Cymbopogon nardus*) and lemongrass (*Cymbopogon citratus)* essential oils. IOP Conf Ser: Mater Sci Eng 1053: 012118. DOI: 10.1088/1757899X/1053/1/012118.

Li X, Siddique KHM. 2020. Future smart food: Harnessing the potential of neglected and underutilized species for Zero Hunger. Matern Child Nutr Suppl 3 (Suppl 3): e13008. DOI: 10.1111/mcn.13008.

Marhaeni LS. 2020. Potential of aloe vera (*Aloe vera* Linn) as medicine and food source. AGRISIA-Jurnal Ilmu-Ilmu Pertanian 13 (1): 32-39. [Indonesian]

Mirzaman Z, Kayani S, Manzoor M, Jameel MA, Waheed M, Gillani SW, Babar CM, Bussmann RW. 2023. Ethnobotanical study of Makra Hills District Muzaffarabad, Azad Jammu and Kashmir, Pakistan. Ethnobot Res Appl 26: 1-17. DOI: 10.32859/era.26.38.1-17.

Murtini ES, Yuwono SS, Putri WDR, Nisa FC, Mubarok AZ, Ali DY, Fathuroya V. 2022. Indonesian Tropical Fruit Processing Technology. Universitas Brawijaya Press, Malang. [Indonesian]

Nasution I, Jayanthi S, Nurliyanti, Hijjati N, Yurida, Anggri. 2023. Inventarisasi edible plant yang tumbuh liar di Kawasan Universitas Samudra. Jurnal Biosense 6 (2): 233-246. DOI: 10.36526/biosense.v6i02.3360. [Indonesian]

Nimma VL, Talla HV, Bairi JK, Gopaldas M, Bathula H, Vangdoth S. 2017. Holistic healing through herbs: Effectiveness of *Aloe vera* on post extraction socket healing. J Clin Diagn Res 11 (3): ZC83-ZC86. DOI: 10.7860/JCDR/2017/21331.9627.

Novita A, Purba AN, Julia H. 2023. Utilization of home yards for planting a living pharmacy as a provider of herbal medicines. Kaibon Abhinaya: Jurnal Pengabdian Masyarakat 5 (1): 45-49. DOI: 10.30656/ka.v5i1.4649.

Nurrochmat DR, Nugroho IA, Hardjanto, Purwadianto A, Maryudi A, Erbaugh JT. 2017. Shifting contestation into cooperation: Strategy to incorporate different interest of actors in medicinal plants in Meru Betiri National Park, Indonesia. For Policy Econ 83: 162-168. DOI: 10.1016/j.forpol.2017.08.005.

Ojelel S, Mucunguzi P, Katuura E, Kakudidi EK, Namaganda M, Kalema J. 2019. Wild edible plants used by communities in and around selected forest reserves of Teso-Karamoja Region, Uganda. J Ethnobiol Ethnomed 15 (1): 3. DOI: 10.1186/s13002-018-0278-8.

Pariamanda S, Sukmono A, Haniah H. 2016. Analisis kesesuaian lahan untuk perkebunan kopi di Kabupaten Semarang. Jurnal Geodesi Undip 5 (1): 116-124. DOI: 10.14710/jgundip.2016.10564. [Indonesian]

Pujinisa W, Henri H, Romdhoni E. 2023. Etnobotani tumbuhan bahan pangan di Taman Wisata Alam Gunung Permisan, Kabupaten Bangka Selatan. Jurnal Ilmu Lingkungan 21 (3): 453-462. DOI: 10.14710/jil.21.3.453462. [Indonesian]

Purwantisari S, Jannah SN, Handayani D, Yulianto ME, Ardiansari A. 2021. Produksi serbuk jamu instan dengan alat kristalisasi di UMKM Kecamatan Ungaran Timur Kabupaten Semarang. E-Dimas: Jurnal Pengabdian Kepada Masyarakat 12 (3): 527-532. DOI: 10.26877/e-dimas.v12i3.7070. [Indonesian]

Putri MH, Septiyani P, Aryani W, Abriyani E. 2023. Literatur riview: penetapan kadar vitamin C pada buah jambu biji, jeruk, dan nanas, menggunakan metode spektrofotometri Uv-Vis. Jurnal Ilmiah Wahana Pendidikan 9 (4): 333-342. DOI: 10.5281/zenodo.7681039. [Indonesian]

Prabayanti H, Sutrisno J, Antriyandarti E. 2022. Aspects of food security in Central Java Province: Development of rice harvested area, land productivity, input subsidies, rice prices, population, rice production and consumption. Proc Ser Phys Formal Sci 4: 23-31. DOI: 10.30595/pspfs.v4i.480.

Radha, Kumar M, Puri S, Pundir A, Bangar SP, Changan S, Choudhary P, Parameswari E, Alhariri A, Samota MK, Damale RD, Singh S, Berwal MK, Dhumal S, Bhoite AG, Senapathy M, Sharma A, Bhushan B, Mekhemar M. 2021. Evaluation of nutritional, phytochemical, and mineral composition of selected medicinal plants for therapeutic uses from cold desert of Western Himalaya. Plants 10 (7): 1429. DOI: 10.3390/plants10071429.

Rahayu T, Rachmawatie SJ, Pamujiasih T, Ihsan M. 2022. Intensification of backyard land with horticultural crops. Darmabakti: Jurnal Pengabdian dan Pemberdayaan Masyarakat 3 (1): 32-36. DOI: 10.31102/darmabakti.2022.3.1.032-036. [Indonesian]

Rahmayani SP, Palennari DM, Rachmawaty DR. 2020. Flora Angiospermae (Vol. 1). Ellunar.

Ruiz Rodríguez LG, Zamora Gasga VM, Pescuma M, Van Nieuwenhove C, Mozzi F, Sánchez Burgos JA. 2021. Fruits and fruit by-products as sources of bioactive compounds. Benefits and trends of lactic acid fermentation in the development of novel fruit-based functional beverages. Food Res Intl 140: 109854. DOI: 10.1016/j.foodres.2020.109854.

Sánchez M, González-Burgos E, Iglesias I, Gómez-Serranillos MP. 2020. Pharmacological update properties of *Aloe vera* and its major active constituents. Molecules 25 (6): 1324. DOI: 10.3390/molecules25061324.

Santoso DK, Setyabudi I, Rahmawati A. 2023. Modeling of Madurese Residential yard spatial planning based on local edible plants. TekstuReka 1 (1): 50-55. DOI: 10.32502/tekstureka.v0i0.6364.

Shah A, Rahim S. 2017. Ethnomedicinal uses of plants for the treatment of malaria in Soon Valley, Khushab, Pakistan. J Ethnopharmacol 200: 84-106. DOI: 10.1016/j.jep.2017.02.005.

Sujarwo W, Caneva G. 2016. Using quantitative indices to evaluate the cultural importance of food and nutraceutical plants: Comparative data from the Island of Bali (Indonesia). J Cult Herit 18: 342-348. DOI: 10.1016/j.culher.2015.06.006.

Sukenti K, Sukiman S, Suripto S, Rohyani IS, Jupri A. 2019. Optimizing the utilization of yard land as an effort to assist food availability and the community economy in Sukarema Village, East Lombok District. Jurnal Pengabdian Magister Pendidikan IPA 2 (2): 97-101. DOI: 10.29303/jpmpi.v2i1.362. [Indonesian]

Sumarni W, Sudarmin S, Sumarti SS, Kadarwati S. 2022. Pengetahuan asli tentang pengobatan tradisional Indonesia dalam pengajaran dan pembelajaran sains menggunakan pendekatan sains–teknologi–rekayasa–matematika (STEM). Studi Budaya Pendidikan Sains 1-44. [Indonesian]

Surya R, Romulo A, Nurkolis F, Kumalawati DA. 2023. Compositions and Health Benefits of Different Types of *Jamu*, Traditional Medicinal Drinks Popular in Indonesia. In: Mérillon JM, Riviere C, Lefèvre G (eds.). Natural Products in Beverages. Reference Series in Phytochemistry. Springer, Cham. DOI: 10.1007/978-3-031-04195-2_123-1.

Tahir M, Asnake H, Beyene T, Van Damme P, Mohammed A. 2023. Ethnobotanical study of medicinal plants in Asagirt District, Northeastern Ethiopia. Trop Med Health 51 (1): 1. DOI: 10.1186/s41182023-00493-0.

Tiwi AH, Cahyaningrum ED. 2024. Guava leaf steeping to reduce the frequency of diarrhea in children. J Lang Health 5 (1): 15-22. DOI: 10.37287/jlh.v5i1.2733. [Indonesian]

Tono, Andayani DW, Hidayat A, Maheswari LD, Ulfa NA. 2022. Food Security Index. Badan Pangan Nasional. [Indonesian]

Triyanto A, Purnamasari F, Paramita FS, Wicaksono FR, Ramadhan FA, Budiharta S, Saensouk S, Setyawan AD. 2024. Ethnobotany of wild edible plants used by local communities in three districts along the upper Bengawan Solo River, Central Java, Indonesia. Biodiversitas 25 (4): 1596-1605. DOI: 10.13057/biodiv/d250428.

Ulfa SW, Nabila M, Nahombang SZ, Afrianti B, Nayla N, Amalia Q, Husnaa T. 2024. Inventory of high level plant species in Veteran Complex Jalan Vetpur Raya I, II, and II, Percut Sei Tuan Sub-district, Deli Serdang District. El-Mujtama: Jurnal Pengabdian Masyarakat 4 (3): 1263-1277. DOI: 10.47467/elmujtama.v4i3.1222. [Indonesian]

UNDP. 2022. Goal 2: Zero Hunger. Available at: https://www.id.undp.org/content/indonesia/en/home/sustainable-development-goals/goal-2-zerohunger.html.

Yang J, Chen WY, Fu Y, Yang T, Luo XD, Wang YH, Wang YH. 2020. Medicinal and edible plants used by the Lhoba people in Medog County, Tibet, China. J Ethnopharmacol 249: 112430. DOI: 10.1016/j.jep.2019.112430.

Yeşil Y, Çelik M, Yılmaz B. 2019. Wild edible plants in Yeşilli (Mardin-Turkey), a multicultural area. J Ethnobiol Ethnomed 15 (1): 52. DOI: 10.1186/s13002-019-0327-y.

Zenderland J, Hart R, Bussmann RW, Paniagua Zambrana NY, Sikharulidze S, Kikvidze Z, Kikodze D, Tchelidze D, Khutsishvili M, Batsatsashvili K. 2019. The use of "use value": Quantifying importance in ethnobotany. Econ Bot 73: 293-303. DOI: 10.1007/s12231-019-09480-1.