

Original Article

Ethnopharmacology Analysis of Antidiabetic Medicinal Plants from Menoreh Hills: Linking Local Knowledge to Pharmacological Evidence

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Abstract: Type 2 diabetes mellitus (T2DM) continues to increase globally, underscoring the need for evidence-based phytotherapy grounded in local medicinal knowledge. This ethnopharmacological study documents and prioritises antidiabetic medicinal plants used in Samigaluh (Menoreh Hills, Indonesia) by combining quantitative ethnobotanical analysis with a narrative review of pharmacological evidence. Semi-structured interviews were conducted with 10 key informants. Four quantitative indices, Use Value (UV), Relative Frequency of Citation (RFC), Fidelity Level (FL), and Plant Part Value (PPV), were calculated. *Vernonia amygdalina* emerged as the most diabetes-specific species (FL 100%, RFC 0.7), whereas *Curcuma mangga* was identified as a widely used multipurpose species (UV 1.3, RFC 0.6). Pharmacological studies confirm that the two plants act through distinct yet complementary mechanisms. *V. amygdalina* functions primarily as a metabolic regulator through inhibition of carbohydrate-digesting enzymes and suppression of hepatic gluconeogenesis. In contrast, *C. mangga* offers tissue-protective benefits, including pancreatic β -cell support, antioxidant activity, and immunomodulation. The complementary mechanisms and high local consensus support the potential of combining *V. amygdalina* and *C. mangga* as a culturally acceptable, locally available herbal formulation for T2DM management. Further preclinical and clinical studies are warranted to validate efficacy, safety, and possible synergistic effects.

Keywords: *Curcuma mangga*; indigenous knowledge; pharmacological evidence; phytotherapy; *Vernonia amygdalina*

1. INTRODUCTION

The Menoreh Hills harbor high biodiversity, and their rich flora forms an essential component of the local ecosystem [1,2]. This diversity offers substantial potential for exploration, particularly for managing metabolic diseases such as type 2 diabetes mellitus (T2DM), whose prevalence continues to rise globally [3]. According to the IDF Diabetes Atlas 11th Edition (2025), an estimated 589 million adults aged 20–79 years currently live with diabetes worldwide, and this figure is projected to reach 853 million by 2050, reflecting a rapidly escalating global disease burden [3]. T2DM accounts for more than 90% of all diabetes cases, with genetic and lifestyle factors playing major roles in its etiopathogenesis [4]. A similar trend is observed in Indonesia, where the International Diabetes Federation (2025) places the country fifth globally, with an estimated 20.4 million people living with diabetes [5].

Beyond its high prevalence, type 2 diabetes mellitus (T2DM) poses a progressive, often silent threat that affects multiple organ systems [6]. It increases the risk of cardiovascular complications, chronic kidney disease, neuropathy, retinopathy, and lower-extremity amputations, collectively reducing quality of life and contributing to higher morbidity and mortality rates [7]. In addressing the complexities of T2DM, phytotherapy has emerged as a complementary therapeutic approach that is gaining growing scientific attention [8]. Several medicinal plants have been reported to exhibit hypoglycemic effects and protective activities against diabetes-related complications through

mechanisms including the inhibition of carbohydrate-digesting enzymes, enhancement of insulin sensitivity, and antioxidant and anti-inflammatory actions [9].

In this context, ethnopharmacological studies play an essential role. This approach documents and analyzes traditional knowledge on medicinal plant use, allowing researchers to identify species with potential antidiabetic properties [10]. Beyond safeguarding local wisdom, ethnopharmacology also provides a scientific framework to evaluate traditional practices and relate them to modern pharmacological evidence [10]. This relevance is particularly apparent in Kapanewon Samigaluh, a region within the Menoreh Hills of Kulon Progo Regency, which spans a broad elevation gradient from lowland to highland areas [11]. Variation in elevation influences plant distribution, with species richness generally increasing at higher altitudes [2]. This condition aligns with findings that the management and utilization of medicinal plants are most intensive in mid-elevation communities (400–500 meters above sea level) and highland areas (>800 meters above sea level), where communities cultivate and use medicinal plants for both household needs and as economic commodities [11]. In addition to elevation factors, agroforestry practices such as home gardens and fields in Samigaluh also contribute to the preservation of medicinal plant diversity, which is utilized by the community for both household needs and traditional health purposes [12].

Previous research in Kapanewon Nanggulan documented 40 species of medicinal plants, with *Curcuma longa* (turmeric) showing the highest priority based on both its Use Value (0.78) and Frequency of Citation (78%) [13]. In comparison, an ethnomedicine study on antimicrobial plants among the Tengger community in Ngadas, East Java, employed four quantitative indices: Ethnobotanical Richness (ER), Use Value Index (UVI), Fidelity Level (FL), and Knowledge Value Index (KVI) [14]. Their evaluation highlighted *Prunus persica* as the species with the strongest community consensus for antimicrobial use, while *Alstonia macrophylla* emerged as another priority species due to high recognition despite limited pharmacological evidence. Both plants were identified as promising candidates for further investigation as antimicrobial agents [14].

Building on these previous studies while offering a different perspective, the present research focuses on the ethnopharmacological investigation of antidiabetic medicinal plants in Kapanewon Samigaluh, another region of the Menoreh Hills that has not yet been systematically documented. This study employs four quantitative ethnobotanical parameters, Use Value (UV), Relative Frequency of Citation (RFC), Fidelity Level (FL), and Plant Part Value (PPV), to identify locally prioritized species. The selected species are subsequently examined through a narrative review of pharmacological evidence to evaluate their therapeutic potential and to explore their suitability for the development of antidiabetic plant combinations based on locally available resources.

2. MATERIALS AND METHOD

2.1. Research Setting

This study was conducted in Samigaluh Subdistrict, an administrative area located in the northern part of Kulon Progo Regency, Special Region of Yogyakarta (Figure 1). Samigaluh covers 6,929.31 hectares (69.29 km²) and consists of seven villages. According to the 2023 population registry from the Department of Population and Civil Registration of Kulon Progo Regency, the subdistrict is inhabited by 27,848 residents. Geographically, Samigaluh lies within the Menoreh Hills, with an average elevation of approximately 504 meters above sea level (masl) [15].

The landscape is characterized by steep hills and slopes with moderate to high inclines, supported by a humid tropical climate with consistently high annual rainfall and stable humidity throughout the year [2]. Based on agroclimatic classification, the region spans both mid-elevation (301–600 masl) and high-elevation zones (>600 masl). In the mid-elevation zone, soils are predominantly Latosol, with slopes ranging from 15° to 40°, an average monthly rainfall of 160.92 mm, and an average temperature of 25.0°C. The high-elevation zone similarly consists of Latosol soils but with slopes exceeding 40°, an average monthly rainfall of 160.92 mm, and a mean temperature of around 25.0°C [2].

2.2. Ethics Statement, Interviews, and Data Collection

This research received ethical approval from the Research Ethics Committee of Ahmad Dahlan University (KEP UAD) under approval number REC-UAD/01/01/07-2025/229. All informants participated voluntarily after receiving an explanation of the study objectives and procedures, and their involvement was documented through informed consent forms. The confidentiality of informants' identities was ensured, and each participant retained the right to withdraw from the study at any stage. Data collection was carried out from July to August 2025.

Data were obtained through semi-structured interviews and participatory observation. The interviews explored: (a) local names of antidiabetic medicinal plants, (b) plant parts used, (c) methods of preparation, and (d) intended uses, whether specifically for diabetes or for other ailments. This study also established collaboration with the Samigaluh 1 and Samigaluh 2 Community Health Centers, which facilitated access to information regarding traditional healers in the Samigaluh Subdistrict, Kulon Progo Regency.

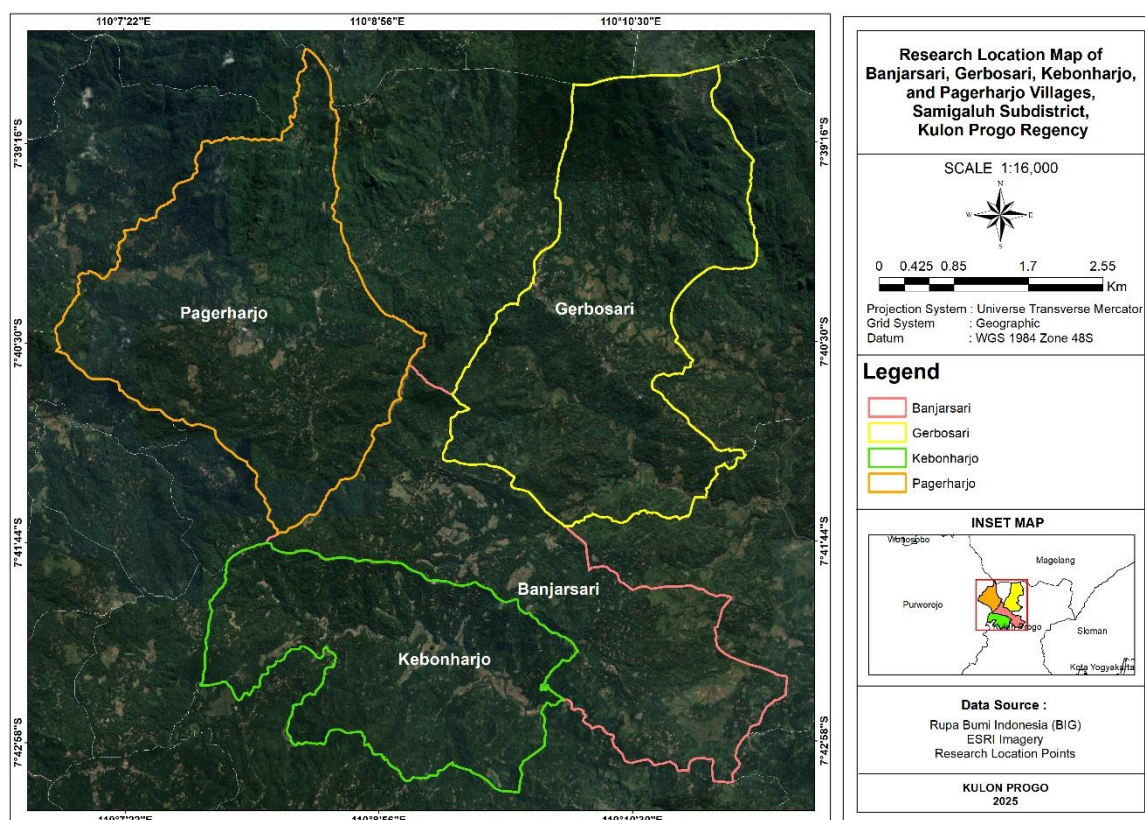


Figure 1. Research Location in Samigaluh Subdistrict, Kulon Progo Regency

2.3. Determining Informant Samples

Informants in this study consisted of traditional healers and community-recognized individuals with knowledge of antidiabetic medicinal plants in Samigaluh Subdistrict, Kulon Progo, Yogyakarta. They were selected using purposive sampling based on their relevance to traditional medicinal practices, particularly those associated with type 2 diabetes management.

Inclusion criteria were: (a) residing in Samigaluh Subdistrict, (b) aged 30–65 years, (c) recognized by the community as traditional healers or knowledgeable individuals regarding antidiabetic medicinal plants, and (d) willing to participate by providing informed consent. Exclusion criteria included individuals who were unable to provide information due to physical limitations or those who withdrew or discontinued participation despite having previously agreed to take part.

Identification of informants was strengthened through triangulation. Initial referrals were provided by the Samigaluh 1 and Samigaluh 2 Primary Healthcare Centers, followed by snowball recruitment to reach additional knowledge holders recommended by earlier participants. The process

also involved consultation with a key informant: the owner of Rumah Jamu Menoreh, who offered local expertise and assisted in validating eligible participants through community-based recognition [16].

A total of ten informants were reached and interviewed, representing all individuals who could be identified and who met the inclusion criteria during the study period. Recruitment continued until data saturation was achieved, indicated by the absence of new names in subsequent snowball referrals. While the possibility of undocumented healers cannot be excluded, these ten participants represent the full reachable population of recognized traditional knowledge holders relevant to antidiabetic medicinal plant use in Samigaluh.

2.4. Data Analysis

The data obtained from interviews and observations were subsequently transcribed and statistically processed using Microsoft Excel 2021 software. The quantitative parameters analyzed in this study include:

2.4.1. Use Value (UV)

Use Value (UV) is an ethnobotanical index employed to assess the relative significance of a plant species within traditional medicine. It is determined by the number of different uses reported by informants.

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

In this index, $\sum U$ represents the the cumulative use reports for a given species, whereas N represents the number of informants interviewed [17].

2.4.2. Relative Frequency of Citation (RFC)

Relative Frequency of Citation (RFC) is an ethnobotanical index used to evaluate the cultural prominence of a plant species, determined by the proportion of informants who cite it.

$$RFC = \frac{FC}{N}$$

In this index, FC denotes the number of informants mentioning the species (Frequency of Citation), while N represents the total sample size. The RFC value varies from 0 to 1, with values approaching 1 reflecting greater cultural relevance [18].

2.4.3. Fidelity Level (FL)

Fidelity Level (FL) is an indicator used to assess the extent to which a species is consistently utilized for addressing a specific disease compared to its overall uses. Thus, FL emphasizes the degree of specificity of a species for particular medical indications.

$$FL = \frac{I_p}{I_u} \times 100\%$$

Within this index, I_p refers to the number of informants citing a plant species for the treatment of a particular disease, whereas I_u indicates the total number of informants who report the use of that species for all disease categories [19].

2.4.4. Plant Part Value (PPV)

Plant Part Value (PPV) is used to measure the proportion of use of specific plant parts relative to the total parts utilized. The PPV value provides information regarding which parts of the plant are considered most important by the community.

$$PPV = \frac{RU_{plant\ part}}{RU}$$

In this index, RU for a plant part is the number of reports mentioning the use of a specific plant part, while RU is the total number of reports covering all plant parts [20].

The four parameters are used complementarily: FL emphasizes the specificity of plants for diabetes, while UV and RFC illustrate the intensity of use and the general popularity of plants in traditional medicine. PPV complements the analysis by indicating the parts of the plant that are most frequently utilized in antidiabetic preparations.

2.5. Narrative Review of Selected Species

To further evaluate the pharmacological potential of the two selected species, a narrative review-based literature analysis was conducted. The publication range was not restricted to ensure that all relevant pharmacological evidence could be captured. Literature searches were carried out through the PubMed database (<https://pubmed.ncbi.nlm.nih.gov/>), supplemented by supporting sources such as Plants of the World Online (<https://powo.science.kew.org/>) to verify the validity of the species names, families, and synonyms used.

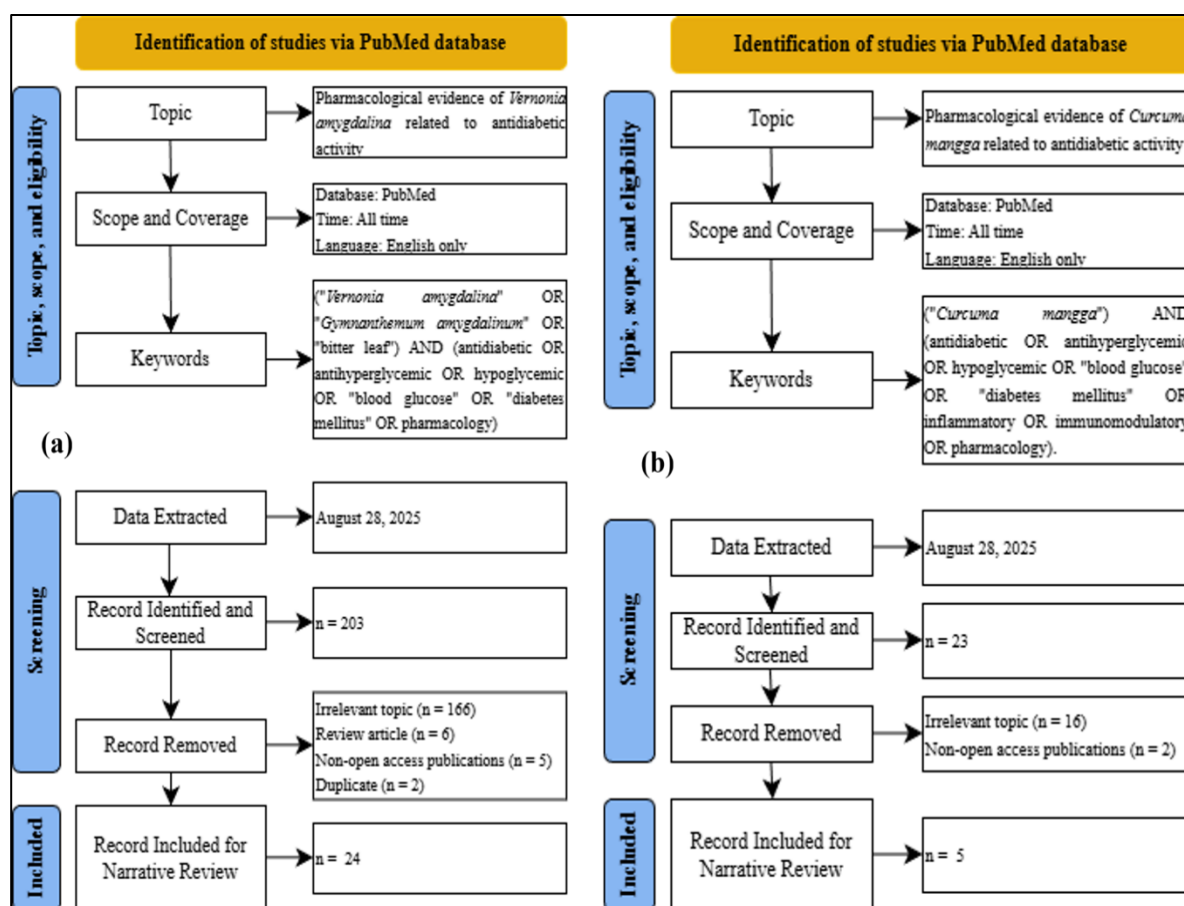


Figure 2. PRISMA flowcharts for the literature selection of (a) *Vernonia amygdalina* and (b) *Curcuma mangga*

The inclusion criteria for the articles reviewed include: (a) original research articles, (b) written in English, (c) discussing antidiabetic activity or relevant pharmacological mechanisms, (d) based on *in vitro*, *ex vivo*, or *in vivo* studies, and (e) available as open access. The exclusion criteria comprise: (a) review articles, (b) duplicate articles, (c) non-open access publications, and (d) articles that are not relevant to antidiabetics, even if they mention both species. For the species *Vernonia amygdalina*, the literature search strategy employed the following keywords: ("Vernonia amygdalina" OR "Gynnanthemum amygdalinum" OR "bitter leaf") AND (antidiabetic OR antihyperglycemic OR hypoglycemic OR "blood glucose" OR "diabetes mellitus" OR pharmacology), while for *Curcuma mangga*, the literature search strategy utilized the following keywords: ("Curcuma mangga") AND (antidiabetic OR antihyperglycemic OR hypoglycemic OR "blood glucose" OR "diabetes mellitus" OR inflammatory OR immunomodulatory OR pharmacology). The literature selection involved

identification, screening of titles and abstracts, and eligibility assessment of full-text articles. The flow of the article selection process is presented in Figure 2.

3. RESULTS AND DISCUSSION

3.1. Characteristics of Informants

A total of ten informants participated in this study, consisting of four males (40%) and six females (60%). Most informants were within the 50–65-year age group (80%), while the remaining 20% were aged 32–49 years. Their educational backgrounds were relatively balanced, with half completing primary school and half completing high school. Occupationally, entrepreneurs represented the largest group (40%), followed by village officials (20%), farmers (20%), private sector employees (10%), and housewives (10%). Although these occupations do not formally categorize them as traditional healers, all ten individuals were included because they are recognized by the community as holders of traditional knowledge related to antidiabetic medicinal plants. In this context, the designation of “traditional healer” reflects a social and cultural role grounded in knowledge and practice rather than a primary profession [21]. These characteristics align with the study’s inclusion criteria, in which informants were purposively selected based on their experience, community recognition, and involvement in the use of medicinal plants for traditional health practices.

The profile of the informants shows that knowledge of antidiabetic medicinal plants in Samigaluh is not limited to a particular profession or educational group, but is instead distributed across individuals with diverse livelihoods. This pattern suggests that traditional healing practices are embedded in everyday community life and are not restricted to formal practitioner roles. The predominance of older informants (50–65 years), as presented in Table 1, aligns with common ethnobotanical observations in which older community members act as custodians of intergenerational knowledge related to medicinal plants [21]. The higher proportion of women (60%) may reflect the central role of women in family care, including the management of medicinal plants and kitchen remedies, as frequently observed in several ethnomedicine studies [11,18,20]. The presence of village officials (20%) among the informants is also noteworthy, as they can function as channels for disseminating health-related knowledge within the community. These characteristics correspond with the purposive and snowball sampling strategies used in this study, which deliberately engage influential and knowledgeable individuals while expanding the network of informants through community-based recommendations [16].

Table 1. Sociodemographic profile of the informants

Characteristics	Category	Number	Percentage (%)
Gender	Male	4	40%
	Female	6	60%
Age (year)	32-49	2	20%
	50-65	8	80%
Level of education	Primary School	5	50%
	Senior High School	5	50%
Occupation	Farmer	2	20%
	Entrepreneur	4	40%
	Private Sector	1	10%
	Employee	1	10%
	Village official	2	20%
	Housewife	1	10%

Source: Personal Data

From a methodological perspective, we acknowledge a limitation regarding the relatively small number of informants, which may restrict generalization [23]. Through the informant identification process, the ten individuals selected represent the complete set of knowledge holders who met the inclusion criteria and were identified until data saturation was achieved, forming a coherent basis for interpreting local ethnomedicinal practices. This limited number also reflects the intentional focus of the research design, which targets traditional healers and individuals with recognized expertise in antidiabetic medicinal plants, rather than a broad survey of the general population [23].

3.2. Taxonomic Diversity

At the family level, Zingiberaceae was the most represented group, comprising seven species, followed by Acanthaceae with three species. Several other families, such as Myrtaceae, Asteraceae, and Apiaceae, were each represented by two species, while the remaining families were represented by a single species, as shown in Figure 3. This “long-tail” pattern reflects the presence of a few dominant families that contribute substantially to the list of antidiabetic species, alongside a larger number of families with more limited representation.

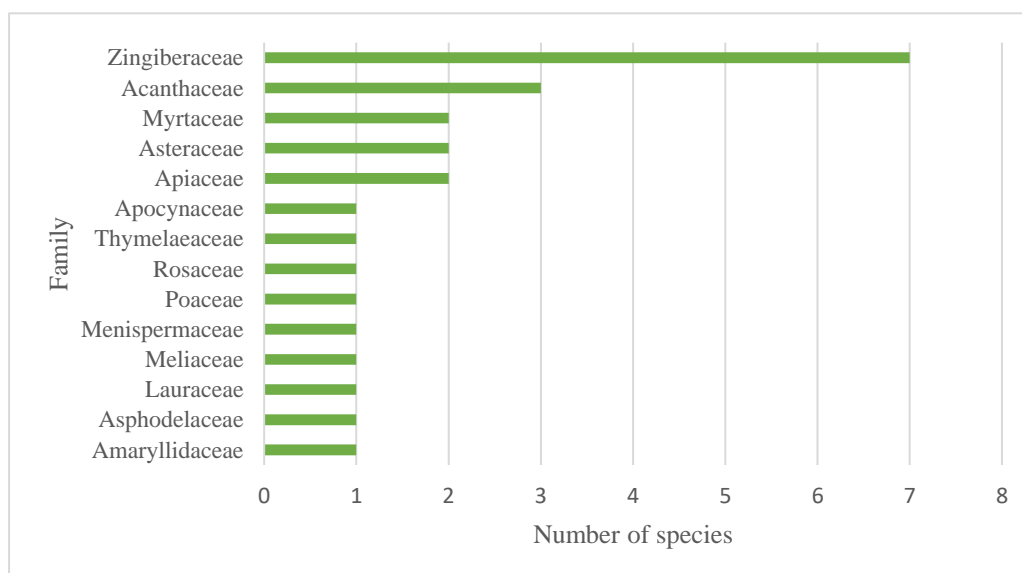


Figure 3. Antidiabetic medicinal plant species by family

The prominence of Zingiberaceae corresponds with ecological and cultural conditions in Samigaluh, where members of this family, such as ginger and various types of turmeric, thrive in agroforestry systems, are readily available in local markets, and occupy a central position within the food–medicine continuum. This pattern is consistent with previous reports identifying Zingiberaceae as one of the most frequently encountered and utilized groups of medicinal plants in the Menoreh Hills region [2,11,22]. Ecologically, the dominance of this family suggests that plant availability plays an important role in shaping therapeutic choices, complementing community perceptions of efficacy [24].

3.3. Quantitative Ethnobotanical Analysis

3.3.1. Relative Importance of Plant Species: Use Value (UV)

The Use Value (UV) analysis reflects the cultural significance of each species based on how frequently it is mentioned and the diversity of its reported uses. Higher UV values indicate that a plant plays a more prominent role in local medicinal practices [17]. In this study, UV values ranged from 0.1 to 1.6 (Table 2). The species with the highest UV values were *Zingiber officinale* (ginger; UV = 1.6), *Curcuma longa* (turmeric; UV = 1.4), *Curcuma mangga* (mango ginger; UV = 1.3), and *Andrographis paniculata* (king of bitters; UV = 1.1). In contrast, several species showed low UV values (0.1–0.2), indicating limited and uneven use among informants.

Table 2. List of antidiabetic medicinal plants in Samigaluh and their ethnobotanical quantitative indices

Local name, scientific name, and family of species	UV	RFC	FL (%)	Part used	Preparation
Acanthaceae					
Dandang Gula (<i>Clinacanthus nutans</i> (Burm.f.) Lindau)	0.1	0.1	100	Leaf, stem	Boiled
Keji Beling (<i>Strobilanthes crispata</i> (L.) Blume)	0.2	0.1	100	Leaf	Boiled
Sambiloto (<i>Andrographis paniculata</i> (Burm.f.) Wall. ex Nees)	1.1	0.6	100	Leaf	Boiled
Amaryllidaceae					
Bawang Putih Lanang (<i>Allium sativum</i> L.)	0.2	0.1	100	Clove	Boiled
Apiaceae					
Adas (<i>Foeniculum vulgare</i> Mill.)	0.3	0.1	100	Seed	Boiled
Ketumbar (<i>Coriandrum sativum</i> L.)	0.2	0.1	100	Seed	Boiled
Apocynaceae					
Pule (<i>Alstonia scholaris</i> (L.) R.Br.)	0.3	0.3	100	Bark	Boiled
Lidah Buaya (<i>Aloe vera</i> (L.) Burm.f.)	0.4	0.2	100	Leaf	Eaten raw
Asteraceae					
Rondo Noleh (<i>Tithonia diversifolia</i> (Hemsl.) A.Gray)	0.2	0.2	100	Leaf	Boiled
Daun Pait (<i>Vernonia amygdalina</i> Delile)	0.8	0.7	100	Leaf	Boiled
Lauraceae					
Kayu Manis (<i>Cinnamomum burmanni</i> (Nees & T.Ness) Blume)	0.7	0.5	100	Bark	Boiled
Meliaceae					
Mahoni (<i>Swietenia macrophylla</i> King)	0.2	0.1	100	Seed	Boiled, eaten raw
Menispermaceae					
Brotowali (<i>Tinospora crispa</i> (L.) Hook.f. & Thomson)	0.7	0.4	100	Stem	Boiled
Myrtaceae					
Cengkeh (<i>Syzygium aromaticum</i> (L.) Merr. & L.M.Perry)	0.3	0.1	100	Flower	Boiled
Poaceae					
Sereh (<i>Cymbopogon citratus</i> (DC.) Stapf)	0.5	0.2	100	Stem	Boiled
Rosaceae					
Apel (<i>Malus domestica</i> (Suckow) Borkh.)	0.3	0.1	100	Fruit	Fermented
Thymelaeaceae					
Mahkota Dewa (<i>Phaleria macrocarpa</i> (Scheff.) Boerl.)	0.1	0.1	100	Fruit peel	Boiled
Zingiberaceae					
Jahe (<i>Zingiber officinale</i> Roscoe)	1.6	0.7	42.86	Rhizome	Boiled, pressed
Kapulaga (<i>Elettaria cardamomum</i> (L.) Maton)	0.2	0.1	100	Seed	Boiled
Kunyit (<i>Curcuma longa</i> L.)	1.4	0.5	60	Rhizome	Boiled, pressed
Lempuyang (<i>Zingiber zerumbet</i> (L.) Roscoe ex Sm.)	0.2	0.1	0	Rhizome	Boiled
Temu Ireng (<i>Curcuma aeruginosa</i> Roxb.)	0.2	0.1	0	Rhizome	Boiled
Temu Mangga (<i>Curcuma mangga</i> Valetton & Zijp)	1.3	0.6	66.67	Rhizome	Boiled
Temulawak (<i>Curcuma zanthorrhiza</i> Roxb.)	1	0.5	40	Rhizome	Boiled, pressed

Source: Personal Data

The high UV values of ginger, turmeric, and mango ginger can be attributed to their strong presence in the Samigaluh landscape. These Zingiberaceae species are easily cultivated in home gardens, widely available in local markets, and commonly used within both culinary and medicinal contexts [11]. Additionally, although *A. paniculata* is not a food plant, it is widely recognized as a traditional remedy for various ailments, including diabetes, and is frequently mentioned by many informants [25].

Species with high UV values occupy an important position in traditional medicinal systems and are therefore promising candidates for further phytochemical and pharmacological investigation

[20]. At the same time, high UV values may signal intensive use or potential harvesting pressure, highlighting the need for sustainable management and conservation to safeguard these biological resources [20].

3.3.2. Consensus and Popularity of Plant Use: Relative Frequency of Citation (RFC)

The RFC reflects the degree of consensus among informants regarding the use of a particular species. A higher RFC value indicates broader recognition and more widely shared knowledge within the community [18]. In this study, RFC values ranged from 0.1 to 0.7 (Table 2). The species with the highest RFC values are *Vernonia amygdalina* (bitter leaf; RFC = 0.7) and *Zingiber officinale* (ginger; RFC = 0.7), followed by *Curcuma mangga* (mango ginger; RFC = 0.6) and *Andrographis paniculata* (king of bitters; RFC = 0.6). Several other plants, including *Cymbopogon citratus* (lemongrass), *Aloe vera*, *Clinacanthus nutans* ("dandang gula" leaf), and *Tithonia diversifolia* ("rondo noleh" leaf), showed low RFC values (0.1–0.2), indicating more limited or sporadic recognition among informants.

The high RFC values for *V. amygdalina*, *Z. officinale*, *C. mangga*, and *A. paniculata* reflect strong community recognition of these species, which are commonly acknowledged as traditional remedies for diabetes [22]. *V. amygdalina* and *A. paniculata* stand out for their roles as specific medicinal plants traditionally used for targeted therapeutic purposes, whereas *Z. officinale* and *C. mangga* are favored for their abundant availability and their dual roles in both culinary and medicinal applications [24,25,26]. In contrast, species with low RFC values likely represent knowledge that is confined to certain individuals or used in narrower contexts [18]. Consequently, species with high RFC values can be considered pillars of local ethnopharmacological knowledge that warrant prioritization in documentation and further research efforts, while species with low RFC values remain important to note as part of biodiversity and traditional knowledge, despite their relatively infrequent use [18].

3.3.3. Specificity of Plant Use for Diabetes: Fidelity Level (FL)

The Fidelity Level (FL) analysis assesses how consistently a plant species is used specifically for diabetes treatment within the local knowledge system. A higher FL value indicates a stronger degree of therapeutic specificity [19]. In this study, FL values ranged from 0% to 100% (Table 2). Several species exhibited an FL of 100%, including *Vernonia amygdalina* (bitter leaf), *Andrographis paniculata* (king of bitters), *Cinnamomum burmannii* (cinnamon), and *Tinospora crispa* (brotowali). For these species, all informants who mentioned them reported their use explicitly for diabetes, reflecting a clear consensus regarding their therapeutic purpose [19].

In contrast, many Zingiberaceae species showed lower FL values. These include *Curcuma mangga* (mango ginger, 66.67%), *Curcuma longa* (turmeric, 60%), *Zingiber officinale* (ginger, 42.86%), *Curcuma zanthorrhiza* (temulawak, 40%), and even *Zingiber zerumbet* (lempuyang) and *Curcuma aeruginosa* (black turmeric), both of which recorded an FL of 0%. These lower values can be attributed to the multifunctional nature of Zingiberaceae species, which are widely used not only for diabetes but also for digestive health, inflammation, and general wellness, leading to less specificity in their medicinal use [27].

This pattern becomes notable when examined alongside UV and RFC. While Zingiberaceae species generally score high in UV and RFC, reflecting their cultural importance, availability, and frequent use, their lower FL values indicate that this use is spread across multiple indications rather than concentrated on diabetes alone [19]. Conversely, species such as *V. amygdalina* and *A. paniculata* combine high UV and RFC values with a 100% FL, reinforcing their position as primary antidiabetic plants with strong local consensus [15,17,20].

Species with 100% FL therefore hold particular significance as candidates for further phytochemical and pharmacological investigation, as they reflect consistent community reliance for diabetes management [19]. Meanwhile, species with moderate or low FL remain valuable components of the ethnomedical repertoire as multipurpose plants, although their consensus for diabetes-specific use is comparatively weaker [19].

3.3.4. Dominant Plant Parts Used in Antidiabetic Remedies: Plant Part Value (PPV)

The Plant Part Value (PPV) analysis identifies which plant organs are most frequently used in antidiabetic preparations [20]. This parameter reflects community preferences that are shaped by factors such as availability, ease of processing, and perceived therapeutic effectiveness [20]. In this study, 140 use reports (UR) were recorded, with plant parts distributed across several categories (Figure 4). Rhizomes constituted the most frequently used part (40.71%), followed by leaves (22.14%) and stems (17.14%). Other parts were used in smaller proportions, including barks (7.14%), seeds (6.43%), fruits (2.14%), flowers (2.14%), cloves (1.43%), and fruit peels (0.71%).

The prominence of rhizomes is closely linked to the Zingiberaceae family, which is widely cultivated in Samigaluh and deeply integrated into both daily consumption and local medicinal practices [11]. This aligns with Javanese culture, which places rhizomes as a primary ingredient in traditional herbal medicine (jamu), both for health maintenance and the treatment of metabolic diseases [28]. Leaves, on the other hand, are predominantly associated with species such as *Vernonia amygdalina* (bitter leaf), *Strobilanthes crispata* (keji beling), and *Tithonia diversifolia*, while stems are used almost exclusively in *Tinospora crispa* (brotowali). In some species, notably *Andrographis paniculata* and *Clinacanthus nutans*, both leaves and stems are utilized, reflecting community perceptions that these organs share similar medicinal properties.

The tendency to utilize rhizomes, stems, and leaves also reflects practical considerations: these parts are readily accessible and easily processed into herbal preparations [24]. Conversely, plant parts such as flowers, fruits, cloves, and peels were mentioned infrequently, suggesting more specialized or limited use. Overall, the dominance of rhizomes highlights the central role of Zingiberaceae in traditional antidiabetic therapies in Samigaluh, whereas leaf-based preparations underscore the importance of species such as *V. amygdalina*, *S. crispata*, and *T. diversifolia*. These findings provide a valuable basis for future phytochemical and pharmacological exploration and emphasize the need for sustainable management strategies to ensure the availability of heavily utilized plant organs [20].

In addition to the plant parts utilized, the preparation methods also reveal interesting patterns. The research findings indicate that boiling is the predominant method for preparing most antidiabetic formulations. This dominance can be understood as boiling is considered the most practical, hygienic method and is effective in extracting water-soluble active compounds from the plant material [13]. Other methods are recorded less frequently, such as consuming fresh (eaten raw): *Aloe vera* and *Swietenia macrophylla* (mahogany seeds), pressing (pressed): *Curcuma longa* (turmeric) and *Curcuma zanthorrhiza* (temulawak), and fermenting (fermented): *Malus domestica* (apples). These variations reflect community adaptation to the physical characteristics of plant materials: fresh consumption is favored for fleshy tissues, hard rhizomes require boiling or crushing to release juices, and fermentation may be used to enhance bioactivity or extend shelf life [27,28,29].

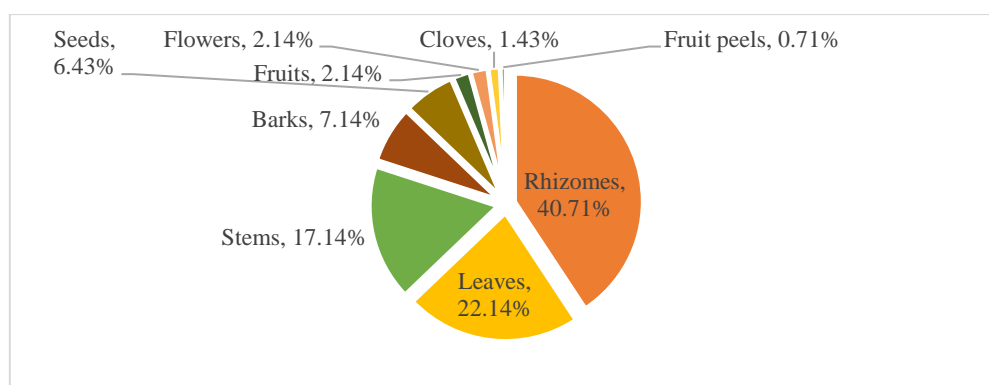


Figure 4. Part of the plant used to treat diabetes in the study area

3.3.5. Selection of Two Promising Species based on Ethnobotanical Indices

The selection of priority species was conducted through an integrated filtering process using four quantitative parameters (UV, RFC, FL, and PPV) to identify candidates that represent two

distinct therapeutic roles: disease specificity and multipurpose versatility [17,19]. *Vernonia amygdalina* was identified as the primary specialist, demonstrating the highest consistency for diabetes specificity (FL = 100%) supported by the highest popularity among specific antidiabetic plants (RFC = 0.7). Although *Andrographis paniculata* shared an identical FL (100%), *V. amygdalina* was prioritized due to its higher Relative Frequency of Citation (RFC = 0.7) compared to *A. paniculata* (RFC = 0.6), indicating a broader consensus among the community regarding its efficacy [21]. The PPV analysis further supports this position, showing that the leaf is the exclusive part utilized, thereby providing a clear focus for subsequent pharmacological review (Table 2).

Curcuma mangga, in contrast, represents a complementary generalist profile, characterized by high practical use intensity (UV = 1.3) and broad popularity (RFC = 0.6) within the Zingiberaceae group. Its moderate FL value (66.67%) reflects multipurpose functionality rather than weak antidiabetic relevance, supported by the dominance of rhizome utilization (Figure 4) [31]. This species is abundantly available in the Samigaluh environment, forming part of daily consumption, and among the Zingiberaceae family, *Curcuma mangga* exhibits the most prominent combination of quantitative indices [2].

To visualize this distinction, a comparative analysis of the ten priority species is presented in Figure 5. The graph shows a clear differentiation between species with high UV but low disease specificity and those with high FL. Within the 'specialist' cluster (FL = 100%), *V. amygdalina* stands out with the highest consensus (RFC = 0.7), affirming its role as the primary diabetes-specific species [18,19]. Conversely, within the 'generalist' group characterized by high UV, *C. mangga* maintains the highest Fidelity Level (66.67%) compared with other dominant Zingiberaceae such as *Curcuma longa* (60%) and *Zingiber officinale* (42.86%), indicating the most favourable balance between multifunctional use and therapeutic relevance [17].

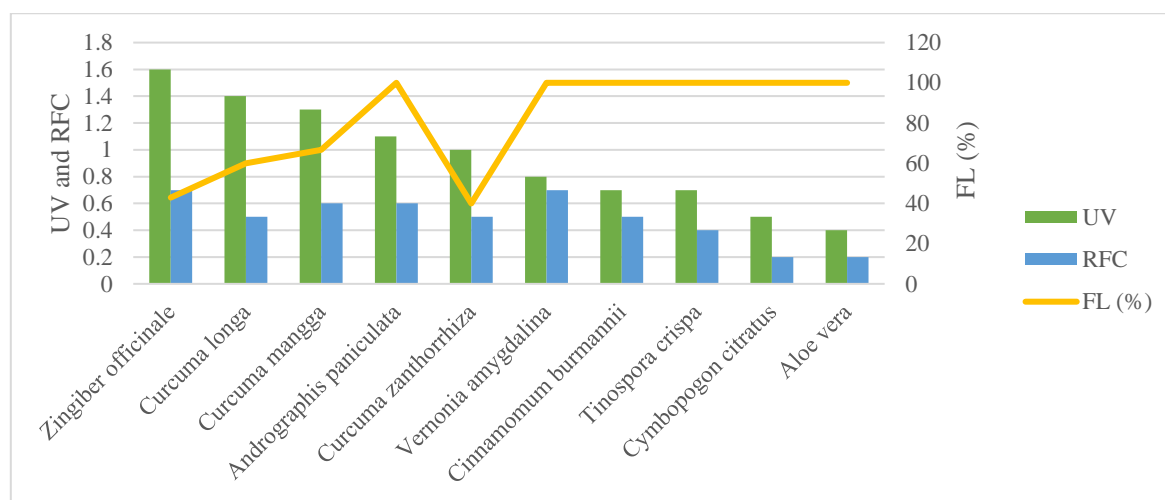


Figure 5. Comparative ethnobotanical indices of the ten priority antidiabetic medicinal plants species used in Samigaluh

Taken together, the UV–RFC–FL–PPV constellation positions *V. amygdalina* as a consensus-driven, disease-specific intervention, whereas *C. mangga* functions as a high-use, metabolically versatile adjunct (Figure 6). This dual-model selection provides a quantifiable and culturally grounded ethnobotanical basis for integrating both species into subsequent pharmacological evaluation [21,31]. To contextualize these ethnomedicinal findings, we conducted a systematic pharmacological review to evaluate how the biological mechanisms of these two species align with their traditional uses in diabetes management.



Figure 6. Photo of *Vernonia amygdalina* and *Curcuma mangga* in the Samigaluh region

3.4. Pharmacological Evidence of Selected Antidiabetic Plants: *Vernonia amygdalina* and *Curcuma mangga*

The literature selection (illustrated in Figure 2) resulted in 24 eligible articles for *V. amygdalina* (VA) and 5 articles for *C. mangga* (CM), restricted to open-access publications, which may have excluded relevant studies. A synthesis of these findings indicates that the two species address diabetes pathophysiology through distinct functional pathways. The comparative evidence is summarized in Table 3 and detailed below.

Table 3. Comparative pharmacological mechanisms of VA and CM relevant to diabetes management

Target Pathway	VA	CM	Combinatorial Implication
Carbohydrate Digestion	Potently inhibits α -amylase and α -glucosidase; reduces intestinal glucose absorption. Downregulates gluconeogenic enzymes	Not the primary mechanism reported in eligible studies.	Reduction of postprandial glucose spikes (VA dominates).
Hepatic Glucose Production	(PEPCK, G6Pase) and activates AMPK pathway to stop hepatic glucose production.	Not the primary mechanism reported in eligible studies.	VA corrects fasting hyperglycemia; CM adds supportive protection.
Peripheral Glucose Uptake	Upregulates GLUT4 in skeletal muscle; improves glycogen synthesis.	Enhances GLUT4 expression in adipocytes; modulates PPAR- γ , showing anti-adipogenic effects.	Dual-site increase in insulin sensitivity (muscle and adipose).
Pancreatic Function	Reduces oxidative stress in β -cells.	Promotes β -cell regeneration; increases insulin levels; antioxidant effects.	Preservation of insulin secretory capacity.
Inflammation & Immune Modulation	Inhibits NF- κ B/MAPK pathway and reduces general oxidative stress.	Downregulates pro-inflammatory cytokines (IL-1 β , IL-6, TNF- α) and stimulates adaptive immunity (IgG, DTH).	Mitigation of chronic inflammation while boosting defense against secondary infections.
Diabetic Complications	Neuroprotection & Hepatoprotection: Protects brain tissue under hyperglycemic conditions and improves liver function.	Analgesic: Strong antinociceptive activity via opioid pathways.	Management of comorbidities.
Safety & Pharmacokinetics	Potential inhibition of CYP3A4/CYP2C9 (drug interaction risk); elevated urea reported in some cases.	No significant toxicity reported in animal models.	Requires dosage optimization to minimize renal load/interactions.

3.4.1. Regulation of Glucose Metabolism

Pharmacological evidence shows that VA functions as a potent regulator of glucose homeostasis through several mechanisms that act on carbohydrate digestion, hepatic glucose production, and peripheral glucose uptake. First, VA targets postprandial hyperglycemia by inhibiting key carbohydrate-digesting enzymes. Polar extracts and specific saponins such as vernoamyoside E exhibit strong α -amylase and α -glucosidase inhibitory activity, effectively delaying glucose absorption [32-35]. This enzymatic inhibition is consistent with *ex vivo* findings demonstrating reduced intestinal glucose uptake [36].

Second, VA suppresses hepatic glucose output, which is a major contributor to fasting hyperglycemia, by downregulating gluconeogenic enzymes (Phosphoenolpyruvate carboxykinase-PEPCK and G6Pase) and activating the AMPK pathway [37,38]. Third, VA enhances peripheral glucose utilization through increased GLUT4 translocation in muscle tissue [36,39]. These combined effects are supported by *in vivo* studies showing marked reductions in blood glucose levels across chemically induced (STZ or alloxan) and genetic diabetes models [40-45]. Functional food applications, such as bitterleaf-flavored non-alcoholic beverages, further demonstrate preserved regulatory activity on GLUT-2 and insulin levels [46]. Although CM also exhibits hypoglycemic activity, primarily through GLUT4 upregulation and PPAR- γ modulation in adipocytes (suggesting an anti-adipogenic effect), it does not display the broad enzymatic inhibition characteristic of VA [47]. Consequently, within a combined herbal formulation, VA would serve as the primary metabolic regulator.

3.4.2. Pancreatic Protection and Immunomodulation

The therapeutic relevance of CM lies primarily in its protective effects on pancreatic tissue and its capacity to modulate the immune response, two processes that are central to the progression of T2DM, particularly in the context of chronic inflammation and β -cell dysfunction [47]. Studies in diabetic rat models have shown that CM promotes pancreatic β -cell regeneration, accompanied by increases in circulating insulin levels and improvements in oxidative stress markers, including reductions in MDA and elevations in SOD activity [48].

More recent molecular findings further strengthen this profile. Extracts of CM significantly downregulate the expression of key pro-inflammatory cytokines (IL-1 β , IL-6, and TNF- α), indicating a direct influence on inflammatory gene pathways [49]. In addition, the plant demonstrates dual immunomodulatory activity by enhancing innate phagocytic function while also stimulating adaptive immune responses, as reflected in increased IgG production and augmented delayed-type hypersensitivity (DTH) reactions in immunosuppressed models. This immunostimulatory capacity is particularly relevant for mitigating the high susceptibility to secondary infections and impaired wound healing frequently observed in diabetic patients [48,49].

Although VA also exhibits antioxidant and anti-inflammatory activity, including inhibition of the NF- κ B pathway and neuroprotective effects in hyperglycemic conditions, the protective actions of CM are more specifically oriented toward preserving pancreatic integrity [51-54]. Moreover, its demonstrated analgesic and anti-inflammatory effects via opioid-mediated pathways may offer additional benefits for managing diabetic neuropathic symptoms, an effect that has not been prominently reported for VA [55].

3.4.3. Synergy, Safety, and Interaction Potential

Previous studies have shown that VA can produce synergistic effects when combined with other medicinal plants, such as *Ocimum gratissimum*, *Azadirachta indica*, and *Tamarindus indica*, resulting in enhanced glycemic control and additional improvements in lipid profiles or antioxidant benefits depending on the combination [43, 56-58]. However, safety considerations remain essential. Although subacute toxicity studies generally report stable liver function (ALT/AST), some findings indicate increased urea levels following administration of VA and *Zingiber officinale* infusions, suggesting the need for caution regarding renal health [59].

In addition, pharmacokinetic research has demonstrated that VA may inhibit CYP3A4 and CYP2C9, two major drug-metabolizing enzymes, potentially elevating the plasma concentration of co-administered agents such as metformin [60]. These mechanisms highlight the importance of evaluating herb–drug interactions when considering combined therapeutic approaches. Taken together, the proposed herbal combination relies on the high metabolic specificity of VA and the complementary tissue-protective and immunomodulatory properties of CM. Nonetheless, appropriate dosage optimization and safety validation are required to minimize potential renal risks or interaction-related complications.

4. CONCLUSION

This study provides the first quantitative ethnopharmacological documentation of antidiabetic plants in Samigaluh, establishing a scientific basis for connecting local medicinal knowledge with modern phytotherapy. The integrated analysis of ethnobotanical indices (UV, RFC, and FL) identified two priority species with distinct therapeutic profiles: *Vernonia amygdalina* as a high-consensus disease specialist and *Curcuma mangga* as a versatile therapeutic generalist. The key contribution of this research lies in proposing a complementary combinatorial model. Pharmacological synthesis demonstrates that *V. amygdalina* functions as a potent metabolic regulator, primarily through digestive enzyme inhibition and suppression of hepatic gluconeogenesis, while *C. mangga* provides supportive benefits through pancreatic β -cell protection, antioxidant activity, and immunomodulation. Together, these mechanisms theoretically address the multifactorial nature of type 2 diabetes by targeting both hyperglycemia and tissue-level dysfunction. Based on these findings, we recommend specific directions for future research. Priority should be given to in vivo studies evaluating the synergistic effects of combined extracts on glucose tolerance, insulin secretion, and pancreatic histology. Additionally, considering the potential CYP-mediated interactions reported for *V. amygdalina*, pharmacokinetic assessment and renal safety monitoring are essential prerequisites before advancing toward translational or clinical application.

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