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RESEARCH ARTICLE

Phytochemical Analysis and *In Vitro* Evaluation of Antidiabetic Potential of Banana Bract Lehya

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Abstract: Banana Bract Lehya, a traditional Ayurvedic formulation, has gained recognition for its potential therapeutic applications. This study aimed to prepare, characterize, and evaluate the physicochemical properties and biological activities of Banana Bract Lehya. The lehya was prepared using banana bract powder (*Musa paradisiaca*), jaggery, tamarind, and a blend of spices including cumin, ajwain, ginger, fennel, and black pepper. Phytochemical screening revealed the presence of various bioactive compounds, with high concentrations of flavonoids and phenolic compounds, and moderate levels of tannins and terpenoids. Physicochemical analysis showed a pH of 6.20, loss on drying of 70%, total ash content of 3.2%, and total solid content of 96%. Organoleptic evaluation indicated a light brown and black color, pungent and spicy taste, and jelly-like texture. The total phenolic content was 78.5 ± 3.2 mg GAE/g, while the total flavonoid content was 42.3 ± 2.1 mg QE/g. Antioxidant activity, assessed by DPPH free radical scavenging assay, showed an IC50 value of 127.6 ± 5.4 µg/mL, compared to ascorbic acid's 23.8 ± 1.2 µg/mL. Glucose adsorption capacity increased with rising glucose concentration, suggesting potential anti-diabetic effects. The lehya exhibited concentration-dependent inhibition of α-amylase and α-glucosidase enzymes, with IC50 values of 156.3 ± 7.2 µg/mL and 143.7 ± 6.5 µg/mL, respectively, compared to acarbose's 83.2 ± 3.8 µg/mL and 95.6 ± 4.1 µg/mL. These findings provide valuable insights into the composition, physicochemical properties, and potential health benefits of Banana Bract Lehya. The results suggest promising antioxidant and anti-diabetic activities, supporting its traditional use and potential for modern therapeutic applications.

Keywords: Banana bract lehya; Ayurvedic medicine; Phytochemicals; Traditional formulation; Herbal therapy.

1. Introduction

Ayurveda, the ancient Indian system of medicine, has been a cornerstone of traditional healthcare for thousands of years [1]. Among its vast repertoire of therapeutic formulations, lehyas hold a special place due to their unique composition and versatile applications. Lehyas, also known as avalehas, are semi-solid preparations that combine herbal ingredients with sweetening agents, resulting in a palatable and potent medicinal formulation [2]. One such lehya that has garnered attention in recent years is the Banana Bract Lehya, derived from the bracts of *Musa paradisiaca*. The banana plant, *Musa paradisiaca*, has been cultivated for millennia across tropical and subtropical regions [3]. While its fruit is widely consumed and appreciated, the plant's other parts, including the bracts, have traditionally been used for medicinal purposes in various cultures [4]. The bracts, which are large, modified leaves that protect the developing fruit, have been found to contain a range of bioactive compounds with potential therapeutic properties [5]. Banana Bract Lehya is a traditional Ayurvedic formulation that harnesses the medicinal properties of banana bracts along with other herbal ingredients [6]. The preparation typically involves the use of banana bract powder, jaggery (unrefined cane sugar), tamarind, and a carefully selected blend of spices such as cumin, ajwain, ginger, fennel, and black pepper [7]. Each of these components contributes to the overall therapeutic profile of the lehya, making it a complex and potentially effective remedy for various health conditions. The use of lehyas in Ayurvedic medicine dates back to ancient times, with references found in classical texts such as the Charaka Samhita and Sushruta Samhita [8]. These semi-solid preparations were developed as a means to preserve the medicinal properties of herbs for extended periods and to enhance their palatability. The addition of sweetening agents like jaggery or honey not only improves taste but also acts as a natural preservative, extending the shelf life of the preparation [9].

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The process of preparing Banana Bract Lehya involves several steps, each crucial to the final product's efficacy [10]. Initially, a decoction is prepared from the banana bracts and other herbal ingredients. This decoction is then concentrated through careful heating, and jaggery is added to achieve the desired consistency. The addition of spices not only enhances the flavor but also contributes to the lehya's therapeutic properties [11]. The potential health benefits of Banana Bract Lehya are multifaceted, reflecting the diverse array of bioactive compounds present in its ingredients [12]. Preliminary studies and traditional usage suggest that this lehya may have applications in managing blood sugar levels, promoting lactation in nursing mothers, and addressing various digestive issues [13]. The antioxidant and anti-inflammatory properties of many of its constituents further expand its potential therapeutic scope [14]. The banana bract itself is rich in dietary fibers, flavonoids, and anthocyanins [15]. These compounds have been associated with various health benefits, including improved digestive health, antioxidant effects, and potential anti-diabetic properties [16]. The addition of spices like cumin, ajwain, and ginger brings in their respective therapeutic properties, such as carminative, anti-spasmodic, and anti-inflammatory effects [17]. Despite its long history of use in traditional medicine, Banana Bract Lehya has only recently begun to attract scientific attention [18]. The growing interest in natural and traditional remedies, coupled with the need for new therapeutic approaches to chronic diseases, has sparked research into the potential applications of this Ayurvedic formulation [19]. However, much work remains to be done to fully understand its mechanisms of action, standardize its preparation, and establish its efficacy and safety through rigorous clinical trials [20].

The exploration of traditional formulations like Banana Bract Lehya represents a bridge between ancient wisdom and modern scientific inquiry [21]. It offers an opportunity to tap into the vast knowledge accumulated over centuries of traditional practice while subjecting it to the scrutiny of contemporary research methodologies [22]. This approach not only holds the potential for developing new therapeutic options but also contributes to the preservation and validation of traditional medical knowledge [23]. As research into Banana Bract Lehya progresses, several key areas demand attention [24]. These include the identification and characterization of all bioactive compounds present in the formulation, the elucidation of their individual and synergistic effects, and the investigation of potential interactions with other medications [25]. Additionally, the development of standardized preparation methods and quality control measures is crucial to ensure consistency and reliability in both research and potential clinical applications [26]. The growing global interest in complementary and alternative medicine further underscores the importance of studying traditional formulations like Banana Bract Lehya [27]. As healthcare systems worldwide grapple with the challenges of chronic diseases and the limitations of conventional treatments, the exploration of natural remedies offers a promising avenue for expanding therapeutic options [28-32]. The primary objective of this study is to evaluate the phytochemical composition and potential antidiabetic properties of Banana Bract Lehya, an Ayurvedic polyherbal formulation

2. Materials and methods

2.1. Plant Material Collection and Authentication

Banana bracts (*Musa paradisiaca*) were collected from local banana plantations in Shivamogga, Karnataka, India. The plant material was authenticated by a qualified botanist from the Department of Botany, National College, Shivamogga. A voucher specimen was deposited in the herbarium for future reference.

2.2. Preparation of Banana Bract Lehya

The following ingredients were used in the preparation of the herbal Lehya:

Sl no	Ingredients	Biological source	Family	Part use	Quantity taken
1	**Banana bract powder**	*Musa paradisiaca*	Musaceae	Bract	20gm
2	**Jaggery:**	*Saccharum officinarum*	Poaceae	Jaggery syrup	40gm
3	**Tamarind**	*Tamarindus indica*	Fabaceae	Fruit	50gm
4	**Cumin powder**	*Cuminum cyminum*	Apiaceae	Seed	10gm
5	**Ajwain seeds**	*Trachyspermum ammi*	Apiaceae	Seed	5gm
6	**Ginger**	*Zingiber officinale*	Zingiberaceae	Rhizome	5gm
7	**Fennel**	*Foeniculum vulgare,*	Apiaceae	Seeds	10gm
8	**Black pepper**	*Piper nigrum*	Piperaceae	Seeds	2gm

The Banana Bract Lehya was prepared following traditional Ayurvedic methods with slight modifications [33]:

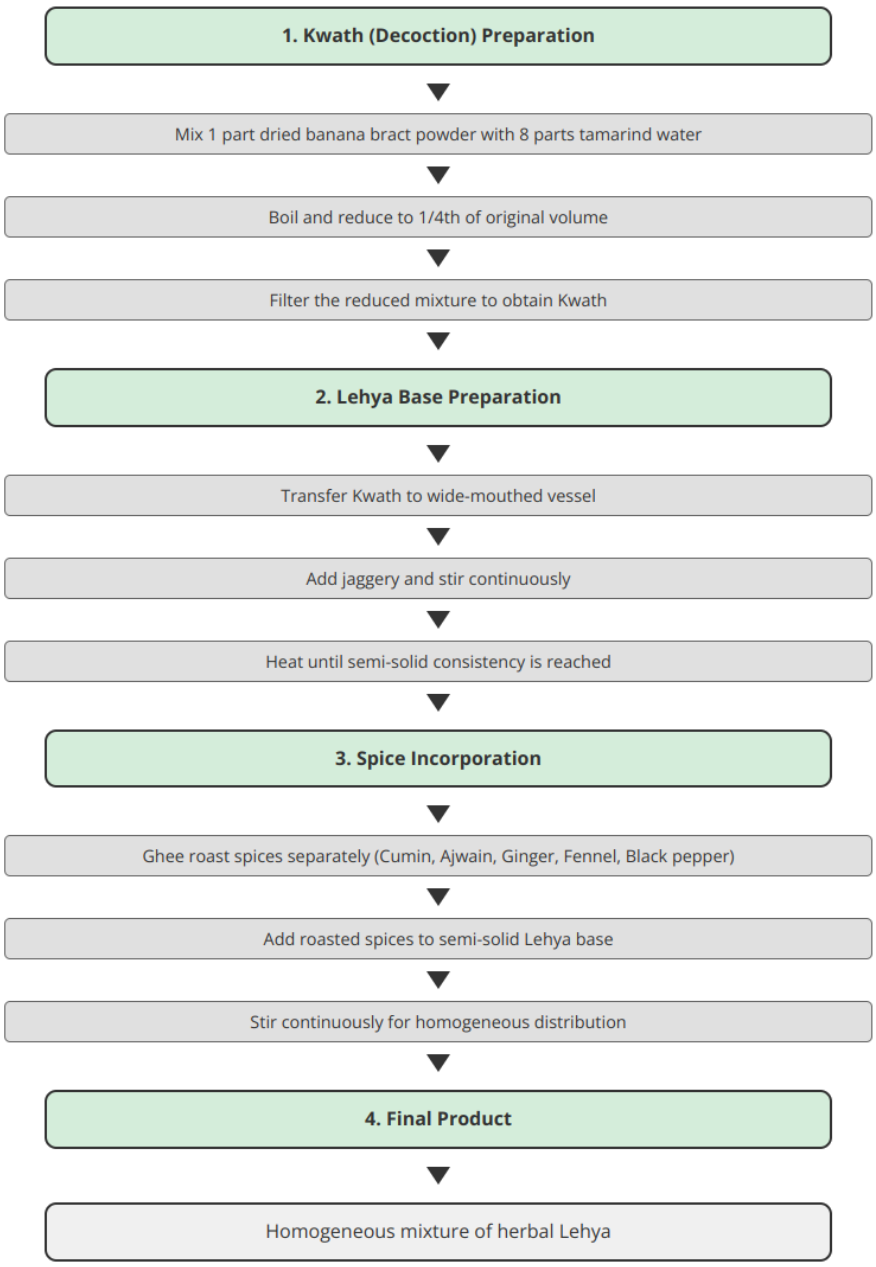

Figure 1. Process of herbal lehya preparation

2.3. Phytochemical Screening

Preliminary phytochemical screening of the Banana Bract Lehya was carried out to identify the presence of various phytoconstituents using standard methods [34]. Tests were performed for alkaloids, flavonoids, tannins, saponins, terpenoids, and phenolic compounds.

2.4. Physicochemical analysis

2.4.1. pH Determination

A 10% aqueous solution of the Lehya was prepared. The pH was measured using a calibrated pH meter with an electrode system at room temperature (25°C ± 2°C). [34, 35]

2.4.2. Loss on Drying

2 g of Lehya was accurately weighed and placed in a pre-weighed porcelain crucible. The sample was heated on a hot plate at 110°C for 3 hours. The crucible was then cooled in a desiccator and reweighed. This process was repeated until a constant weight was achieved. The loss on drying was calculated as a percentage of the initial weight. [34, 35]

2.4.3. Total Ash Content

5 g of air-dried, ground Lehya was placed in a pre-ignited, weighed crucible. The sample was gradually heated to 500-600°C until it turned white, indicating complete combustion. The crucible was cooled in a desiccator and reweighed. This process was repeated until a constant weight was achieved. The total ash content was calculated as a percentage of the initial air-dried sample weight. [34, 35]

2.4.4. Total Solid Content

10 g of Lehya was placed in a pre-weighed, clean beaker. The beaker was initially placed on a water bath at a low temperature to remove most of the moisture. It was then transferred to an oven set at 40°C and dried until a constant weight was reached. The total solid content was calculated as a percentage of the initial sample weight. [34, 35]

2.4.5. Organoleptic Evaluation

The following parameters were assessed [34, 35]:

a) Color: Visual observation under standard lighting conditions

b) Taste: Small samples were tasted and described

c) Texture: Evaluated by feel and appearance.

2.5. Determination of Total Phenolic Content

The total phenolic content of the lehya was determined using the Folin-Ciocalteu method [35]. Gallic acid was used as a standard, and the results were expressed as mg of gallic acid equivalents (GAE) per gram of lehya.

2.6. Determination of Total Flavonoid Content

The total flavonoid content was estimated using the aluminum chloride colorimetric method [36]. Quercetin was used as a standard, and the results were expressed as mg of quercetin equivalents (QE) per gram of lehya.

2.7. Antioxidant Activity Assay

The antioxidant activity of the Banana Bract Lehya was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging assay [37]. Various concentrations of the lehya extract (50-250 µg/mL) were prepared. The DPPH solution was added to each concentration, and the absorbance was measured at 517 nm after 30 minutes of incubation in the dark. Ascorbic acid was used as a positive control.

2.8. Glucose Adsorption Capacity

The glucose adsorption capacity of the lehya was determined using the method described by Ou et al. [38] with slight modifications. Different concentrations of glucose solution (5, 10, 15, and 20 mmol/L) were prepared in phosphate buffer (pH 6.8). One gram of lehya was mixed with 100 mL of glucose solution and incubated at 37°C for 6 hours. After centrifugation, the glucose content in the supernatant was determined using a GOD-POD glucose diagnosing kit.

2.9. In vitro α-Amylase Inhibition Assay

The α-amylase inhibition assay was performed according to the method described by Bernfeld [39] with some modifications. Various concentrations of lehya extract (50-250 µg/mL) were incubated with α-amylase enzyme and starch solution. The reaction was stopped by adding DNS (3,5-dinitrosalicylic acid) reagent, and the absorbance was measured at 540 nm. Acarbose was used as a positive control.

2.10. In vitro α-Glucosidase Inhibition Assay

The α-glucosidase inhibition assay was carried out using the method described by Kim et al. [40]. Different concentrations of lehya extract (50-250 µg/mL) were incubated with α-glucosidase enzyme and p-nitrophenyl-α-D-glucopyranoside substrate. The absorbance was measured at 405 nm, and acarbose was used as a positive control.

2.11. Statistical Analysis

All experiments were performed in triplicate, and the results were expressed as mean ± standard deviation (SD). Statistical analysis was carried out using one-way ANOVA followed by Tukey's post-hoc test. A p-value < 0.05 was considered statistically significant. GraphPad Prism software.

3. Results and Discussion

3.1. Phytochemical Screening

The preliminary phytochemical screening of Banana Bract Lehya revealed the presence of various bioactive compounds, as shown in Table 1. The lehya was found to be rich in flavonoids, phenolic compounds, and alkaloids, which are known for their diverse pharmacological activities [41].

Table 1: Phytochemical screening of Banana Bract Lehya

Phytoconstituent	Presence
Alkaloids	+
Flavonoids	+++
Tannins	++
Saponins	+
Terpenoids	++
Phenolic compounds	+++

+++ (high), ++ (moderate), + (low), - (absent)

3.2. Physicochemical analysis

The physicochemical analysis of the prepared Lehya revealed several important characteristics. The pH value was found to be 6.20, indicating a slightly acidic nature. The loss on drying was substantial at 70%, suggesting a high moisture content in the preparation. The total ash content was relatively low at 3.2%, which may indicate a low amount of inorganic components. The total solid content was high at 96%, suggesting a concentrated preparation. Organoleptic evaluation showed that the Lehya had a light brown and black color, a pungent and spicy taste, and a jelly-like texture. These properties are consistent with the ingredients used and the preparation method [42].

Parameter	Result
pH Value	6.20
Loss on Drying	70%
Total Ash Content	3.2%
Total Solid Content	96%
Organoleptic Evaluation	Color: Light brown and black Taste: Pungent and spicy Texture: Jelly

3.3. Total Phenolic and Flavonoid Content

The total phenolic content of Banana Bract Lehya was found to be 78.5 ± 3.2 mg GAE/g, while the total flavonoid content was 42.3 ± 2.1 mg QE/g. These results indicate a significant presence of phenolic compounds and flavonoids, which contribute to the antioxidant properties of the lehya [42].

3.4. Antioxidant Activity

The DPPH free radical scavenging assay demonstrated a dose-dependent increase in the antioxidant activity of Banana Bract Lehya (Figure 2). The IC50 value of the lehya was found to be 127.6 ± 5.4 µg/mL, compared to the ascorbic acid standard with an IC50 of 23.8 ± 1.2 µg/mL. While the lehya exhibited lower antioxidant activity than ascorbic acid, its significant free radical scavenging potential suggests it may offer protection against oxidative stress-related disorders [43].

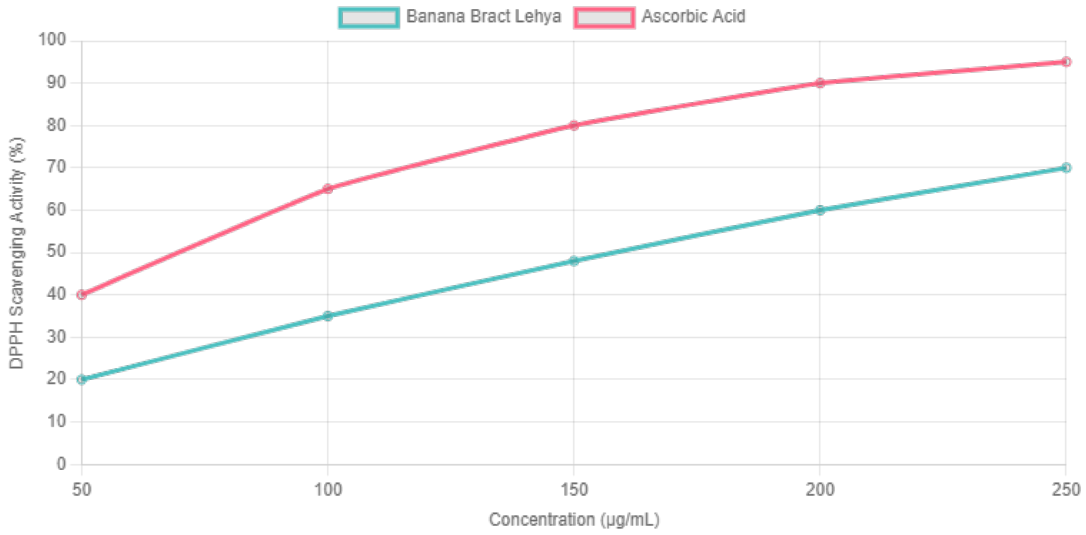

Figure 2: DPPH free radical scavenging activity of Banana Bract Lehya and ascorbic acid

3.5. Glucose Adsorption Capacity

The glucose adsorption capacity of Banana Bract Lehya increased with rising glucose concentration (Table 2). This property may contribute to its potential anti-diabetic effects by reducing glucose absorption in the gastrointestinal tract [44]

Table 2: Glucose adsorption capacity of Banana Bract Lehya

Glucose Concentration (mmol/L)	Glucose Bound (mmol/g lehya)
5	0.42 ± 0.03
10	0.87 ± 0.05
15	1.35 ± 0.08
20	1.78 ± 0.11

3.6. α-Amylase and α-Glucosidase Inhibition

Banana Bract Lehya exhibited concentration-dependent inhibition of both α-amylase and α-glucosidase enzymes (Figure 3). The IC50 values for α-amylase and α-glucosidase inhibition were 156.3 ± 7.2 µg/mL and 143.7 ± 6.5 µg/mL, respectively. In comparison, the standard drug acarbose showed IC50 values of 83.2 ± 3.8 µg/mL for α-amylase and 95.6 ± 4.1 µg/mL for α-glucosidase inhibition. These results suggest that Banana Bract Lehya may have potential as a natural anti-diabetic agent by inhibiting carbohydrate-hydrolyzing enzymes [45].

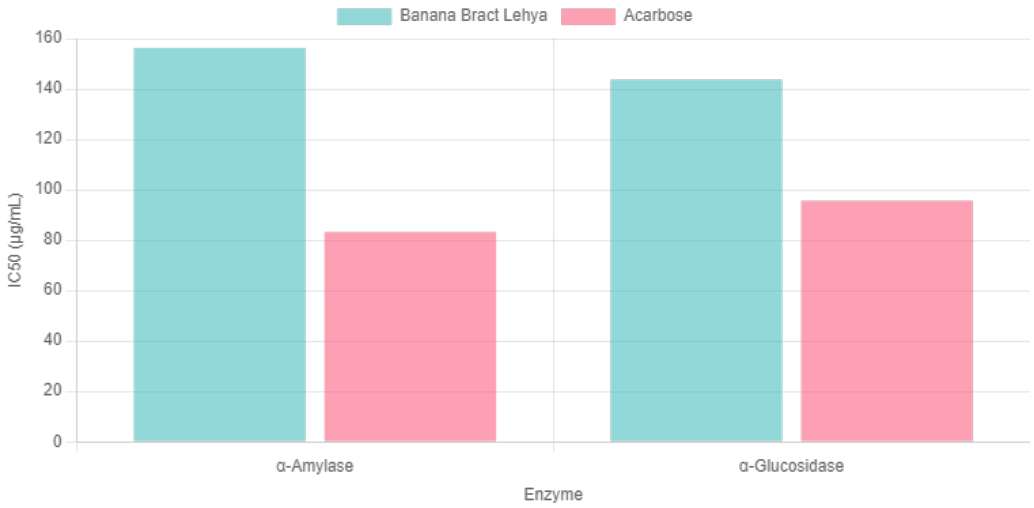

Figure 3: α-Amylase and α-Glucosidase inhibition by Banana Bract Lehya and acarbose

4. Discussion

The phytochemical analysis of Banana Bract Lehya revealed a rich composition of bioactive compounds, particularly flavonoids and phenolic compounds. These findings are consistent with previous studies on banana plant parts, which have reported similar phytoconstituents [46]. The high phenolic and flavonoid content observed in our study correlates with the significant antioxidant activity exhibited by the lehya.

The antioxidant potential of Banana Bract Lehya, as demonstrated by the DPPH assay, suggests its ability to neutralize free radicals. This property is particularly relevant in the context of diabetes management, as oxidative stress plays a crucial role in the pathogenesis and progression of diabetes mellitus [47]. The antioxidant activity of the lehya can be attributed to its phenolic and flavonoid content, which are known for their free radical scavenging abilities [48].

The glucose adsorption capacity of Banana Bract Lehya indicates its potential to reduce glucose absorption in the gastrointestinal tract. This mechanism could contribute to the management of postprandial glucose levels, which is an important aspect of diabetes control [49]. The observed increase in glucose binding with higher glucose concentrations suggests that the lehya may be more effective in hyperglycemic conditions.

The inhibition of α-amylase and α-glucosidase enzymes by Banana Bract Lehya is a significant finding, as these enzymes play key roles in carbohydrate digestion and glucose absorption. By inhibiting these enzymes, the lehya may help in reducing postprandial glucose spikes [50]. Although the inhibitory effect was less potent than that of acarbose, the natural origin of the lehya may offer advantages in terms of fewer side effects and better tolerability.

5. Conclusion

This study provides valuable insights into the phytochemical composition and potential anti-diabetic properties of Banana Bract Lehya. The lehya demonstrated significant antioxidant activity, glucose adsorption capacity, and inhibition of α-amylase and α-glucosidase enzymes, all of which are relevant to diabetes management. These findings support the traditional use of this Ayurvedic formulation and suggest its potential as a natural therapeutic agent for diabetes. However, further in vivo studies and clinical trials are necessary to fully elucidate its efficacy and safety profile. The results of this study lay a foundation for future research into the development of standardized, evidence-based natural remedies for diabetes, bridging the gap between traditional wisdom and modern scientific inquiry.

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