JURNAL PHARMA BHAKTA

OVERVIEW OF PHYTOCHEMICAL COMPOUNDS AND PHARMACOLOGICAL ACTIVITIES OF *Borassus flabellifer* Linn. AS A REGIONAL EMBLEM PLANT OF SOUTH SULAWESI

Wahyuni Agus

Department of Chemistry, Universitas Negeri Makassar

Article Information
Article History :
Submitted: 1 September 2025
Accepted: 12 September 2025
Publish Online: 29 November 2025

Keywords:
Borassus flabellifer, Phytochemical, Pharmacological

ABSTRACT

Background: *Borassus flabellifer Linn*. (palmyra palm) is a member of the Arecaceae family with important ecological, economic, and pharmacological roles, and serves as the floral emblem of South Sulawesi, Indonesia. Traditionally, almost all parts of the plant have been used for food, beverages, and handicrafts. **Objective:** This review summarizes its phytochemical constituents and pharmacological activities. **Methods:** Relevant articles were collected from Scopus, ScienceDirect, PubMed, and Google Scholar. Publications from 2005 to 2025 were screened using the keywords *Borassus flabellifer*, palmyra palm, phytochemistry, and pharmacological activity. Based on inclusion and exclusion criteria, 19 articles were analyzed. **Result:** Findings indicate that plant parts contain bioactive compounds such as flavonoids, phenols, alkaloids, saponins, tannins, terpenoids, and steroidal saponins including flabelliferins and borassosides. These metabolites are linked to antioxidant, anti-inflammatory, cytotoxic, antidiabetic, antibacterial, antifungal, and diuretic effects, through mechanisms such as free radical scavenging, suppression of inflammation, induction of apoptosis, inhibition of carbohydrate-digesting enzymes, and regulation of renal electrolyte excretion. **Conclusion:** Overall, Borassus flabellifer shows strong potential as a source of phytopharmaceuticals and natural drug candidates. Beyond pharmacological value, its ecological resilience, cultural significance, and economic importance support its designation as the floral emblem of South Sulawesi. Further preclinical and clinical studies are needed to validate therapeutic efficacy and safety.

ABSTRAK

Latar belakang: *Borassus flabellifer* Linn. (lontar) adalah anggota famili Arecaceae yang memiliki peran penting secara ekologi, ekonomi, dan farmakologis, serta menjadi bunga lambang Provinsi Sulawesi Selatan, Indonesia. Secara tradisional, hampir seluruh bagian tanaman ini telah dimanfaatkan sebagai sumber makanan, minuman, dan kerajinan tangan. **Tujuan:** Tinjauan ini merangkum kandungan fitokimia serta aktivitas farmakologinya. **Metode:** Artikel-artikel relevan dikumpulkan dari Scopus, ScienceDirect, PubMed, dan Google Scholar. Publikasi dari tahun 2005 hingga 2025 diseleksi menggunakan kata kunci *Borassus flabellifer*, palmyra palm, phytochemistry, dan pharmacological activity. Berdasarkan kriteria inklusi dan eksklusi, sebanyak 19 artikel dianalisis. **Hasil:**

Korespondensi : wahyuni.agus@unm.ac.id **ISSN 2797-1163**

Temuan menunjukkan bahwa berbagai bagian tanaman mengandung senyawa bioaktif seperti flavonoid, fenol, alkaloid, saponin, tanin, terpenoid, dan saponin steroidal termasuk flabelliferin dan borassosida. Metabolit-metabolit ini terkait dengan efek antioksidan, antiinflamasi, sitotoksik, antidiabetes, antibakteri, antijamur, dan diuretik, melalui mekanisme seperti penangkapan radikal bebas, penekanan respon inflamasi, induksi apoptosis, inhibisi enzim pencernaan karbohidrat, serta regulasi ekskresi elektrolit ginjal. **Kesimpulan:** Secara keseluruhan, *Borassus flabellifer* menunjukkan potensi kuat sebagai sumber fitofarmaka dan kandidat obat alami. Di luar nilai farmakologisnya, ketahanan ekologis, makna budaya, dan peran ekonominya mendukung penetapannya sebagai bunga lambang Sulawesi Selatan. Penelitian praklinis dan klinis lebih lanjut diperlukan untuk memvalidasi efektivitas dan keamanannya.

INTRODUCTION

Borassus flabellifer Linn. belongs to the subfamily Coryphoideae and the family Arecaceae, and is distributed across tropical Africa and Madagascar, South and Southeast Asia, as well as New Guinea. In Indonesia, Borassus flabellifer Linn. is commonly known as Lontar, with various local names such as Tala' (Bugis Makassar), Siwalan (Java), Rontal (Bali), and Tarebung (Madura). Lontar is a type of palm classified as an Angiosperm, a monocotyledonous plant (Monocotyledons) within the order Arecales. This plant serves as the floral emblem or floral symbol of South Sulawesi, officially designated through the Decree of the Minister of Home Affairs No. 48 of 1 September 1989, concerning the Guidelines for the Determination of Regional Floral Identity. The provincial floral identities in Indonesia are part of the national Flora Nusantara, which hold the status of national floral symbols representing Indonesia and its floral biodiversity (Bayton, 2007., Sukamaluddin et al., 2016., Nasri et al., 2017).

In South Sulawesi, Lontar (*Borassus flabellifer*) predominantly grows in the districts of Jeneponto, Takalar, Gowa, and Bone. The distribution of *Borassus flabellifer* is generally sporadic or in clusters, with the highest population found in Jeneponto District. The proportion of productive Lontar trees is estimated at 41–43%, while those being processed account for about 22–23%. The estimated population of *Borassus flabellifer* covers approximately 10% of dryland areas (fields/gardens), with 5–120 trees per hectare of varying ages, or an average of 28 trees per hectare. The total population of *Borassus flabellifer* trees in this region is approximately 250,000–300,000 trees.

In terms of utilization, almost all parts of the *Borassus flabellifer* tree are useful. Commonly used parts include the leaves, trunk, fruits, and flowers, which can be tapped for sap to be consumed fresh (in Indonesia, it is known as 'nira'), fermented into 'tuak' (palm wine), or processed into palm sugar (similar to brown sugar). Due to its numerous benefits, *Borassus flabellifer* is often referred to as the 'tree of 800 uses' (Tambunan, 2010). Essentially, the main products of *Borassus flabellifer* are its sap and fruits, while handicraft materials are considered by-products. The sap can be collected from both

male and female trees, whereas fruits are produced only by female trees (Tambunan, 2010; Nasri et al., 2017).

The purpose of this review article is to comprehensively examine the phytochemical aspects and pharmacological activities of *Borassus flabellifer* Linn. (Lontar palm) as the floral emblem of South Sulawesi. The designation of *Borassus flabellifer* as a regional symbol has not yet been fully supported by scientific studies on its bioactive compounds and health benefits. Considering the diverse uses of *Borassus flabellifer* as food, beverage, and various derivative products with economic value and competitive advantages, a literature review is required to strengthen the basis for its designation. Therefore, this study is expected to provide a scientific foundation regarding the health potential of *Borassus flabellifer* while simultaneously supporting its use as a source of improved welfare for local communities.

METHOD

This review was carried out through a structured literature search to ensure transparency and systematic selection of references. Relevant publications on *Borassus flabellifer* were retrieved from major scientific databases, including Scopus, PubMed, ScienceDirect, and Google Scholar. The search covered the period between 2005 and 2025, using Boolean operators (and/or) with the keywords: *Borassus flabellifer,* palmyra palm, phytochemistry, bioactive compounds, and pharmacological activities.

The inclusion criteria were: (i) original research or review articles focusing on the phytochemical constituents and pharmacological properties of *Borassus flabellifer*; (ii) studies published in English or Indonesian; and (iii) availability of full-text access. Exclusion criteria included duplicate records, articles with insufficient scientific data, or publications unrelated to phytochemistry or pharmacological activity.

From the initial screening, 30 references were identified as relevant, all of which were included in this review. Among them, 19 primary articles served as the main basis for phytochemical and pharmacological analysis, while the remaining 11 publications covering ecology, ethnobotany, conservation, and compound data from the NCBI PubChem database were used as supporting references to strengthen the background and discussion.

This systematic approach ensured that the review not only summarized the pharmacological potential of *Borassus flabellifer* but also integrated ecological and cultural perspectives, strengthening the rationale for its recognition as a regional floral emblem.

RESULT

Borassus flabellifer Linn. is a palm tree that can grow up to 30-35 meters in height with a trunk diameter reaching up to 3 meters, gray in color, and marked with

leaf scars. This species is dioecious, meaning male and female trees are separate. The male flowers are small and arranged in clusters, whereas the female flowers are round, about the size of a golf ball, and borne separately on flower stalks. The fruits measure 15-25 cm in diameter, brownish-black in color, containing a sweet edible pulp with one to three seeds enclosed in a hard layer.

The roots possess a hairy epidermal layer, a cortex functioning as food storage, and an endodermis that regulates the entry of water and other substances. The central root cylinder is radially arranged with polyarch xylem bundles (11-20 bundles) and lacks cambium, thus secondary growth does not occur. The stem is composed of an epidermis with vascular bundles scattered irregularly (a typical monocot characteristic), lacks an endodermis, and does not possess cambium (Sorimuthu et al., 2024; Davinsy et al., 2024)."

Table 1. Traditional applications of *Borassus flabellifer* L.

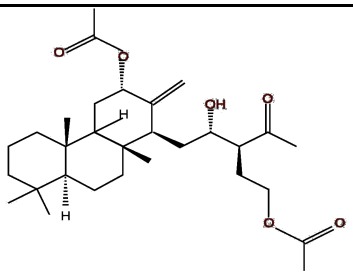
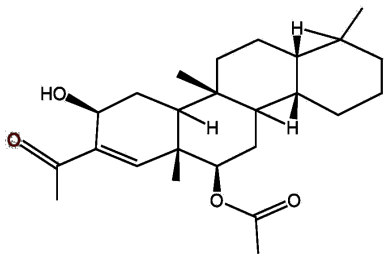
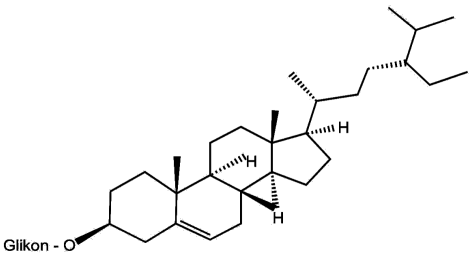
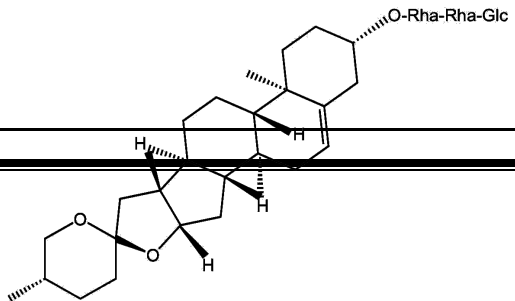
Plant Parts	Traditional Applications	References
Fruit	It serves as a traditional food source, with the sap (derived from the inflorescence stalk) utilized as a natural sweetener, while the fruit pulp is applied in the treatment of skin infections and as an anti-inflammatory agent	Mary et al, 2022 Mohan et al., 2016
Palm Sap	It is traditionally consumed as a beverage, used as a laxative and as a source of B-complex vitamins	Mohan et al., 2016
Leaves	It is used for making various handicrafts such as waterproof buckets, hats, and decorative boxes and also as an anti-inflammatory agents	Singh et al., 2021 Mohan et al., 2016
Root	It has traditionally been used as a diuretic and an antiparasitic agent	Prasad et al., 2023 Mohan et al., 2016
Seed coat	It exhibits antibacterial, antifungal, antioxidant activities, and has been employed in the treatment of halitosis and oral inflammation	Angeline et al., 2025 Mohan et al., 2016
Trunk	It is utilized for construction materials, household furnishings, and handicraft production	Tnunay, et al., 2021 Mohan et al., 2016

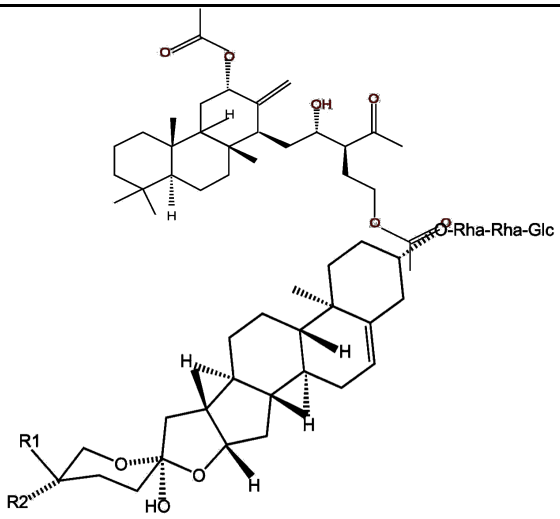
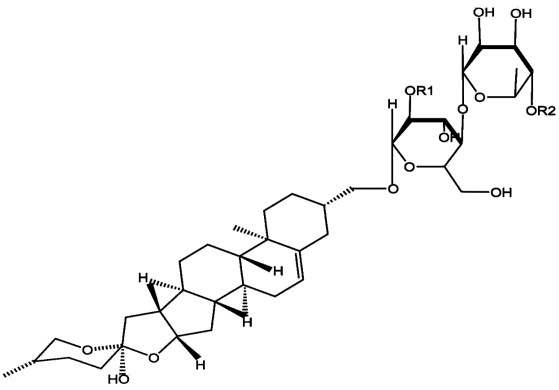
Table 2. Phytochemical compounds of *Borassus flabellifer* L.

Plant Parts	Phytochemical Compounds	Specific Phytochemical	References
Fruit,	Flavonoids, tannins,	Quercetin, keampferol	Mary et al., 2022

Plant Parts	Phytochemical Compounds	Specific Phytochemical	References
seed coat	minerals dan vitamins		
Seed coat, sap	Phenols	Galac acid, catechin derivatives	Wiboonsirikul, 2024
Seed coat	Alkaloids, Terpenoids	-	Trisfilha, et al., 2025
Leaves (Prond)	Lignins	Biopolymers	Rusdin et al., 2025

Table 3. Marker Compounds of *Borassus flabellifer* L.

Compounds	Structures	References
Flabelliferin A		Pubchem: CID 66554037
Flabelliferin B		Pubchem: CID 66554038
Flabelliferin (Steroidal Saponin)	 Glycone : Rha-Glc-Glc-Rha (Flabelliferin II) Glc-α-1,4-Rha & α-1,2-Rha (Flabelliferin B) Rha-Glc-Rha / Glc-Rha-Rha (Flabelliferin C) Glc-Rha (Flabelliferin D) Glc-Rha-Glc (Flabelliferin N)	Pubchem: CID 222284 Thayaparan et al., 2023
Borassoside A		Pubchem: CID 441900 Yoshikawa et al., 2007

Compounds	Structures	References
Borassoside B-C	 Borassoside B : R1 = CH_2OH, R2 = H Borassoside C : R1 = H, R2 = CH_2OH	Pubchem: CID 441900 Yoshikawa et al., 2007
Borassoside D-F	 Borassoside D : R1 = R2 = H Borassoside E : R1 = Rha, R2 = H Borassoside F : R1 = R2 = Rha	Pubchem: CID 441900 Yoshikawa et al., 2007

Note: Glc = Glucose; Rha = Rhamnose

Table 4. Pharmacological aActivities of *Borassus flabellifer* L.

Plant Samples	Pharmacological Activities	References
Fresh fruit,	Antioxidant activity (reduces oxidative	Angeline et al., 2025
Seed coat extract	damage)	Digambiro et al., 2025
Seed coat extract,	Anticancer/cytotoxic (antiproliferative	Tyatana et al., 2021
Flower extract	activities)	
Seed coat extract,	Antidiabetic activity (inhibits glucose-	Banu et al., 2022
Flower extract	absorbing enzymes)	
Seed coat extract,	Antibacterial, antifungal (inhibits the	Banu et al., 2022
Root extract, Sap	growth of bacteria and fungi)	

Fresh fruit, Seed coat extract	Anti-inflammatory (reduce oral swelling through antioxidant effects)	Mohan et al.,2016
Leaves extract	Diuretic (increases urine production and excretion)	Mahmoodi et al., 2021

DISCUSSION

Phytochemical Compounds

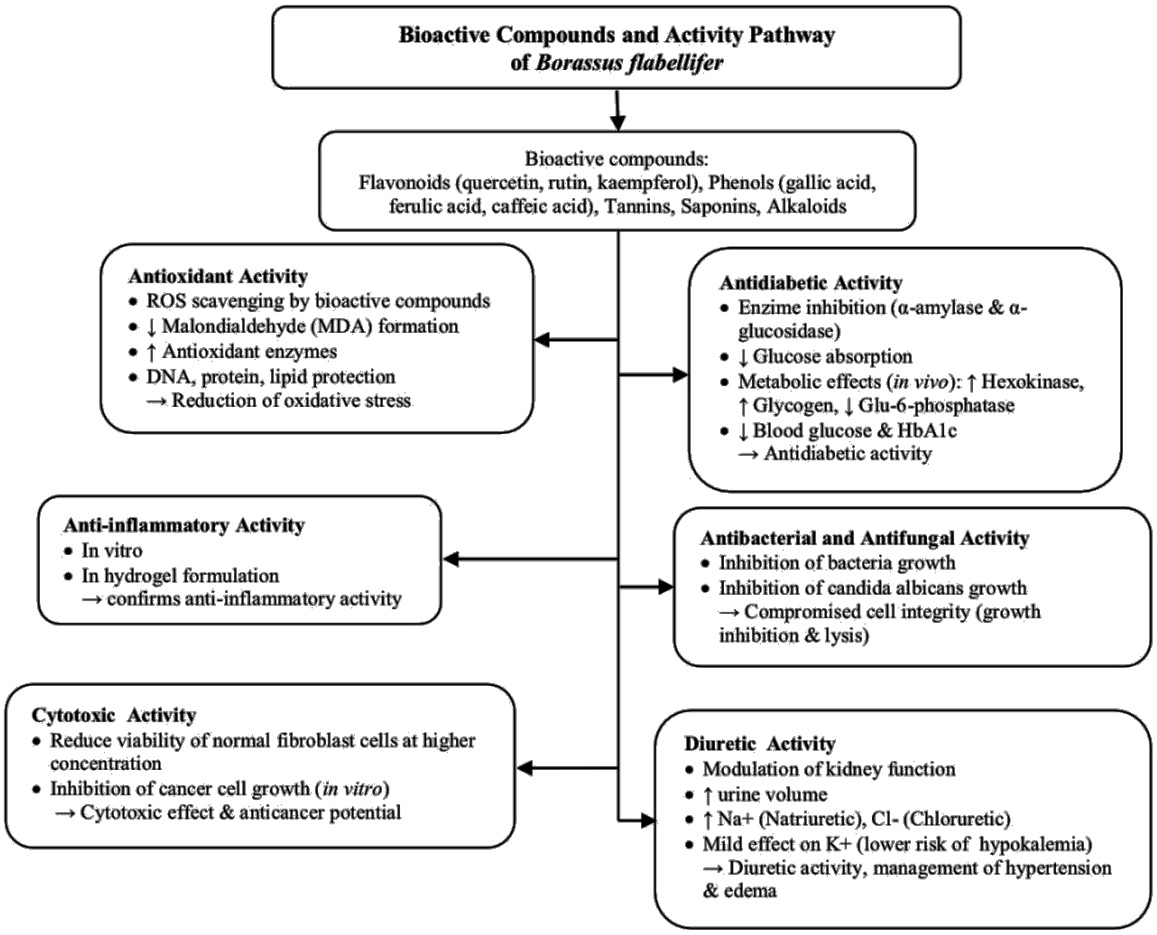
The main phytochemical compounds found in the fruit of *Borassus flabellifer* include flavonoids, phenols, alkaloids, saponins, tannins, and terpenoids. Qualitative analysis revealed the presence of flavonoids, tannins, and saponins, whereas alkaloids and terpenoids were not detected in some qualitative tests. Additionally, nutritional analysis showed that the fruit contains carbohydrates, proteins, calcium, and phosphorus, which contribute to its nutritional value and potential health benefits.

The sap (nira) of *Borassus flabellifer* exhibited a high phenolic content, with these phenolic compounds functioning as antioxidants (Mary, et al, 2022; Wiboonsirikul, 2024). The ethanolic extract of the seed coat *Borassus flabellifer* contains various phytochemical compounds, including flavonoids, tannins, alkaloids, and terpenoids. These compounds are known to possess antioxidant, anti-inflammatory, and anticancer activities (Trisfilha et al., 2025).

Borassus flabellifer contains quercetin, particularly in the ethanolic extract of the male flowers and the germinating endosperm (sprouts). Based on LC-MS analysis, the presence of quercetin, coumarin, and gallic acid was confirmed. *Borassus flabellifer* also contains a characteristic compound known as flabelliferin. Flabelliferin possesses a basic structure of a triterpenoid aglycone of the spirostanol type, bound to one or more sugar residues (glycosides). The glucosyl group in flabelliferin is attached at the 3-β OH position of the triterpenoid structure. The structural complexity allows variations in glycosidic linkages, contributing to the diversity of flabelliferin isomers with different bioactivities. Functionally, flabelliferin exhibits antioxidant, antidiabetic, anticancer, hepatoprotective, and immunomodulatory activities, making it highly promising as a nutraceutical compound. This compound has been identified in the fruit, tuber, and flowers of *Borassus flabellifer.* Fourteen types of flabelliferin have been isolated, with several fully characterized (see Table 3). Flabelliferin also contributes to the bitter taste of the fruit pulp of *Borassus flabellifer* (Thayaparan et al., 2023; Tunit et al., 2022).

In addition to flabelliferin, *Borassus flabellifer* also contains a phytochemical marker compounds in the ethanolic extract of the male flowers, known as borassoside. Borassoside is a triterpenoid saponin with a basic structure consisting of a triterpenoid aglycone linked to a complex glycoside chain. Its structure is composed of yamogenin glycone with additional sugar moieties (glucose or rhamnose), typically attached at the C-3 or C-28 positions via O-glycosidic bonds. The complexity in the number and type of sugar residues generates various borassoside derivatives with differing bioactivities. The amphipathic nature of borassoside, with a lipophilic aglycone portion and a hydrophilic sugar portion, allows interactions with lipid membranes and biological proteins. This property supports its roles in antioxidant, antimicrobial, and anti-inflammatory activities. In the study by Tunit et al. (2022), the male flower extract of *Borassus flabellifer*, rich in borassoside, was shown to scavenge free radicals, inhibit the growth of pathogenic bacteria, and suppress inflammatory mediators (Yoshikawa et al., 2007).

Pharmacological Activities



Antioxidant, Anti-inflammatory, and Cytotoxic Effects

Borassus flabellifer is a natural source rich in bioactive compounds, such as flavonoids, phenols, and tannins, which play a crucial role in antioxidant activity. These compounds act by neutralizing free radicals and reducing oxidative stress, thereby protecting cells from DNA damage. The mechanism of free radical suppression is not only important for maintaining the body's oxidative balance but is also closely associated with the regulation of inflammatory pathways, as oxidative stress is known to be a major trigger for chronic inflammatory responses.

Preliminary clinical evidence has suggested that in populations with high oxidative stress, daily consumption of 150 g of *Borassus flabellifer* fruit for 30 days may reduce malondialdehyde (MDA) levels. This reduction indicates decreased oxidative damage and may imply reduced activation of inflammatory mediators triggered by oxidative stress. Therefore, the antioxidant properties of *Borassus flabellifer* may act synergistically with its anti-inflammatory effects. The combination of free radical control, suppression of inflammatory signaling, and the presence of bioactive phytochemicals directly contributes to inflammation reduction. Together, these mechanisms highlight the potential of *Borassus flabellifer* as a natural agent for the prevention and management of diseases associated with oxidative stress and chronic inflammation. However, details regarding sample size, methodology, and statistical

significance were not fully reported; thus, these findings should be considered preliminary and require further validation through well-designed clinical trials (Angeline et al., 2025; Digambiro et al., 2025).

In addition, several studies have also demonstrated the anti-inflammatory potential of *Borassus flabellifer*. Mohan et al. (2016) reported that extracts from the dried leaves exhibited significant in vitro anti-inflammatory activity by inhibiting pathways responsible for the synthesis of inflammatory mediators. Similarly, Tunit et al. (2022) showed that hydrogel formulations containing male flower extracts possessed notable anti-inflammatory effects, which were associated with the suppression of pro-inflammatory responses. These findings suggest that, beyond its antioxidant role, *Borassus flabellifer* also modulates inflammatory mechanisms, potentially through the downregulation of NF-κB activation and the reduction of cytokine release, thereby contributing to the overall protection against chronic inflammation.

The study conducted by Tyatana et al., (2021) evaluated the cytotoxic effects of *Borassus flabellifer* seed coat extract on fibroblast cells. The cytotoxicity assay was performed to assess both its potential toxicity and its prospective use as a natural anticancer agent. The results demonstrated that the seed coat extract exhibited significant cytotoxic activity, indicated by a decrease in fibroblast cell viability at specific concentrations. Compounds such as flavonoids, phenols, and tannins present in the seed coat are believed to contribute to this cytotoxic mechanism through induction of oxidative stress and disruption of cell membrane function. Based on this study, *Borassus flabellifer* shows potential as a source of natural compounds with anticancer effects; however, further research is required, particularly regarding specific cancer cell types, the underlying molecular mechanisms, and *in vivo* studies to confirm safety and efficacy. Thus, the seed coat of *Borassus flabellifer* holds not only ethnobotanical value but also pharmacological prospects as a candidate for herbal-based alternative therapies.

Similar results were reported by Banu et al. (2022), who investigated the freeze-dried aqueous seed powder extract of *Borassus flabellifer*. In vitro assays demonstrated that this extract not only exhibits antibacterial and antidiabetic activities but also shows significant anticancer effects. The seed extract was able to inhibit the growth of certain cancer cells through mechanisms associated with bioactive compounds such as polyphenols and flavonoids, which are known to induce apoptosis and suppress cancer cell proliferation.

Overall, both studies confirm that *Borassus flabellifer* has pharmacological potential as a source of natural anticancer compounds. The seeds, including both the seed coat and seed powder, contain bioactive metabolites capable of inhibiting cell growth through cytotoxic activity (Tyatana et al, 2021; Banu et al., 2022).

Antidiabetic Effects

The study by Banu et al. (2022) evaluated the antidiabetic potential of *Borassus flabellifer* seed powder extract prepared via freeze-drying. In vitro assays were conducted using α-amylase and α-glucosidase inhibition approaches, two key enzymes involved in carbohydrate digestion that influence blood glucose levels. The results demonstrated that the seed extract significantly inhibited the activity of both enzymes, with effectiveness increasing in a dose-dependent manner. This activity indicates the extract's potential to slow down glucose breakdown and absorption, thereby contributing to the control of blood sugar levels.

These findings reinforce the use of *Borassus flabellifer* seeds as a natural source with antidiabetic activity and support the development of safe and effective herbal products for the prevention and management of diabetes mellitus.

In addition to in vitro studies on *Borassus flabellifer* seeds, an in vivo study using streptozotocin-induced diabetic rats, demonstrated that the ethanolic extract of palm sprouts significantly reduced blood glucose and HbA1c levels and improved glucose metabolism. Specifically, the extract increased hexokinase activity and glycogen content while decreasing glucose-6-phosphatase and fructose-1,6-bisphosphatase activities, showing effects comparable to glibenclamide, a standard antidiabetic drug (Peter et al., 2023).

Antibacterial and Antifungal Effects

The freeze-dried seed extract of *Borassus flabellifer* tested in vitro demonstrated significant antibacterial activity against both Gram-positive and Gram-negative bacteria. In studies using Staphylococcus aureus and Escherichia coli , the extract produced substantial inhibition zones, indicating its effectiveness in suppressing the growth of these pathogens. This effect is closely associated with the presence of secondary metabolites such as flavonoids, alkaloids, saponins, and phenols, which act by disrupting bacterial cell membranes, interfering with ion transport, and inactivating essential enzymes involved in microbial metabolism. The antibacterial activity highlights the potential of *Borassus flabellifer* seed extract as a natural alternative antimicrobial agent, particularly in addressing antibiotic resistance.

In addition, antifungal assays showed that the seed extract effectively inhibited the growth of pathogenic fungi, especially *Candida albicans*, a common cause of opportunistic infections. The observed inhibition zones indicate that the bioactive compounds in the extract possess both bactericidal and fungicidal properties, acting through disruption of fungal cell wall and plasma membrane structures, thereby compromising cell integrity and inducing lysis. This is particularly relevant given the limitations of conventional antifungal therapies, which are often associated with side effects and resistance.

Therefore, *Borassus flabellifer* holds significant potential as a phytopharmaceutical source with synergistic antibacterial and antifungal activities, further reinforcing its status as a plant with high pharmacological value (Banu et al., 2022).

Diuretic Effects

The study conducted by Mahmoodi et al. (2021) aimed to evaluate the diuretic activity of *Borassus flabellifer* seed extract using an animal model. The diuretic assay was performed on *Wistar albino* rats, which were divided into a control group, a standard group (treated with furosemide), and treatment groups receiving various doses of ethanolic seed extract of *Borassus flabellifer*. Observed parameters included urine volume, urine pH, and major electrolytes such as sodium (Na^+), potassium (K^+), and chloride (Cl^-). The results showed that administration of *Borassus flabellifer* extract significantly increased urine volume compared to the control group. Additionally, there was an increase in Na^+ and Cl^- excretion, indicating natriuretic and chloruretic properties, while K^+ excretion was relatively lower compared to the standard drug. These findings suggest that the diuretic mechanism of *Borassus flabellifer* is similar to

loop-type diuretics, albeit with a more moderate effect, potentially offering a safer profile regarding the risk of hypokalemia.

Overall, the study concluded that *Borassus flabellifer* seed extract possesses diuretic activity, likely due to bioactive compounds such as flavonoids, saponins, tannins, and phenolic compounds, which play a role in modulating kidney function. This research supports the traditional use of *Borassus flabellifer* in herbal medicine and highlights its potential as a phytotherapeutic candidate for managing conditions requiring diuretic therapy, such as hypertension and edema.

CONCLUSION

Borassus flabellifer Linn., as the floral identity of South Sulawesi, is a palm species with significant ecological, economic, and pharmacological value. The utilization of nearly all parts of this plant has long been recognized in traditional practices, and modern research supports the presence of various important secondary metabolites, including flavonoids, phenols, tannins, saponins, alkaloids, terpenoids, as well as characteristic compounds such as flabelliferin and borassosides.

These compounds contribute to a wide range of biological activities, including antioxidant, anti-inflammatory, cytotoxic/anticancer, antidiabetic, antibacterial, antifungal, and diuretic effects. Various in vitro and in vivo studies have demonstrated that the pharmacological mechanisms of *Borassus flabellifer* are associated with free radical scavenging, suppression of inflammatory responses, induction of cancer cell apoptosis, inhibition of glucose-digesting enzymes, and modulation of renal electrolyte excretion.

However, despite the promising evidence, critical research gaps remain. Comprehensive toxicological evaluations, bioavailability studies, and pharmaceutical formulation development are still limited, which hinders the translation of preclinical findings into clinical applications. In addition, large-scale and well-designed clinical trials are required to validate the therapeutic efficacy and safety of *Borassus flabellifer* in humans.

Therefore, while *Borassus flabellifer* shows great a potential phytopharmaceutical source supporting the prevention and management of various degenerative and infectious diseases, future research should prioritize addressing these gaps. This review highlights that the designation of *Borassus flabellifer* as a regional floral identity is not only culturally justified but also scientifically supported, reinforcing its strategic value in public health and the development of natural product-based medicines.

RECOMMENDATION

Further research is needed to further identify the main bioactive compounds of *Borassus flabellifer* and to elucidate the molecular mechanisms underlying its pharmacological activities. Comprehensive preclinical and clinical studies should be conducted to ensure the efficacy and safety of its use as a phytopharmaceutical candidate. In addition, the utilization of *Borassus flabellifer* should be integrated with conservation strategies and local community empowerment, thereby supporting the development of herbal medicines while enhancing economic value and maintaining the sustainability of biological resources.

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