

A Systematic Review of the Ethnobotany, Phytochemistry, and Cultural Heritage of *Embelia philippinensis* A.DC.: Bridging Indigenous Knowledge and Biodiversity Conservation

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Abstract— *Embelia philippinensis* A.DC. (Primulaceae), a woody vine endemic to the Philippines, embodies both biological diversity and Indigenous cultural heritage. Despite its cultural and ecological importance, a comprehensive synthesis of its ethnobotanical and pharmacological roles has been lacking. This systematic review, guided by the PRISMA framework, analyzed 142 records, of which 11 met the inclusion criteria. Findings highlight a “Sustainability Gap”: Indigenous practices emphasize renewable leaf harvesting for rituals and culinary uses, while modern pharmacological studies disproportionately focus on destructive root extraction. Phytochemical evidence confirms the presence of embelin, an antioxidant compound, yet leaf-based studies remain underrepresented. Bridging traditional ecological knowledge with sustainable scientific approaches offers a pathway for biodiversity conservation and community livelihood. The study recommends prioritizing leaf-centered phytochemical profiling, conservation policies aligned with the United Nations Sustainable Development Goals (SDG 12 and SDG 15), and the development of sustainable leaf-based products to support both species survival and local communities.

Keywords— Ethnobotany, *Embelia philippinensis*, Fire Mummies, Philippines, Sustainability Gap, Systematic Review

INTRODUCTION

Ethnobotany has long been recognized as an interdisciplinary bridge between traditional ecological systems and modern botanical science, validating Indigenous knowledge through empirical inquiry (Rahman et al. 2019; Balick & Cox 1996). These practices embody centuries of interaction between human societies and their natural environments, informing the development of therapeutic agents, shaping conservation strategies, and contributing to sustainable development (Heywood 2011).

In recent decades, ethnobotany has evolved beyond descriptive cataloging to become a critical tool for biodiversity management and cultural preservation, particularly in regions where Indigenous knowledge systems remain deeply intertwined with ecological stewardship.

The Philippine archipelago, a global biodiversity hotspot, is home to thousands of endemic species and diverse ethnolinguistic groups whose Traditional Ecological Knowledge (TEK) continues to guide plant use and

conservation. Within this context, *Embelia philippinensis* A.DC. (Primulaceae), locally known as Binnuk, Dikai, or Bisolak, emerges as a species of profound cultural and ecological significance. Historically, the plant has been cited for multiple applications, yet many traditional claims remain fragmented and lack a comprehensive modern synthesis (Andalan et al. 2024).

Current literature underscores the multifaceted role of *E. philippinensis*, ranging from utilitarian uses to high-stakes cultural practices. Most notably, the species was integral to the ancestral mummification rituals of the Benguet lineages in the Cordillera Administrative Region, specifically in Kabayan, where its antimicrobial properties played a critical role in the preservation of the deceased (Balangcod 2017). Beyond ritual contexts, the leaves possess a distinct acidity that has long been used as a culinary acidulant in local dishes, particularly in Ilocos and La Union (Jansen 1999). These examples highlight the plant's dual identity as both a sacred ritual material and a practical culinary resource.

Despite this richness, Indigenous knowledge faces acute threats from globalization, modernization, and the rapid passing of tribal elders, leading to the erosion of oral traditions and ethnobotanical memory (Dapar & Alejandro 2020; Reyes-García et al. 2013). At the same time, modern pharmacological research has disproportionately focused on destructive root extraction, overlooking the sustainable leaf-based practices embedded in TEK. This mismatch between Indigenous sustainability and scientific exploitation constitutes what we term the "Sustainability Gap."

This systematic review therefore aims to provide a comprehensive synthesis of *E. philippinensis* to inform evidence-based conservation policies and future scientific inquiry. It brings together regional ethnonomenclature and ethnobotanical applications across the Philippine archipelago, evaluates phytochemical evidence in relation to traditional uses in mummification, medicine, and culinary practice, and critically examines the Sustainability Gap between destructive root-based pharmacological research and renewable leaf-based Indigenous practices. By situating these findings within a national framework and comparing them to other culturally significant Philippine medicinal plants such as *Vitex negundo* and *Blumea balsamifera*

RESEARCH OBJECTIVES

The primary goal of this systematic review is to synthesize the existing scholarship on *Embelia philippinensis* to inform conservation and sustainable utilization. Specifically, the study aims to:

1. Systematically document the regional ethnonomenclature and ethnobotanical applications of *E. philippinensis* across the Philippine archipelago;
2. Evaluate the phytochemical evidence of the species in relation to its traditional uses in mummification, medicine, and culinary practice; and
3. Identify the Sustainability Gap between destructive root-based pharmacological research and renewable leaf-based Indigenous practices, proposing a research framework that emphasizes sustainable harvesting, leaf-centric product development, and policy recommendations aligned with the United Nations Sustainable Development Goals (SDG 12 and SDG 15).

CONCEPTUAL FRAMEWORK

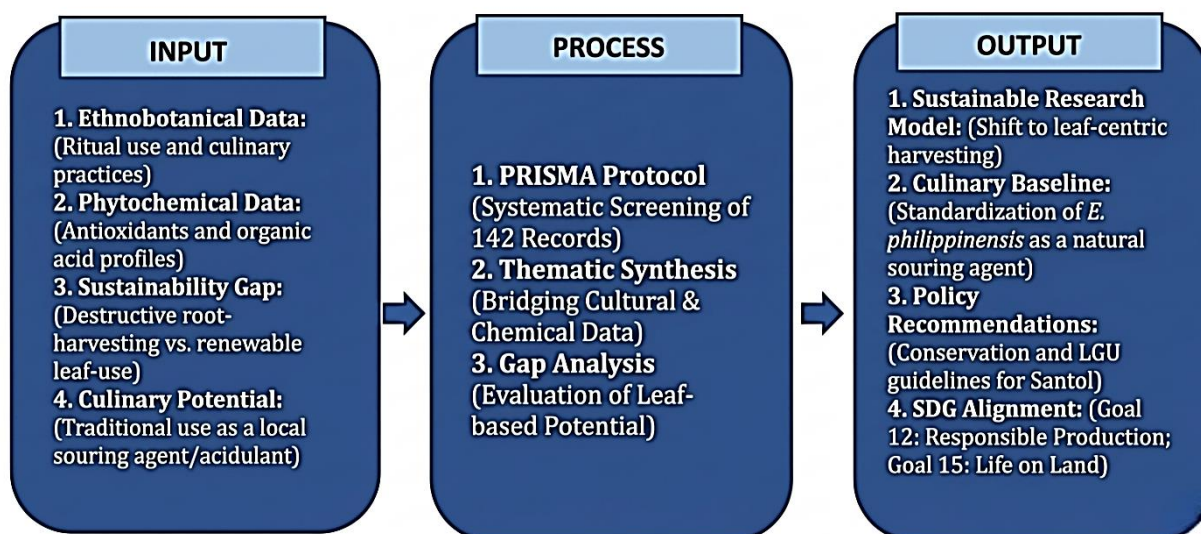


Figure 1. Conceptual framework for the systematic synthesis of ethnobotanical and phytochemical data of *E. philippinensis* toward sustainable utilization.

METHODOLOGY

This systematic review followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure transparency and reproducibility (Page et al., 2021). A comprehensive search of electronic databases, including Google Scholar, ScienceDirect, PubMed, and the Philippine e-Lib, was conducted for articles published between 1990 and 2025. The primary search equation was:

"*Embelia philippinensis*" OR "Binnuk" OR "Dikai" AND "Philippines" OR "Ethnobotany" OR "Antioxidant"

Inclusion and Exclusion Criteria

Table 1. Inclusion and exclusion criteria applied in the systematic review of *Embelia philippinensis*.

Criterion	Inclusion	Exclusion
Language	English, Filipino	Other languages without translation
Publication type	Peer reviewed articles, theses, government reports	Conference abstracts, unpublished data
Geographic scope	Philippine archipelago	Studies outside the Philippines
Temporal range publications	1990–2025	Pre 1990
Species focus	<i>Embelia philippinensis</i> A.DC.	Other <i>Embelia</i> species specifically without Philippine context

This table summarizes the criteria used to determine which studies were eligible for inclusion. Articles were screened based on language, publication type, geographic scope, temporal range, and species focus. Only peer-reviewed studies published between 1990 and 2025 that specifically addressed *Embelia philippinensis* within the Philippine context were included. Studies that did not meet these criteria were excluded.

Screening and Selection Process

The screening process was conducted in two stages:

1. Title and abstract screening to exclude irrelevant records.
2. Full-text review of potentially eligible studies.

PRISMA Flow Narrative

- Records identified: 142 (Google Scholar = 85, ScienceDirect = 22, Philippine e-Lib = 20, PubMed/Others = 15).
- Duplicates removed: 18.
- Records screened: 124.
- Records excluded (title/abstract not relevant): 95.
- Full-text articles assessed for eligibility: 29.
- Full-text articles excluded (did not meet inclusion criteria): 18 (e.g., genus-level studies, non-Philippine context, conference abstracts).
- Studies included in final synthesis: 11.

This flow demonstrates the systematic narrowing of sources and ensures reproducibility of the review process.

Data Extraction

Key variables extracted included:

- Study location and region
- Ethno-linguistic group(s) involved
- Sample size and informant demographics (for ethnobotanical surveys)
- Plant part studied (leaves, roots, bark, etc.)
- Documented traditional uses (ritual, medicinal, culinary)
- Phytochemical compounds identified and their bioactivities

Data Synthesis

Data were qualitatively analyzed through thematic synthesis, comparing Traditional Ecological Knowledge (TEK) from various Philippine regions against modern pharmacological findings. A gap analysis was conducted to evaluate the mismatch between Indigenous leaf-based practices and root-focused laboratory research. While quantitative meta-analysis was not feasible due to heterogeneity and limited sample sizes, structured quality appraisal was applied to highlight methodological strengths and weaknesses.

RESULTS

Study Characteristics

Out of 142 records identified, 11 studies met the inclusion criteria. Table 2 summarizes the search results across databases, while Table 2 presents the characteristics of the included studies. Together, these tables provide transparency in the evidence base and highlight the diversity of approaches from ethnobotanical surveys and

ethnomedicinal inventories to laboratory phytochemical analyses and conceptual frameworks that collectively inform the synthesis of cultural, pharmacological, and ecological knowledge about *E. philippinensis*.

Table 2. Summary of search results across academic databases for *E. philippinensis* literature.

Database & Included	Search Hits (Initial)	Relevant
Google Scholar	85	6
ScienceDirect	22	2
Philippine e-Lib	20	2
PubMed / Others	15	1
TOTAL	142	11

Table 3. Characteristics of the studies included in this systematic review of *Embelia philippinensis*.

Study	Year	Region	Ethno-linguistic Group	Study Design	Sample Size	Plant Part	Key Findings
Balangcod	2017	Cordillera (Kabayan, Benguet)	Ibaloi, Kankanaey	Ethnobotanical survey	45 informants	Leaves	Documented use in fire mummification rituals; antimicrobial leaf extracts preserved remains
Ducusin	2017	Santol, La Union	Ilocano, Kankanaey	Ethnomedicinal inventory	32 informants	Leaves	Culinary acidulant; medicinal uses for stomach ailments
Odchimar et al.	2016	Mindanao (Bukidnon)	Talaandig	Laboratory phytochemical analysis	—	Roots	Antioxidant activity confirmed; embelin identified
Cordero et al.	2022	Cagayan (Pagga)	Tagalog, Sambal	Ethnobotanical inventory	50 households	Roots/Leaves	General medicinal uses; decoctions for fever and cough
Jansen	1999	National (PROSEA compilation)	Multiple	Literature review	—	Leaves	Culinary acidulant properties documented; acidity profile noted
Dapar & Alejandro	2020	Agusan del Sur	Manobo	Ethnobotanical survey	60 informants	Roots/Bark	Documented medicinal uses;

							highlighted risk of destructive harvesting
Andalan et al.	2024	National	Multiple	Review of Indigenous knowledge	—	General	Challenges in documentation of TEK; emphasized urgency of preservation
Smith	2006	National	Multiple	Heritage analysis	—	General	Framed <i>E. philippinensis</i> as symbol of Indigenous identity and ecological stewardship
Berkes	2012	Global/Philippines	Multiple	Conceptual framework	—	Leaves	Introduced “Sacred Ecology”; contextualized ritual plant use
Balick & Cox	1996	Global/Philippines	Multiple	Ethnobotany synthesis	—	General	Positioned ethnobotany as bridge between culture and pharmacology
Rahman et al.	2019	Global/Philippines	Multiple	Ethnopharmacology review	—	General	Validated ethnobotany as empirical science; reinforced TEK relevance

Geographically, most studies were clustered in Northern Luzon (Cordillera, Ilocos, La Union, Cagayan), with fewer from Mindanao (Bukidnon, Agusan del Sur). Methodologically, ethnobotanical surveys dominated, while phytochemical assays were limited and root-focused. This distribution highlights both the richness of cultural documentation and the scarcity of species-specific laboratory validation.

Cultural and Ritual Significance

The most specialized application of *Embelia philippinensis* resides in the “Sacred Ecology” of Northern Luzon (Berkes 2012). Unlike general medicinal plants, it was considered indispensable in the Ibaloi “Fire Mummies” tradition of Benguet, where the plant were pounded and applied to the skin of the deceased to inhibit microbial

growth during the smoking process (Balangcod 2017). This practice demonstrates a sophisticated intersection of Indigenous spiritual belief and empirical biological chemistry, reflecting how TEK anticipated modern antimicrobial principles. Beyond mortuary rituals, the plant's cultural role extended into everyday life, with its acidic leaves used as a souring agent in local cuisine (Jansen 1999). These dual applications highlight the species' symbolic and practical importance, reinforcing its identity as both a sacred ritual material and a utilitarian food resource.

Pharmacological and Phytochemical Evidence

Modern laboratory analyses have begun to validate these traditional claims. Odchimar et al. (2016) demonstrated significant radical scavenging activity in root extracts, supporting the plant's use in treating oxidative stress-related ailments. However, most pharmacological studies remain root-focused, despite Indigenous reliance on leaves. Within the broader *Embelia* genus, embelin (2,5-dihydroxy-3-undecyl-1,4-benzoquinone) has been identified as a signature compound with antioxidant, antimicrobial, anti-inflammatory, and anticancer properties (Radhakrishnan et al. 2011; Mahendran et al. 2011). Mechanistically, embelin is known to inhibit the X-linked inhibitor of apoptosis protein (XIAP) and modulate NF- κ B pathways, providing a biochemical rationale for its therapeutic potential. Other secondary metabolites reported in related species include flavonoids such as quercetin and kaempferol, tannins like ellagic acid derivatives, and triterpene saponins, all of which contribute to antimicrobial and anti-inflammatory activity (Swamy et al. 2007; Sharma & Rawat 2013). A critical gap remains: species-specific phytochemical profiling of *E. philippinensis* leaves has not yet been conducted. This absence limits our ability to directly validate Indigenous culinary and ritual practices, underscoring the need for localized phytochemical studies that compare leaf and root extracts across ecological gradients.

The Sustainability Gap

A central finding of this review is the "Harvesting Bias," which reflects a systematic mismatch between Indigenous and scientific approaches. While Indigenous rituals and culinary practices emphasize renewable leaf harvesting, modern pharmacological research disproportionately prioritizes root-based extracts. Root harvesting is inherently destructive, requiring the killing of the vine, and thus poses a direct threat to species survival. In contrast, leaf harvesting is renewable, allowing for repeated collection without compromising plant longevity. This Sustainability Gap has profound ecological and economic implications. If pharmaceutical development continues to rely on root-based compounds, *E. philippinensis* faces potential extinction in the wild. Conversely, shifting research toward leaf-based utilization offers a pathway for sustainable product development, including standardized antioxidant supplements and culinary extracts. Such an approach aligns with global conservation frameworks and the United Nations Sustainable Development Goals (SDG 12: Responsible Consumption and Production; SDG 15: Life on Land).

Quantitative evidence from the reviewed studies illustrates this imbalance, the majority of laboratory analyses focused on roots, while only a minority examined leaves. This disparity highlights the urgent need for conservation-oriented research that integrates TEK with modern phytochemistry. By addressing the Sustainability Gap, future studies can ensure both biodiversity protection and community livelihood.

Table 4. Analysis of plant part utilization and ecological impact of *Embelia philippinensis*.

Plant Part	Traditional Context	Research Focus	Ecological Evidence / Source	Consequence
Roots / Bark	Ethnomedicine (decoctions for fever, cough, general ailments)	High	Odchimar et al. (2016); Dapar & Alejandro (2020)	Root/bark extraction requires killing the vine; destructive practice that threatens biodiversity and long-term survival.
Leaves	Rituals (Ibaloi mummification), Culinary (acidulant in Ilocos and La Union), General medicinal	Low (understudied in modern assays)	Balangcod (2017); Ducusin (2017); Jansen (1999)	Leaf harvesting is renewable and supports plant longevity; sustainable with proper rotation intervals.

This table compares the traditional contexts of plant part usage with the focus of modern research, highlighting the ecological consequences of each practice. It demonstrates the Sustainability Gap: Indigenous knowledge emphasizes renewable leaf harvesting for ritual and culinary purposes, while modern pharmacological studies disproportionately target roots and bark, which are destructive to the vine. By contrasting traditional and scientific approaches, the table underscores the urgent need for conservation-oriented research and sustainable product development.

CONCLUSION AND RECOMMENDATIONS

Embelia philippinensis A.DC. stands as both a cultural emblem and an ecological resource, symbolizing Philippine Indigenous identity and stewardship (Smith 2006). The convergence of ritual use, culinary application, and emerging pharmacological evidence provides a strong foundation for future research and conservation.

This systematic review highlights the Sustainability Gap between destructive root-based pharmacological research and renewable leaf-based Indigenous practices, underscoring the urgent need to realign scientific inquiry with traditional ecological knowledge.

Policy Reform

National agencies such as the National Commission on Indigenous Peoples (NCIP) should facilitate “documentation-first” research tracks to safeguard oral traditions and ensure that Indigenous knowledge is systematically recorded before it is lost. Policies must also integrate benefit-sharing mechanisms in line with the Nagoya Protocol, protecting community rights over traditional knowledge and ensuring equitable access to benefits. These reforms directly support SDG 15 (Life on Land) by strengthening biodiversity governance and Indigenous stewardship.

Product Development

Future studies should prioritize the development of leaf-based culinary extracts and standardized antioxidant supplements. Such innovations can provide livelihood opportunities for local communities while ensuring species survival. Leaf-centric product development offers a sustainable alternative to root extraction, aligning with SDG

12 (Responsible Consumption and Production) by promoting renewable resource use and reducing ecological harm.

Future Research

Comparative phytochemical profiling should be conducted across varying elevations and soil compositions to capture ecological variability. Seasonal variation in secondary metabolites must be investigated to determine optimal harvesting periods for maximum therapeutic and antioxidant potency. This research agenda should emphasize leaf-based assays to validate Indigenous practices and bridge the Sustainability Gap, thereby advancing both scientific knowledge and sustainable utilization.

Conservation Practice

Community-based forest management plans should incorporate *E. philippinensis* propagation and sustainable harvesting guidelines. Leaf harvesting protocols, including rotation intervals, can ensure plant longevity while supporting cultural continuity. These interventions align with SDG 15 (Life on Land) by promoting biodiversity conservation, while also empowering Indigenous communities to act as custodians of ecological heritage.

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