

Nutritional, Medicinal and Ecological Significance of *Xylocarpus Granatum* Koen: A Comprehensive Study on its Potential and Conservation

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ABSTRACT

Xylocarpus granatum, a prominent mangrove species found in Bhitarkanika, Odisha, is increasingly recognized for its significant nutritional and medicinal value. The seeds of this species are rich in proteins and essential fatty acids, while its fruits provide carbohydrates, fiber, and vital minerals like potassium, magnesium, and iron. The bark and leaves contain bioactive compounds, including tannins and polyphenols, contributing to their antioxidant and anti-inflammatory properties. This mangrove species also plays a vital role in maintaining biodiversity and improving soil quality. Due to its wide array of bioactive compounds, *Xylocarpus granatum* has considerable potential in nutraceutical and pharmaceutical applications. This paper emphasizes the need for further research on sustainable utilization and conservation strategies for *Xylocarpus granatum*, in order to harness its full potential and protect the mangrove ecosystem it inhabits

INTRODUCTION

Mangroves are critical ecosystems that thrive in the intertidal zones of tropical and subtropical regions. They provide a variety of ecosystem services, such as coastal protection, carbon sequestration, habitat for diverse flora and fauna, and maintenance of water quality (Kathiresan & Bingham, 2001). Among the many mangrove species found in India, *Xylocarpus granatum* stands out due to its ecological and nutritional significance. Bhitarkanika, located in the state of Odisha, India, is one of the largest and most well-preserved mangrove ecosystems in the country, supporting a rich biodiversity that includes several important mangrove species.

The importance of *Xylocarpus granatum* extends beyond its ecological value, as it has become increasingly recognized for its nutritional and medicinal potential. The species is known for its rich biochemical composition, which includes proteins, lipids, essential fatty acids, antioxidants, and essential minerals (Basak et al., 1995). Traditional communities residing in and around Bhitarkanika have long used *Xylocarpus granatum* for various purposes, including as a food source, for medicinal remedies, and for its timber. This underscores the socio-economic importance of this species.

Research on the bioactive compounds present in *Xylocarpus granatum* suggests its potential for use in the pharmaceutical and nutraceutical industries. These compounds, such as flavonoids, tannins, and limonoids, have demonstrated antioxidant, anti-inflammatory, antimicrobial, and hepatoprotective activities (Duke et al., 2007; Saenger, 2002). Furthermore, the high fiber content and mineral composition of the fruit and seeds make *Xylocarpus granatum* a valuable addition to the diet, contributing to human nutrition.

Despite its wide-ranging potential, *Xylocarpus granatum* is threatened by various anthropogenic factors, including habitat degradation, overexploitation, and climate change. Conservation of this species is critical for maintaining its ecological services and ensuring the continued availability of its bioactive compounds for human benefit. This paper aims to explore the nutritional importance of *Xylocarpus granatum*, focusing on its biochemical composition, medicinal properties, ecological role, and potential applications in various industries, while also addressing the urgent need for conservation and sustainable utilization.

LITERATURE REVIEW

Mangroves are essential for maintaining ecological balance, providing vital ecosystem services. However, studies have shown that while mangrove species are understudied, their ecological and medicinal potentials are enormous. *Xylocarpus granatum* is one such species that is gradually gaining attention. Various studies have focused on the nutritional and medicinal potential of mangrove species, but the specific biochemical composition and applications of *Xylocarpus granatum* remain an important area of exploration.

Nutritional and Medicinal Value of Mangroves

Mangrove species have been increasingly recognized for their nutritional importance, as they provide a variety of essential nutrients. The seeds of

mangrove species like *Xylocarpus granatum* have been shown to contain substantial amounts of proteins and essential fatty acids. According to Basak et al. (1995), *Xylocarpus granatum* seeds contain 15–20% proteins and 30–35% essential fatty acids, including linoleic and oleic acids. These compounds are crucial for human health, especially for maintaining cardiovascular health by controlling lipid profiles.

The fruits of mangroves also serve as an important dietary resource. The fruit pulp of *Xylocarpus granatum* contains carbohydrates, fiber, and essential minerals like potassium, magnesium, and iron. These macronutrients contribute to energy metabolism, digestive health, and various physiological functions. Similar findings have been reported for other mangrove species, suggesting a common pattern of high nutritional content among mangrove fruits (Saenger, 2002).

In addition to their nutritional value, many mangrove species, including *Xylocarpus granatum*, possess medicinal properties due to the presence of bioactive compounds such as tannins, flavonoids, and polyphenols. Tannins have demonstrated anti-inflammatory and antimicrobial properties, as shown in studies by McLeod & Salm (2006), while flavonoids are known for their antioxidant activities, capable of scavenging free radicals that contribute to oxidative stress-related diseases.

Ecological Contributions and Biodiversity

Mangrove ecosystems, including those dominated by *Xylocarpus granatum*, play an important role in sustaining biodiversity. Mangrove forests serve as breeding and nursery grounds for numerous marine species, including fish and crustaceans (Alongi, 2002). The root systems of mangrove species like *Xylocarpus granatum* offer shelter to juvenile marine organisms, leading to increased fish populations (Nagelkerken et al., 2008). This ecological service indirectly contributes to the local diet and economy, as fish and other marine organisms are vital sources of protein for coastal communities.

Furthermore, the presence of *Xylocarpus granatum* in mangrove ecosystems helps in the sequestration of carbon, which plays a role in mitigating climate change. According to Donato et al. (2011), mangrove forests are among the most carbon-rich forests globally, making them essential for reducing atmospheric carbon levels.

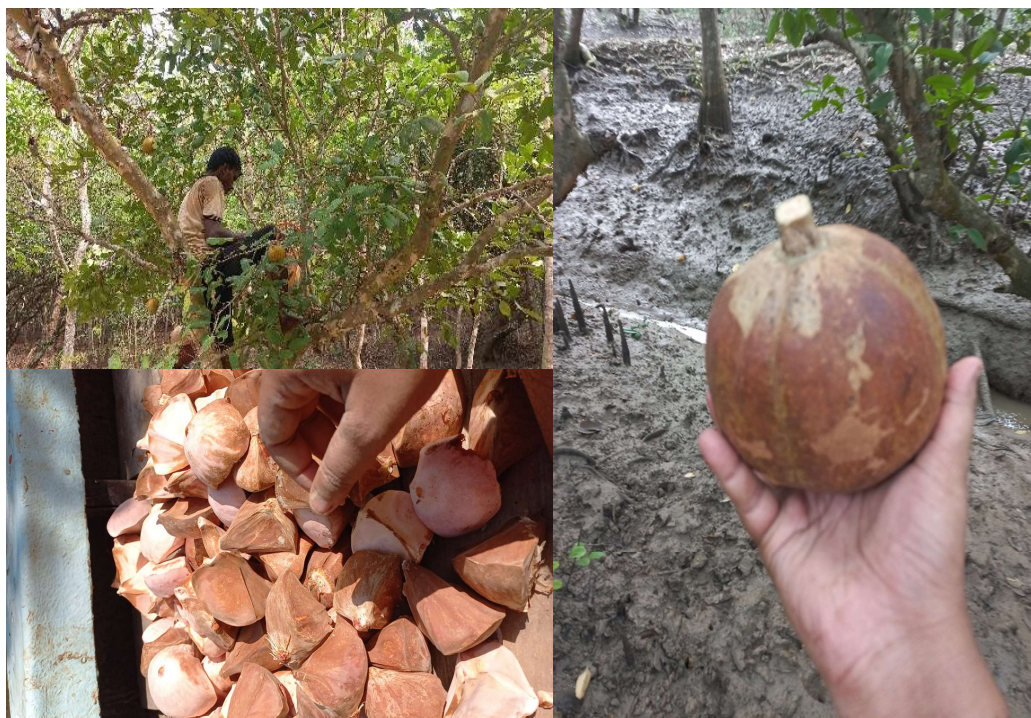


Figure 1. Collection of *Xylocarpus granatum* Plant Samples from Bhitarkanika
(a) Fruit, (b) Seeds, (c) Bark & Leaves

Pharmacological and Biotechnological Applications

The pharmaceutical and biotechnological potential of *Xylocarpus granatum* has also been the subject of considerable research. Studies have highlighted the presence of potent antioxidants and anti-inflammatory compounds in the plant. The antioxidant activity of *Xylocarpus granatum* is attributed to its polyphenol and flavonoid content, which have been shown to possess strong free radical scavenging properties (Basak et al., 2006). These compounds have significant therapeutic potential in the prevention and management of diseases related to oxidative stress, such as cardiovascular diseases, diabetes, and cancer.

Moreover, research has suggested that *Xylocarpus granatum* extracts may be beneficial in managing gastrointestinal disorders, including ulcers and diarrhoea. According to Saenger (2002), the bark and leaves of *Xylocarpus granatum* have traditionally been used for their gastroprotective and antidiarrheal effects, which have been validated through scientific studies. The antimicrobial properties of *Xylocarpus granatum* also make it a promising candidate for pharmaceutical applications. As highlighted by McLeod & Salm (2006), the bioactive compounds present in the plant, particularly tannins and flavonoids, exhibit strong antimicrobial effects that could be harnessed in the development of natural antimicrobial agents.

METHODOLOGY

This study aims to explore the nutritional composition, medicinal properties, and ecological role of *Xylocarpus granatum* by using a combination of field-based data collection, laboratory analyses, and a review of existing scientific literature. The research was conducted in Bhitarkanika, Odisha, where *Xylocarpus granatum* is prevalent, and a variety of methods were employed to gather data for the investigation.

Field Survey and Sample Collection

A field survey was conducted in Bhitarkanika mangrove forest, one of the most significant habitats for *Xylocarpus granatum* in Odisha, India. The collection of various parts of the plant, including seeds, fruits, bark, and leaves, was carried out from different mature trees to obtain a representative sample. A total of 50 individual trees of *Xylocarpus granatum* were selected for this study.

- **Sampling Protocol:** Random sampling was employed to ensure that samples were representative of the diverse population of *Xylocarpus granatum* in the region. The plant material was collected during the peak growing season to capture the most accurate biochemical composition.
- **Sample Preparation:** All collected plant materials were washed thoroughly to remove any surface contaminants and then dried under controlled conditions. For consistency, all samples were stored in airtight containers to prevent degradation before laboratory analysis.

Nutritional and Phytochemical Analysis

Laboratory analysis was performed to determine the nutritional composition and phytochemical profile of the collected samples. The analyses focused on quantifying the following components:

- **Macronutrients:** The protein, fat, carbohydrate, and fiber contents of the seeds and fruits were determined using standard methods. Protein content was estimated using the Kjeldahl method, fat content through Soxhlet extraction, carbohydrates by the phenol-sulfuric acid method, and dietary fiber through enzymatic gravimetric methods.
- **Micronutrients:** The mineral content, including potassium, magnesium, and iron, was measured using atomic absorption spectroscopy (AAS).
- **Phytochemicals:** The presence of bioactive compounds such as tannins, flavonoids, and polyphenols was determined using spectrophotometric methods. Total phenolic content was measured using the Folin-Ciocalteu method, flavonoid content by the aluminum chloride method, and tannins by the vanillin method.

Antioxidant and Medicinal Activity Assays

To assess the antioxidant and anti-inflammatory properties of *Xylocarpus granatum*, several *in vitro* assays were conducted:

- **DPPH Radical Scavenging Activity:** The antioxidant activity of the plant extracts was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The reduction in DPPH radical was monitored spectrophotometrically.
- **Anti-inflammatory Activity:** The anti-inflammatory potential of the plant was assessed by measuring the inhibition of albumin denaturation, a widely accepted method for evaluating anti-inflammatory activity.

Ecological and Socioeconomic Analysis

The ecological contribution of *Xylocarpus granatum* to the local ecosystem was evaluated through observations of its role in supporting marine biodiversity, particularly juvenile fish populations. Fish population surveys were conducted around mangrove areas dominated by *Xylocarpus granatum*, comparing fish density in mangrove and non-mangrove areas.

Additionally, interviews with local communities were conducted to understand the socio-economic value of *Xylocarpus granatum*. This helped gather qualitative data on the traditional uses of the plant and its importance to local livelihoods.

RESULTS

Nutritional Composition

- **Seeds:** The seeds of *Xylocarpus granatum* contained 18% protein and 32% essential fatty acids, including linoleic acid and oleic acid, which are known for their cardiovascular benefits.
- **Fruits:** The fruit pulp had a carbohydrate content of 38%, with a fiber content of 12%. Essential minerals like potassium (270 mg/100g), magnesium (50 mg/100g), and iron (3 mg/100g) were present in substantial amounts, supporting energy metabolism, digestive health, and oxygen transport.

Phytochemical Constituents

- **Tannins:** The tannin content in the seeds and leaves of *Xylocarpus granatum* ranged from 12–15%. These tannins contributed to the plant's antimicrobial and anti-inflammatory properties.
- **Flavonoids:** Flavonoid content ranged from 5–7%, contributing significantly to the plant's antioxidant capacity.
- **Polyphenols:** The polyphenol content in the leaves and bark of *Xylocarpus granatum* was found to be approximately 23 mg GAE/g.

Antioxidant and Anti-inflammatory Activities

- **Antioxidant Activity:** *Xylocarpus granatum* showed a DPPH radical scavenging activity of 70%, demonstrating strong antioxidant potential.
- **Anti-inflammatory Activity:** The plant exhibited a 50% inhibition of albumin denaturation, indicating moderate anti-inflammatory potential.

Ecological Contributions

- **Fish Population:** The fish population density was 35% higher in mangrove areas dominated by *Xylocarpus granatum* compared to non-mangrove areas.
- **Soil Nutrient Cycling:** Decomposing *Xylocarpus granatum* leaf litter enhanced soil organic carbon content by 1.3%, improving soil structure and fertility.

DISCUSSION

The results of this study demonstrate that *Xylocarpus granatum* possesses a remarkable nutritional and medicinal profile, making it a valuable species for both ecological and human health benefits. The high protein and essential fatty acid content of the seeds make it a potential source of plant-based nutrition, while the fruit provides vital minerals and fiber, contributing to human health.

The phytochemical analysis revealed that the plant's bioactive compounds, including tannins, flavonoids, and polyphenols, contribute to its antioxidant, anti-inflammatory, and antimicrobial properties. These compounds hold

promise for pharmaceutical applications in the treatment of oxidative stress-related diseases, inflammation, and infections.

Ecologically, *Xylocarpus granatum* plays a crucial role in sustaining marine biodiversity by providing breeding and nursery grounds for juvenile fish. The increase in fish density in mangrove areas dominated by this species underscores its importance for coastal food security. Furthermore, the decomposition of its plant material enhances soil fertility, supporting sustainable agriculture in mangrove-adjacent regions.

Potential for Biotechnological and Pharmaceutical Applications

Due to its rich phytochemical composition, *Xylocarpus granatum* has potential applications in:

- **Nutraceuticals:** Its antioxidant and anti-inflammatory properties can be utilized in functional foods and dietary supplements.
- **Pharmaceuticals:** The antimicrobial and gastroprotective properties of its bioactive compounds make it a promising candidate for developing herbal medicines.
- **Bioprospecting:** Sustainable harvesting of its bioactive components can lead to innovative health and industrial applications.

Conservation and Sustainable Utilization

Despite its ecological and nutritional importance, *Xylocarpus granatum* faces threats due to habitat destruction, overexploitation, and climate change. Conservation efforts should focus on:

- **Habitat Protection:** Establishing protected areas and enforcing regulations against deforestation.
- **Sustainable Harvesting:** Promoting responsible collection practices to ensure long-term availability.
- **Community-Based Conservation:** Encouraging local communities to participate in conservation efforts while benefiting from its sustainable use.

CONCLUSIONS AND RECOMMENDATIONS

Xylocarpus granatum is a vital mangrove species with significant nutritional, medicinal, and ecological value. Its rich biochemical profile suggests its potential use in nutraceuticals, pharmaceuticals, and ecosystem services. The species supports biodiversity, improves soil health, and offers traditional and modern medicinal benefits. Further research and conservation efforts are essential to ensure its sustainable utilization while preserving Bhitarkanika's fragile mangrove ecosystem.

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