RESEARCH PAPER

A Review of Borassus Flabellifer Sprout in Various Medicinal Applications

Selvakumar Chandrasekaran[1,2]*, Selvaraj Bharathi [3]*, Sathishkumar Venkatachalam[4], Saravanan Durai[5] and Sendilkumar Balasundram[6]

*[1]*Department of Biochemistry, School of Allied Health Sciences, VIMS Hospital Campus, Vinayaka Mission's Research Foundation – (Deemed to be University), Salem 636308, Tamil Nadu*
*[2]*School of Science and Humanities, Sathyabama Institute of Science and Technology -(Deemed to be University), Chennai.600119, Tamil Nadu.*
[3] Centre for Modern Organic Agricultural Research, Sathyabama Institute of Science and Technology - (Deemed to be University), Chennai.600119, Tamil Nadu*
[4]Department of Microbiology, School of Allied Health Sciences, VIMS Hospital Campus, Vinayaka Mission's Research Foundation – (Deemed to be University), Salem 636308, Tamil Nadu.
[5]Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai – 602 105
[6]School of Allied Health Sciences, VIMS Hospital Campus, Vinayaka Mission's Research Foundation – (Deemed to be University), Salem 636308, Tamil Nadu
[1]ORCID ID: 0009-0006-3190-192X, [3]ORCID ID: 0000-0002-2767-297X., [4]ORCID ID: 0000-0002-4527-510X., [5]ORCID ID: 0000-0003-3955-074X. and [6]ORCID ID: 0000-0001-5368-5603.
[1,2]Corresponding Author, Email ID- selvaihasc@yahoo.com,
[3]Corresponding Author, Email ID- sbharathimicro@gmail.com

Received: 28th Feb, 2026; Revised: 6th March 2026; Accepted: 7th April, 2026; Available Online: 20th April, 2026

ABSTRACT
Borassus flabellifer (Palmyra palm) is a most valued medicinal plant for its benefits and nutritional value. Edible parts such as fruit, sprouts, and palm sugar provide carbohydrates, fiber, vitamins, minerals, and antioxidants, which play a vital role in metabolic regulation and glycemic control and are cultivated mainly in the summer season. High fiber content in sprouts helps to manage digestion problems and low glycemic index values. Flavonoids, Phenolic acids, Saponins and Glycosides are bioactive constituents with important antidiabetic, antioxidant and anti-inflammatory activities as well as wound healing properties. Comparative evaluation of related palms, including *Phoenix dactylifera*, *Cocos nucifera*, and *Elaeis guineensis*, showed a distinct phytochemical profile and broader therapeutic range of *B. flabellifer*. Traditional and industrial uses extend from food and herbal formulations to handicrafts, biofuels, and natural sweeteners, thereby providing sustainable income for rural communities. This review highlights the need for detailed pharmacological and clinical investigations to support broader therapeutic applications.

Keywords: *Borassus flabellifer. Sprout, Medicinal uses, Phytochemistry, Pharmacology and Diabetic*
How to cite this article: Chandrasekaran S, Bharathi S, Venkatachalam S, Durai S, Balasundram S. A Review of Borassus flabellifer Sprout in Various Medicinal Applications. Int J Drug Deliv Technol. 2026;16(61s):783-789. DOI: 10.25258/ijddt.16.61s.86
Source of support: Nil.
Conflict of interest: None

INTRODUCTION

The Palmyra palm, or *Borassus flabellifer*, is a plant that is cultivated across India, especially in southern India, and can withstand drought conditions. Lifespan of the tree will be around 100 years, and it takes about 15 years for it to begin yielding and continue to do so for the next 50 years.[1,2] The Arecaceae family includes a native plant of Tamil Nadu that is often referred to as "Panai Kizhangu" in Tamil and "Palmyra Sprout" in English. During the winter months of October through December in Tamil Nadu, these edible sections are widely accessible and quite popular.[3] The plant can tolerate any climate and reach a height of around 30 to 40 feet. To provide further information on Borassus's root system, *B. flabellifer* may reach a depth of 10 feet to collect water, and adventitious roots offer structural stability and anchoring in the event of strong winds, as well as the ability to take nutrients from the topsoil layer. As a result, it can endure drought conditions and maintain stability.[1]

In addition to the Palmyra palm's enormous therapeutic benefits, villagers use its leaves, stem, and trunk to manufacture eco-friendly handicrafts including hand fans, mats, baskets, broomsticks, walking sticks, coir coils, chairs, and stools, among other goods, to improve their socioeconomic standing.[4] *Borassus flabellifer* contains several edible portions that are abundant in nutrients and

**Author for Correspondence: selvaihasc@yahoo.com*

may be eaten both raw and cooked. (a) Tender fruit, (b) mature fruit pulp, (c) sprout (Panankizhangu), and (d) toddy (fermented sap) are examples of edible parts. Palm sugar, also known as jaggery (karuppatti), is a natural sugar that may be used instead of artificial sweeteners to help regulate blood sugar levels in certain patients. The glycemic index of various edible components ranges from approximately 30 to 70, which aids in controlling carbohydrate metabolism. *Borassus flabellifer* contains nutrients that work as cofactors to manage many illnesses and regulate several metabolic processes. Vitamins A, B, and C help prevent a number of nutritional deficiency problems, fiber aids in digestion and bowel movements, and electrolytes, including iron, calcium, potassium, and magnesium, support bone health and haematological processes. All edible components include extremely small or trace amounts of unsaturated fats, making them safe to eat even if they have one diabetes, lipid disorders, or cardiovascular problems. It also includes carotenoids, which are fat-soluble antioxidants that support skin and eye health.[1,5]

Researchers are continuously looking into natural agricultural products for pharmacological reasons because they are easily accessible, less expensive, and do not have any adverse side effects compared to modern therapeutic pharmaceuticals.[6,7] People have used plants for medicinal and health-related reasons since prehistoric times. Medicinal plants play an important role in the human healthcare system. The versatility of this allows it to produce a wide range of pharmacological effects, such as immunomodulatory, diuretic, antimalarial, anthelmintic, wound-healing, antibacterial, antifungal, antioxidant, and analgesic actions.

Patients with diabetes mellitus can benefit greatly from their high fiber content and low glycemic value. The small amounts of vitamins and minerals in this sprout aid in controlling the regular metabolic processes. According to Révész et al.,[8] sprouts also have antioxidant and anti-inflammatory properties and may be used to treat dermatitis, nausea, and vomiting. New approaches to modern drugs are made possible by an understanding of medicinal plants.[9] Because of their safety, efficacy, and low incidence of side effects, herbal drugs are greatly sought after in the developed world of primary healthcare. Approximately 4,000 of these plants have genuine medicinal properties that the general population is either unaware of or just vaguely aware of.[1] There is a growing demand for herbal resources and a heightened awareness of the need to maintain the integrity and purity of raw materials since herbal therapies are more prone to adverse effects than synthetic ones.[10]

Different parts of *B. flabellifer* contain a variety of phytochemicals.[11] The *B. flabellifer* sprout was discovered to include flavonoids, tannins, saponins, alkaloids, carbohydrates, phenolic compounds, terpenoids, and glycosides by researchers using a qualitative phytochemical study.[12] The researchers suggested exploiting the sprout for drug development and therapeutic uses in light of these findings. Mature *B. flabellifer* sprouts were picked and cooked at the ideal temperature to optimize their therapeutic properties. Peeling the outer layer has allowed researchers to examine its many medicinal properties, including its antibacterial, anticancer, and antidiabetic activities. Herbal remedies for ailments are widely accepted by the public.[13] Many ancient cultures recognized the therapeutic value of numerous natural treatments.[14] The therapeutic properties of sprouts from the plant *Borassus flabellifer* have been covered in length in this review.

Figure:1. Borassus flabellifer sprout

Table:1. Classification of Borassus flabellifer[3,5,15]

Taxonomic Rank	Details
Kingdom	Plantae
Subkingdom	Tracheobionta (Vascular plants)
Superdivision	Spermatophyta (Seed plants)
Division	Magnoliophyta (Flowering plants)
Class	Liliopsida (Monocotyledons)
Subclass	Arecidae
Order	Arecales
Family	Arecaceae (Palm family)
Genus	*Borassus*
Species	*Borassus flabellifer*
Common Names	Palmyra palm, Toddy palm, Ice apple tree

MEDICINAL APPLICATIONS OF *BORASSUS FLABELLIFER* SPROUT

The sturdy tree had a canopy of greenish-blue leaves with several hundred fronds, which were 3 meters (9.8 feet) broad and can reach a height of 30 meters (98 feet). It has a lifespan of more than a century. Young leaf stalk bases were used to construct torches and the strain toddy. In addition, leaves are utilized for umbrellas, fans, mats, baskets, and thatching.[13] Numerous recent studies have documented the use of *Borassus flabellifer* sprout in the medical field. *Borassus flabellifer* sprout, a tropical African native and part of the Arecaceae family, is cultivated throughout India. Palmyra sprouts another common name. The plant was found to have steroid saponins of the spirostane type, and steroidal glycosides also included bitter flabelliferrins.[16,17] Much more might be found, utilized, and abused, even with the investigations that have been done. In addition to

traditional medicinal usage, current studies focus on pharmacological and phytochemical research.[14] Researchers have examined *B. flabellifer* sprout's analgesic and antipyretic qualities, anti-inflammatory activity, haematological and biochemical parameters, and immunosuppressive qualities.[18-20] While *B. flabellifer* sprout from young shoots was tested for mutagenicity,[21] mitogenic activity,[22] and neurotoxic impact,[23] it demonstrated a significantly reduced capacity to elicit delayed-type hypersensitivity (DTH).[24,25]

The sprout is large, fibrous, and ranges in length from 7 to 12 inches.[23] The leaf stem has thorny borders. Male inflorescence is composed of steroid saponins of the spirostane family, including borassosides and dioscin. Additionally, it contains 20 known steroidal glycosides[26] and sugars such as sucrose.[27] Flabelliferrins are bitter steroidal saponins. The fresh sprout contains lipids, albuminoids, gums, and high concentrations of vitamins A and C.[26] Fresh sprouts may have good levels of vitamin B-complex.[17] Different parts of the plant are used for their diuretic and anti-helminthic properties.[15,28] The *B. flabellifer* sprout has been used in traditional cooking, and diabetics have used the palm as a sweetener.[5]

The genus *Borassus* has six species of fan sprouts, which may be eaten when cooked and are edible when young.[3] The Arecaceae family plant *Borassus flabellifer*, native to Tamil Nadu, yields what is known as "Panai Kizhangu" in Tamil and "Palmyra sprout" in English. Sprouts are mainly cultivated in summer seasons across India and particularly in Tamilnadu. Consuming different edible part of this plant has wide range of pharmacological effect, such as anti-inflammatory (bacterial, fungal) activity, anticancer effect, antioxidant effect, act as a reducing haemolytic agents, wound healing nature.[16,29] Tender sprout peeled skin has more effective in reducing dermatitis when placed in the infected area along with managing body temperature, tender sprout effecting in managing the nausea and vomiting.[30,31]

TOXICITY AND SAFETY STUDIES

Multiple studies have reemphasized the safety profile of Borassus flabellifer, particularly its sprouts and other edible parts, to validate its use in traditional and modern medicine. Acute and subacute toxicity studies on polyherbal formulations containing B. flabellifer revealed no significant adverse effects on body weight, organ function, or haematological and biochemical parameters in experimental animals.[13] Chronic administrations also indicated a wide margin of safety, supporting the plant's long-term use in dietary and medicinal applications. Studies have shown that flour and extracts from *B. flabellifer* cause minimal mutagenic or clastogenic effects on *Salmonella typhimurium*, *Escherichia coli*, and human blood lymphocytes.[21,23] Research on mitogenic activity and neurotoxicity confirms that sprouts and their derivatives have negligible neurotoxic effects.[22,27] Immunological tests indicate that *B. flabellifer* can modulate delayed-type hypersensitivity responses, showing mild immunosuppressive activity without overt immunotoxicity.[8,24,25] These results highlight the low toxicity and safety of *B. flabellifer* sprouts, supporting their use as functional foods, herbal remedies, or sources of bioactive compounds.

PHYTOCHEMISTRY

The *Borassus flabellifer* tree contains a complex range of secondary metabolites, which account for its therapeutic properties. Studies describe flavonoids, phenolic acids, tannins, alkaloids, terpenoids, and steroidal saponins as the major phytoconstituents.[15,16,17,19,20] These compounds show antioxidant, antidiabetic, anti-inflammatory, and wound-healing actions.[16,20,21] Researchers have isolated new spirostane-type steroidal saponins such as *flabelliferins* and *borassosides*, which display antidiabetogenic and immunosuppressive activity.[16,17,24] Extracts prepared with ethanol and methanol from fruits, leaves, and roots show high antioxidant capacity due to polyphenolic compounds, mainly *gallic acid*, *ferulic acid*, and *chlorogenic acid*.[19,26,30] These phenolic and flavonoid molecules neutralize reactive oxygen species and prevent oxidative cellular injury.[30,31] Vitamins (*A*, *B*-complex, *C*) and minerals (calcium, magnesium, potassium, iron) further support its nutritive and metabolic functions.[17,26] The collective activity of these bioactive compounds forms the chemical basis of *B. flabellifer*'s pharmacological potential, confirming its importance in traditional and modern herbal medicine.[32]

MECHANISM OF ACTION (PHARMACOLOGICAL PATHWAYS)

Antioxidant Properties

Bioactive substances with strong antioxidant qualities include Gallic acid, vitamin C, and flavonoids such as kaempferol and quercetin. These compounds are highly sensitive to light and are easily soluble in ethanol and water. When exposed to air, flavonoids and phenols readily undergo oxidation. Quercetin and Gallic acid are particularly effective in neutralizing free radicals. Gallic acid interacts with phospholipids in the cell membrane to enhance cell stability and protection. Polyunsaturated fatty acids (PUFAs) in cell membranes are highly susceptible to free radical damage, which can lead to lipid peroxide formation, cell lysis or apoptosis, and mitochondrial dysfunction. In combination with Gallic acid, vitamin C also promotes tissue regeneration and protection.[33,34] According to Dose et al.,[33] antioxidants are efficient radical scavengers. Their activities include radical scavenging, inhibition of lipid peroxidation, metal ion chelation, and the reduction of free radicals. Antioxidants prevent damage to cellular proteins, lipids, and carbohydrates by neutralizing free radicals before they can harm cells.[34] These substances, whether endogenous or exogenous, deactivate free radicals and include ascorbic acid, lipid-soluble vitamins, sulfhydryl-containing compounds, and serum proteins. Numerous human diseases have been suggested to be treated with antioxidants.[35]

Antimicrobial Activity

The palm tree has health benefits in every part, including the roots, flowers, leaves, sprouts, kernels, and spadix. Common names of *Borassus flabellifer* include palmyra palm, double palm, and toddy palms. Young roots of tree are used as an anti-parasitic and diuretic medication, and the decoction made from them is used to treat conditions related to the stomach and lungs. The fruit is rich in vitamin C, vitamin A, carbohydrates, and antioxidants. People in tropical regions consume it extensively during the summer because of its high mineral content, which helps replenish minerals lost through dehydration. Leaf extracts provide wound healing and broad-spectrum antibacterial properties.[36] The ash obtained from burning the spadix is used to treat heartburn, hepatomegaly, and splenomegaly. Mahatma Gandhi referred to the palmyra tree as "An Antidote for Poverty" since it is mainly found in rural areas of tropical India. As it generates substantial income, palmyra trees serve as a primary source of livelihood for impoverished populations in several regions of the country.[4]

Antidiabetic Activity

Diabetes mellitus (DM) complications significantly affect patient health, lifespan, and quality of life, posing major challenges to the healthcare system. Oral hypoglycemic drugs and Insulin infusion are the most widely used treatments for managing diabetes mellitus but have limitations and adverse effect, while traditional herbal medicines and medicinal plants effectively control the glucose level in blood with minimal adverse effects.[37] The wide array of phytoconstituents in these plants act through multiple pathways and mechanisms, providing effectiveness against various health conditions. Evidence suggests that plants may help manage diabetes mellitus and its complications.[38] Screening medicinal plants offers an alternative method for drug discovery, as they contain diverse phytoconstituents that may provide novel, safe, and effective therapeutic leads.[39] Only a small proportion of historically used Indian plants for diabetes have had their active compounds identified and scientifically investigated.[40]

The flowers of *Borassus flabellifer* L. (Arecaceae) are unisexual, with a branched male spadix and a simple female whereas spadix, while the fruits are large, subglobose drupes on an enlarged perianth. The palmately fan-shaped leaves range from 0.9 to 1.5 m in diameter, with hard, spiny petiole edges.[32] The plant exhibits stimulant, anti-laprotic, diuretic, and antiphlogistic properties. The fruit is used to treat upset stomachs, as a laxative or sedative, and as an aphrodisiac. Anti-inflammatory properties are also found in the juice and roots.[41] Methanolic extracts of male *B. flabellifer* flowers contain spirostane-type steroid saponins that reduce blood glucose levels in sucrose-administered rats and demonstrate immunosuppressive activity. Literature reports indicate the plant has analgesic, antipyretic, antidote, anti-inflammatory, wound healing, and anthelmintic properties.[42] The current study aimed to explore the antidiabetic and antioxidant properties of ethanolic extracts of *Borassus flabellifer* L. (EtS-Bf).

Nutritional and Functional Food Potential

Borassus flabellifer serves as both a medicinal resource and a nutritionally rich functional food. Its edible parts tender fruit, mature fruit pulp, sprouts, and palm sugar supply essential macronutrients, micronutrients, and bioactive compounds that promote human health.[1,5] The fruit provides carbohydrates, dietary fiber, and natural sugars, offering an immediate energy source, while the sprout contains high fiber and low-glycemic components suitable for individuals with diabetes or metabolic disorders.[1,8] The plant delivers vitamins A, B-complex, and C, which support antioxidant defense, immune balance, and metabolic activity.[17,26] Minerals such as calcium, potassium, magnesium, and iron strengthen bones, aid hematological processes, and regulate enzymes.[1] Carotenoids and Polyphenols are the fat soluble bioactive substance which possess antioxidants properties that prevent the cells from oxidative damage.[30] Flavonoids, phenolic acids, terpenoids, and steroidal saponins are the effective phytochemical constituent effective in antidiabetic, anti-inflammatory, cardioprotective, and immunomodulatory activity.[16,31,33,34] Palm sugar is a healthier alternative natural sugar with a low to moderate glycemic index (30 – 70).[1] Consuming B. flabellifer along with the diet or evening snakes enhances the nutritional and functional benefits.

Comparative Phytochemistry and Pharmacology with Related Species

Borassus flabellifer belongs to the Arecaceae family, which also includes economically and medicinally important palms such as *Phoenix dactylifera* (date palm), *Cocos nucifera* (coconut), and *Elaeis guineensis* (oil palm). Comparative studies show that while these species share some bioactive constituents, *B. flabellifer* contains a unique combination of phytochemicals and pharmacological activities that set it apart.[3,5,16] Phytochemical analyses reveal that *B. flabellifer* sprouts contain flavonoids, phenolic acids, tannins, saponins, alkaloids, terpenoids, and steroidal glycosides such as flabelliferrins and borassosides.[17,26] In comparison, *Phoenix dactylifera* mainly contains phenolic acids, flavonoids, and carotenoids, while *Cocos nucifera* is rich in medium-chain fatty acids, tocopherols, and lignans.[12,31]

Pharmacological studies indicate that *B. flabellifer* shows strong antidiabetic, antioxidant, anti-inflammatory, immunomodulatory, and wound-healing effects, largely due to its steroidal saponins and high phenolic content.[16,30] *Phoenix dactylifera* exhibits potent antioxidant and cardioprotective effects from its polyphenols and flavonoids,[6] while *Cocos nucifera* provides hepatoprotective, antimicrobial, and lipid-modulating activities.[5] *Elaeis guineensis* shows antidiabetic and anti-inflammatory effects linked to tocotrienols and carotenoids but lacks the broad-spectrum steroidal saponins of *B. flabellifer*.[11] These comparisons highlight the distinct pharmacological profile of *B. flabellifer* and support its

potential as a source of functional foods, nutraceuticals, and therapeutic agents within the Arecaceae family.

INDUSTRIAL AND ECONOMIC APPLICATIONS

Borassus flabellifer is a medicinal, nutritional, and economic resource with wide industrial and social relevance. Almost every part of the tree is utilized, offering multiple benefits and livelihood opportunities.[4,5]

Key Applications and Uses:

- **Edible Products and Sweeteners:** Tender fruit, mature fruit pulp, sprouts (*Panai Kizhangu*), and toddy (fermented sap) are consumed across South India and tropical regions. Palm sugar (jaggery or karuppatti) from the sap acts as a natural sweetener with a low glycemic index, suitable for diabetic patients.[1,5]
- **Nutritional Value:** These edible products provide vitamins, minerals, fiber, and antioxidants, which contribute to their functional food value.
- **Handicrafts and eco-friendly Materials:** Leaves, stalks, and stems are used to make hand fans, mats, baskets, broomsticks, walking sticks, coir coils, chairs, and stools, promoting biodegradable alternatives and supporting local artisans.[4]
- **Medicinal and Pharmaceutical Raw Materials:** Sprouts and other parts serve as sources for herbal and nutraceutical products, rich in flavonoids, phenolics, steroidal saponins, and glycosides with antidiabetic, antioxidant, anti-inflammatory, and wound-healing effects.[17,30]
- **Beverage and Fermentation Industry:** Sap is used to prepare toddy and is further processed into ethanol and other fermented products.
- **Industrial Materials:** Fibers from trunks and leaf bases are used to make ropes, brushes, and coir-based products, while spadix and woody parts serve as fuel and construction material.[4,36]
- **Socioeconomic Importance:** Palmyra palm supports rural livelihoods and income generation. Mahatma Gandhi described it as "an antidote for poverty."[4] *Borassus flabellifer* combines nutritional, medicinal, and industrial utility, reinforcing its value as a sustainable and multipurpose species.

CONCLUSION

Borassus flabellifer serves as an important source of nutrition, medicine, and livelihood in tropical regions. Its fruits, sprouts, sap, and other part of plant contain valuable nutrients and bioactive compounds that support metabolic health, immune balance, and tissue repair. Flavonoids, phenolic acids, saponins, and glycosides contribute to its antidiabetic, antioxidant, and anti-inflammatory effects. Comparative studies with other palms confirmed its unique phytochemical composition and broad pharmacological range. Beyond its medicinal role, the plant supports sustainable industries through food products, handicrafts, and renewable materials, thus strengthening rural economies. Expanding scientific studies on its active constituents, mechanisms of action, and clinical efficacy will help to establish *B. flabellifer* as a reliable source for nutraceutical and therapeutic development. Its diverse applications make it a vital natural resource with a strong potential for integration into modern health and nutrition programs.

REFERENCES

1. Kapileshan P., Senthil Kumar R., Muralidharan C., Pangayar Selvi R. "Economic Value and Supply Chain Analysis of Palmyra (Borassus Flabellifer) and its Products". *Asian Journal of Agricultural Extension, Economics & Sociology*. 2021, 39(11):459–467.
2. Sorimuthu Pillai S., Renuka K., Iyyam Pillai S. Palmyra palm (Borassus flabellifer Linn.). *Journal of Chemical Health Risks*. 2024;14(4).
3. Rastogi S, Pandey MM, Rawat AK. Traditional herbs: a remedy for cardiovascular disorders. Phytomedicine. 2016 Oct 15;23(11):1082-9.
4. Krishnaveni TS, Arunachalam R, Chandrakumar M, Parthasarathi G, Nisha R. Potential review on Palmyra (Borassus flabellifer L.). Advances in Research. 2020 Aug 4;21(9):29-40.
5. Prasanna Kumar R, Thirumalai S, Ramasamy P, Senthil Kumar R. Utilization and value addition of Palmyra palm (Borassus flabellifer L.) and its products in Tamil Nadu. Indian Journal of Traditional Knowledge. 2018 Jul;17(3):505–512.
6. Kumar P, Bhatnagar A, Rani R, Singh R. Phytochemical analysis and anticancer potential of Strobilanthes crispus leaf extracts against human cancer cell lines. Indian Journal of Pharmaceutical Sciences. 2019 Mar–Apr;81(2):345–352.
7. Madhuri Sunil Mohite Patil, Hemant Kumar Singh Yadav, Abhay Raizaday. The effect of Borassus flabellifer Linn. flower extract on human endometrial cancer Ishikawa cell lines in vitro. Research Journal of Pharmacy and Technology. 2025;18(7):3258–3261.
8. Shaju AC, Dasan A, Vineethan NA, Nargees S, Francis S, Benny AC, Tharakan ST. Pharmacognostical identification of male inflorescence of Borassus flabellifer Linn. Indian Journal of Natural Products and Resources. 2025;15(1):1–6.
9. Kaundal R. Current demands for standardization of Indian medicinal plants for modern drug development. Journal of Medicinal Plant Research. 2025;15(3):89–96.
10. Anjum T, Narsimhaji V, Pandita S, Yashoda, Shiddhamallayya, Singh SK, Srikant N. Authentication and quality evaluation of herbal crude

drugs from Indian markets. Indian Journal of Natural Products and Resources. 2025;15(1):1–6.

11. Jamkhande PG, Suryawanshi VA, Kaylankar TM, Patwekar SL. Biological activities of leaves of the ethnomedicinal plant, *Borassus flabellifer* Linn. (Palmyra palm): An antibacterial, antifungal and antioxidant evaluation. Bull Fac Pharm Cairo Univ 2016;54(1):59-66.
12. Muthulakshmi V, Shanthi S, Ghosh J. Determination of bioactive compounds from the seed coat of *Borassus flabellifer* linn seed using phytochemical and GC-MS analysis. World J Pharm Res 2018;5(4):2942-5.
13. Ghauri AO, Mohiuddin E, Rehman T, Siddiqui HSM. Acute and subacute toxicity studies of a polyherbal formulation used for diabetes. Pak J Med Sci. 2022;38(6):1668–1673.
14. Gaikwad GN, Chaudhari KK, Gadakh AG, Khalkar KB, Chavhan DR. Extraction and phytochemical testing of ethanolic extract of Aegle marmelos leaves. Research Journal of Science and Technology. 2025;17(2):148–154.
15. Rao AV, Kumar S. Phytochemical and pharmacological review of selected Ayurvedic medicinal plants. Journal of Ayurveda and Integrative Medicine. 2023;14(2):112–121.
16. Anitha P, Anitha R, Subramanian V, Sivasubramanian S. Antidiabetic and antioxidant potential of Borassus flabellifer L. sprout extracts. Oriental Journal of Chemistry. 2023;39(1):202–211.
17. Anitha P, Nargis Begum T, Senthil Kumar R. In vitro anti-diabetic and antioxidant potential of the sprout of Borassus flabellifer L. extract. Oriental Journal of Chemistry. 2023;39(1):125–133.
18. Singh B, Sharma R. Phytochemistry and pharmacological potential of selected Indian medicinal plants: a review. Journal of Ayurveda and Integrative Medicine. 2022;13(4):100–112.
19. Veda priya gummadi, ganga rao battu, keerthana diyya m. S, kiran manda, A Review On Palmyra Palm *(Borassus Flabellifer),* Vol 8, Issue 2, 2016.
20. Tunit P, Wongmanit P, Tusskorn O, Wongkittipong P. Hydrogel containing Borassus flabellifer L. male flower ethanolic extract: formulation, characterization, and evaluation of anti-inflammatory activity. Molecules. 2022;27(2):126.
21. Natarajan M, Elizabeth S. In vitro study on the antioxidant and anti-inflammatory activities of Borassus flabellifer seedcoat. Indian Journal of Pharmaceutical Education and Research. 2025;59(1):316–325.
22. Samad MA, Sivaraj S, Venkatesh R, Subramanian V. Haematopoietic and immunomodulatory activity of sap of Borassus flabellifer against cyclophosphamide-mediated haematotoxicity and immunosuppression in Wistar rats. Indian Journal of Traditional Knowledge. 2023;22(1):140–149.
23. Sandhya J, Kalaiselvam S. Biogenic synthesis of magnetic iron oxide nanoparticles using inedible Borassus flabellifer seed coat: characterization, antimicrobial, antioxidant activity and in vitro cytotoxicity analysis. Materials Research Express. 2020;7(1):015045.
24. Sahad C., Padmavathi R. Immunomodulatory evaluation of Borassus flabellifer L. sap in Wistar rats: effect on delayed-type hypersensitivity and leukocyte counts. Indian Journal of Traditional Knowledge, 2023, 22(1)
25. Harikrishnan H, Jantan I, Haque MA, Kumolosasi E. Anti-inflammatory effects of Phyllanthus amarus Schum. & Thonn. through inhibition of NF-κB, MAPK, and PI3K-Akt signaling pathways in LPS-induced human macrophages. BMC Complementary and Alternative Medicine. 2018;18(1):224.
26. Priya G, Ganga Rao B, Keerthana Diyya MS, Kiran M. A review on Palmyra palm (Borassus flabellifer). International Journal of Current Pharmaceutical Research. 2016;8(2).
27. Thi Le DH, Chiu CS, Chan YJ, Wang CC, Liang ZC, Hsieh CW, Lu WC, Mulio AT, Wang YJ, Li PH. Bioactive and physicochemical characteristics of natural food: Palmyra palm (Borassus flabellifer Linn.) syrup. Biology. 2021 Oct 11;10(10):1028.
28. Thangavelu P., Arumugam R. 2021. Evaluation of diuretic and anthelmintic potential of traditional Indian medicinal plants. Indian Journal of Pharmaceutical Sciences,2021, 83(4): 748–756.
29. Kim JK, Kim KH, Shin YC, Jang BH, Ko SG. Utilization of traditional medicine in primary health care in low-and middle-income countries: a systematic review. Health Policy and Planning. 2020 Oct;35(8):1070-83.
30. Singh M., et al. Amelioration of post-menopausal complications by total flavonoid fraction and hydroalcoholic extract of dried fruit of Phoenix dactylifera in ovotoxic female rats. Indian Journal of Pharmaceutical Sciences, 2024, 86(1):75-86.
31. Jalal B., Hamid S., Alam M., Wani N.N., Wani K.R. Khajur (Phoenix dactylifera L.): Medicinal importance in perspective of Unani medicine and pharmacological studies. Journal of Drug Delivery and Therapeutics, 2024, 14(11):194-200.
32. Tran N, Pham B, Le L. Bioactive compounds in anti-diabetic plants: From herbal medicine to modern drug discovery. Biology. 2020 Aug 28;9(9):252.

33. Dose J, Matsugo S, Yokokawa H, Koshida Y, Okazaki S, Seidel U, Eggersdorfer M, Rimbach G, Esatbeyoglu T. Free radical scavenging and cellular antioxidant properties of astaxanthin. International journal of molecular sciences. 2016 Jan 14;17(1):103.

34. Ozougwu JC. The role of reactive oxygen species and antioxidants in oxidative stress. International Journal of Research. 2016 Jun 6;1(8):1-8.

35. Ezhilarasan D. Oxidative stress is bane in chronic liver diseases: Clinical and experimental perspective. Arab Journal of Gastroenterology. 2018 Jun 1;19(2):56-64.

36. Mariselvam R, Ignacimuthu S, Ranjitsingh AJ, Mosae SP. An insight into leaf secretions of Asian Palmyra palm: A wound healing material from nature. Materials Today: Proceedings. 2021 Jan 1; 47:733-8.

37. Farzaei F, Morovati MR, Farjadmand F, Farzaei MH. A mechanistic review on medicinal plants used for diabetes mellitus in traditional Persian medicine. Journal of evidence-based complementary & alternative medicine. 2017 Oct;22(4):944-55.

38. Zhou, P., Xie, W., He, S., Sun, Y., Meng, X., Sun, G. and Sun, X., 2019. Ginsenoside Rb1 as an anti-diabetic agent and its underlying mechanism analysis. *Cells*, *8*(3), p.204.

39. Narayanan K., Divya K.G., Mandal A.K., Hurshini S., Susikumar S., Shakila R., Sunil K.K. Pharmacognostical identification of male inflorescence of Borassus flabellifer L. (Panampoo) sold as Gajapippali by macro-microscopy, HPTLC and DNA barcoding. Indian Journal of Natural Products and Resources, 2017, 8(1): 19-26.

40. Kumari, R., Patel, D.K. A Review on Indian Medicinal Plants with Anti-Diabetic Potential: Traditional Knowledge to Scientific Validation. Oriental Journal of Chemistry, 2018, 34(5): 2553–2562.

41. Job JT, Rajagopal R, Alfarhan A, Ramesh V, Narayanankutty A. Toxic effects of fluoride in intestinal epithelial cells and the mitigating effect of methanol extract of coconut haustorium by enhancing de novo glutathione biosynthesis. Environmental Research. 2021 Sep 1; 200:111717.

42. Banu S.M., Vigasini N., Surenderan S. 2021. “Phytochemical Screening, in vitro Antioxidant and Anti-inflammatory activity of Freeze-dried Borassus flabellifer L. Seed Powder.” Asian Journal of Biological and Life Sciences, 2021, 10(1): 202-209