



(RESEARCH ARTICLE)



## Phytochemical Profiling and Pharmacological Evaluation of *Caesalpinia Bonducella* Seed Extracts

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International Journal of Science and Research Archive, 2025, 17(02), 717–727

Publication history: Received on 03 October 2025; revised on 15 November 2025; accepted on 18 November 2025

Article DOI: <https://doi.org/10.30574/ijrsra.2025.17.2.3082>

### Abstract

In this work, aqueous and methanolic solvents are used to examine the phytochemical makeup and pharmacological potential of *Caesalpinia bonducella* seed extract. Long acknowledged for their therapeutic value, traditional medical systems like Ayurveda, Siddha, and Unani have shown that this plant, especially its seeds, have anti-inflammatory, antioxidant, antibacterial, and immunomodulatory properties. Qualitative phytochemical screening of aqueous extracts verified the presence of bioactive substances such as phenols, alkaloids, flavonoids, tannins, coumarins, Quinone, and saponins. With a total ash value of 10.3% and an acid-insoluble ash content of 1.8%, physicochemical analyses demonstrated good mineral content and purity. FTIR spectral analysis confirmed the existence of flavonoids, glycosides, and fatty acids by identifying functional groups typical of hydroxyls, amines, alkanes, carbonyls, and aromatic compounds. Strong absorbance was detected by UV-visible spectroscopy in the 200–310 nm range, especially for methanolic extracts. This corresponds to the  $\pi \rightarrow \pi^*$  and  $n \rightarrow \pi^*$  transitions, which are frequently linked to flavonoid and phenolic compounds. In vivo studies confirmed immunomodulatory action by increased neutrophil adherence and antibody response, while biological evaluations revealed a variety of therapeutic potentials, including anti-inflammatory, antibacterial, antidiabetic, and antioxidant properties. Both the ethnopharmacological use of *C. Bonducella* and its potential for development into standardized herbal formulations with broad-spectrum medicinal applications are supported by these findings.

**Keywords:** *Caesalpinia Bonducella* Phytochemical Screening; Methanolic Extract; Anti-Inflammatory; Antibacterial; Monograph

### 1. Introduction

For thousands of years, plants have been used to maintain human health and improve the quality of human life. They are also valuable ingredients in medicines, seasonings, beverages, cosmetics, and dyes. Herbal medicine is based on the idea that plants contain natural substances that can improve health and reduce illness. In recent years, there has been a global increase in interest in plant research, and a substantial amount of evidence has been gathered to demonstrate the enormous potential of medicinal plants used in various traditional systems [1]. Ayurveda, India's traditional Hindu medical system, mentions the plant *Caesalpinia Bonducella*. Researchers worldwide are still interested in ethnopharmacological studies on medicinally significant plants and herbs. However, the absence of standardized quality control profiles is one of the barriers to the use of the Ayurvedic or Siddha formulations [2, 3]. According to the World Health Organization (WHO), medicinal plants are those that have qualities or chemicals that can be utilized therapeutically or that create valuable pharmaceuticals by synthesizing metabolites [4, 5]. Although *Caesalpinia bonducella* is widely used in traditional medicine, there are currently relatively few published systematic pharmacological studies on the plant. The ancient Indian traditional medical system known as Ayurveda mentions the

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plant *Caesalpinia Bonducella* L. The species name "Bonducella," comes from the Arabic word "Bonduce," which means "little ball" and describes the globular form of the seed [6]. The drug's Ayurvedic assay, "kuberakshi," which means "eyes of Kuba," the Hindu God of riches, is explained by the seeds' grey color and eyeball-like appearance. In the Malabar areas, traditional Siddha practitioners employ *C. bonducella* to cure psoriasis. It is also utilized in Pakistan's traditional medical system. *Caesalpinia Bonducella* L. is a medicinal plant belonging to the family Caesalpiniaceae. It is a prickly shrub widely distributed all over the world, especially in Indian tropical regions such as Kerala, the Andaman and Nicobar Islands, and Sri Lanka [7]. It has antibacterial, antiviral, anti-estrogenic and antidiabetic activities due to these properties several preparations of the plant are used in folk medicine [8, 9].

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## 2. Literature Review

Around the world, herbal treatments are crucial to people's health. They are therapeutic in the course of therapy. In addition to being used to cure certain ailments, plants may also help people stay healthy [11]. The precise components of herbal medications that work well for particular treatments must be understood. Numerous examples show the benefits of using herbal plants in different traditional contexts. Numerous medicinal plants have been found to be useful in curing conditions like anomalies of the central nervous system, metabolic issues, liver issues, cardiovascular issues, and stomach issues [12]. Sometimes, traditional treatments use medicinal herbs. "Like people with various illnesses, plants also need phytochemicals to survive. The 300,000 plant species in the world, only around 5% have had their potential as medicines investigated experimentally [13, 14]. Experts have noted that medicinal plants are used to cure ailments in developing nations, especially in places without clinics. Numerous scholars are looking at the pantropical leguminous scandent shrub *Caesalpinia bonducella* for scientific objectives. People have been using it as medicine since ancient times [15]. The Caesalpiniaceae family includes *Caesalpinia bonducella*. It is sometimes referred to as *C. crista* Linn and *C. bonducella* Flem. Other names for it include Nicker Nut, Bonduce Nut, and Fever Nut. It is sometimes referred to as *C. crista* Linn and *C. bonducella* Flem [16]. Other names for it include Nicker Nut, Bonduce Nut, and Fever Nut. In Indian, or Ayurvedic, medicine, *Caesalpinia bonducella* is widely used for its anti-periodic, anti-pyretic, calming, anthelmintic, and anti-malarial properties. It is also used for other ailments such as skin conditions, hydrocele, leprosy, spasms, orchitis, paralysis, and analogous nerve issues. Anti-oxidant, anti-bacterial, anti-cancer, and anti-diabetic qualities are also said to be present. This survey aims to highlight *Caesalpinia Bonducella* chemical components as well as its pharmacological and therapeutic uses [17].

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## 3. Materials And Methods

The aqueous extract of *Caesalpinia bonducella* nut, containing the seed and the shell, has been evaluated for the qualitative analysis of secondary metabolites (tannins, flavonoids, alkaloids, saponins, coumarins, quinones and phenols), in-vitro anti-inflammatory, anti-diabetic assays, anti-oxidant, anti-mitotic, and anti-microbial activities [10].

### 3.1. Taxonomic Status

- Kingdom: Plantae
- Division: Magnoliopsida
- Genus: *Caesalpinia* the *Bonducella* species [18, 19]
- ENGLISH: Bonduc nut, Fever nut
- HINDI: Kantikaranja, Sagar gota
- MARATHI: Gajaga
- UNANI: Karanjwaa
- TAMIL: Kazarci
- KANNADA: Kiri gujjuga [20]

#### 3.1.1. Geographical Indications

The plant is found throughout Asia's tropical and subtropical zones. It has spread to India, Sri Lanka, Bangladesh, Myanmar, China and Vietnam [21].

#### 3.1.2. Plant Materials

Fresh *Caesalpinia bonducella* nuts, including seeds and shells; Solvent: distilled water for preparing the aqueous extract; Chemicals: reagents for qualitative analysis (e.g., specific reagents for tannins, flavonoids, alkaloids, etc.); and standards for biological assays [22]. A systematic approach was used to study the properties of the aqueous extract of *Caesalpinia bonducella* nuts, including the preparation of the extract, qualitative analysis of secondary metabolites, and evaluation

of various biological activities. Techniques for Making an Aqueous Extract: Gathering and Preparing. We gathered, washed, and dried fresh nuts. The seeds were extracted by removing the outer shell [23].



**Figure 1** Plant of *Caesalpinia Bonducella* and Seed Kernel

### 3.1.3. Pharmacogenetic Research

Description of plants For *C. Bonducella*, the following botanical been described evergreen foliage, taproots and deep roots [24].

### 3.1.4. Stem type: woody and hard.

Type of leaf: elliptical, ovate and bipinnately compound.

Leaf placement: Switch up Green is the color of the leaves.

Macroscopic Features: The yellow prickles of the *C. bonduc* are quite solid and straight, and its branches are dark grey [25].

### 3.1.5. Leaves

*C. bonduc* has huge, frequently branched leaves that measure 30 to 60 cm in length. The dorsal side of the leaf has prickly petioles. Six to eight sets of pinnae with a few stipulary spines and smaller pinnae, with an extended mucronate point are found at the leaf base [26, 27].

### 3.1.6. Flowers

The axillary racemes of the densely blooming *C. bonduc* are thick at the top and slender at the base. The flowers of this shrub are between 15 and 25 cm long. The pedicels of buds are short, those of flowers are almost 5 mm, and those of fruits are around 8 mm [28].

### 3.1.7. Seeds

seeds are hard-coated, greenish or grey, and somewhat compressed on one side due to the close squeezing of neighboring seeds [29]. The black, spherical seeds have vertical cracks that run through them. The dried seed kernels are separated from the testa, which has three layers and is between 1 and 1.25 mm thick. The hilum and micropyle are shown to be near to each other [30]. Typically, a dim zone with a yellowish residue around the funicle envelops the hilum. Micropyle is close to the outskirts of a dark neighborhood. Its seed coat is a rather faint, pale blue color that ranges from green to gray. Fixed oil is abundant in *Caesalpinia Bonducella* seeds. Both the seeds kernels and the oil that is extracted from them have notable pharmacological properties. Seeds oil has “anti-arthritis” and “rubefacient”, effects [31].

Production and Extraction: Fine powder was made from the seeds and shells. A known amount of the powdered material (for example, 100 g) was combined with 1 L of distilled water and boiled for 30 minutes [32]. The clear aqueous extract was then obtained by cooling the mixture and filtering it using filter paper or muslin fabric. “Evaluation of Secondary Metabolites Qualitatively” [33].



**Figure 2** Extracted Powder

The following common phytochemical screening techniques were used to conduct the quality analysis.

### 3.2. Quality Analysis

**Tannins:** The ferric chloride test shows the presence of tannins when a dark blue, “greenish-black” color Forms.

- **Alkaloids:** Mayer's test; a cream precipitate indicates the presence of alkaloids.
- **Saponins:** Froth test; persistent froth formation indicates saponins.
- **Coumarins:** UV light test; fluorescence under UV light indicates coumarins.
- **Quinones:** Test with concentrated sulfuric acid; development of a red color indicates quinones
- **Phenols:** Ferric chloride test; a color change to violet indicates phenolic compounds.
- **Flavonoids:** The Shinoda test; a pink or red color upon the addition of magnesium and hydrochloric acid indicates flavonoids [<sup>34</sup>, <sup>35</sup>].

### 3.3. Phytochemical Of *C. Bonducella*

“Significant levels of flavonoids, tannins, proteins, alkaloids, carbohydrates that reduce sugars, phytosterols , saponins, coumarins, and triterpenoids were found in the ethanolic and aqueous extracts of *C. bonduc* after preliminary phytochemical screening Nevertheless, bonducin, proteins, saponins, starch, sucrose, enzymes, two phytosterols—sitosterol and heptacosane—fatty acids, including palmitic acid, stearic acid, lignoceric, oleic, and linolenic acid, as well as furanoditerpenes, were all found in the plant's seeds [<sup>36</sup>, <sup>37</sup>, <sup>38</sup>].

**Table 1** Phytochemicals of *Caesalpinia Bonducella*

Compound name	Amount present in %
Protein	7.4 to 25.3 %
Aspartic acid	9.5%
Lysine	7.9 %
Glycine	6.9%
Leucine	6.3%
Histidine	5.1%
Isoleucine	5.1%
Serine	3.8%
Tyrosine	3.7%
carbohydrates	49%
Mucilage	4.4%
Bonducin	0.35%

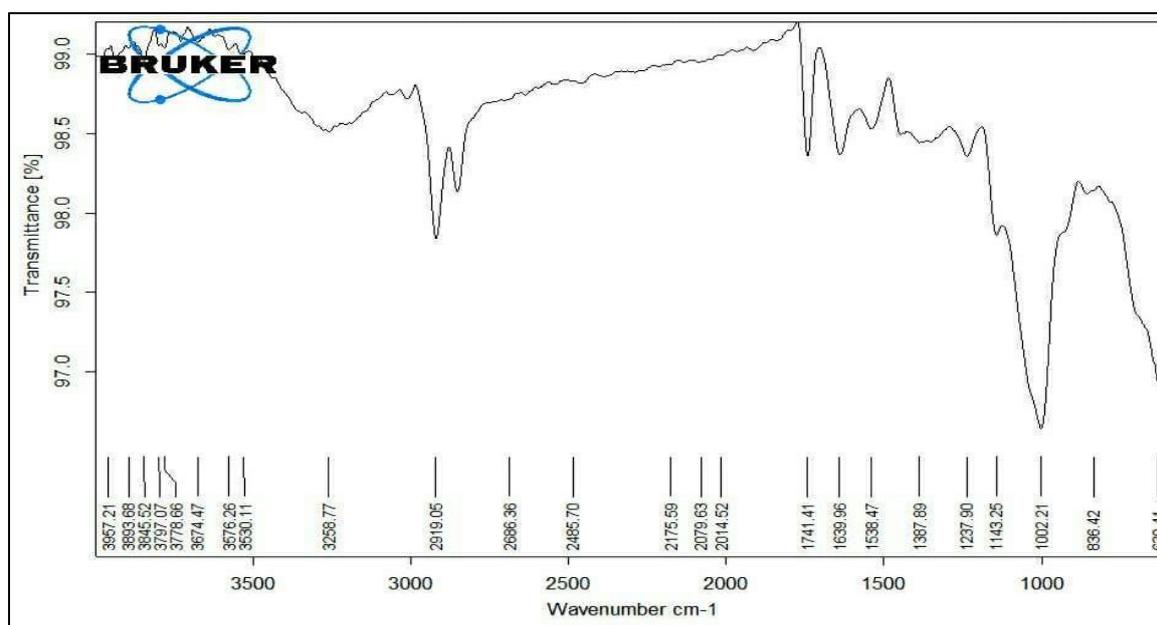
### 3.4. Physicochemical Parameters

**Table 2** Physicochemical properties of Seed Extract

Sr. No.	Parameters	Observations
1	Organoleptic properties A] Color B] Odour C] Taste	Greyish –white Unpleasant Bitter
2	Moisture content	0.68%
3	Acid insoluble ash	1.8%

## 4. Qualitative Analysis

### 4.1. IR Spectroscopy



**Figure 3** IR spectroscopy of *C Bonducella* seed extract

Spectra of *Caesalpinia Bonducella*. FTIR is used to identify functional groups and molecular structures based on characteristic absorption bands (wavenumbers in  $\text{cm}^{-1}$ ) [39].

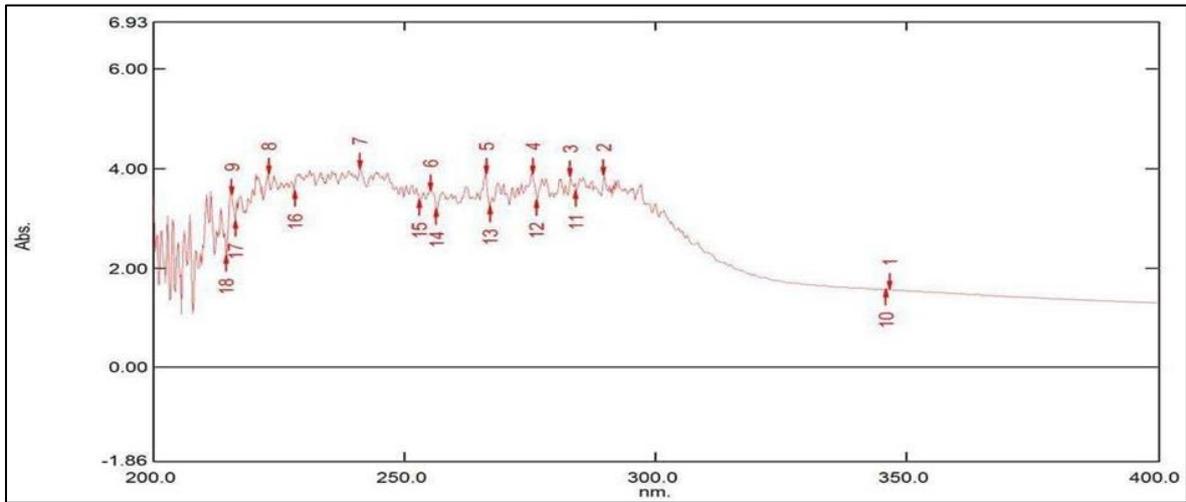
**Table 3** Functional group present in *Caesalpinia Bonducella* seed extract.

Wavenumber ( $\text{cm}^{-1}$ )	Functional Group / Bond Type
3957 – 3674	Alcohols / Phenols (Hydroxyl groups)
3562 – 3500	Amine or Amide groups
2175 – 2014	Alkynes or Nitriles (less intense)
1741	Carbonyl groups: Esters, Aldehydes, Ketones
1143 – 1002	Alcohols, esters, ethers
886 – 630	Aromatic compounds

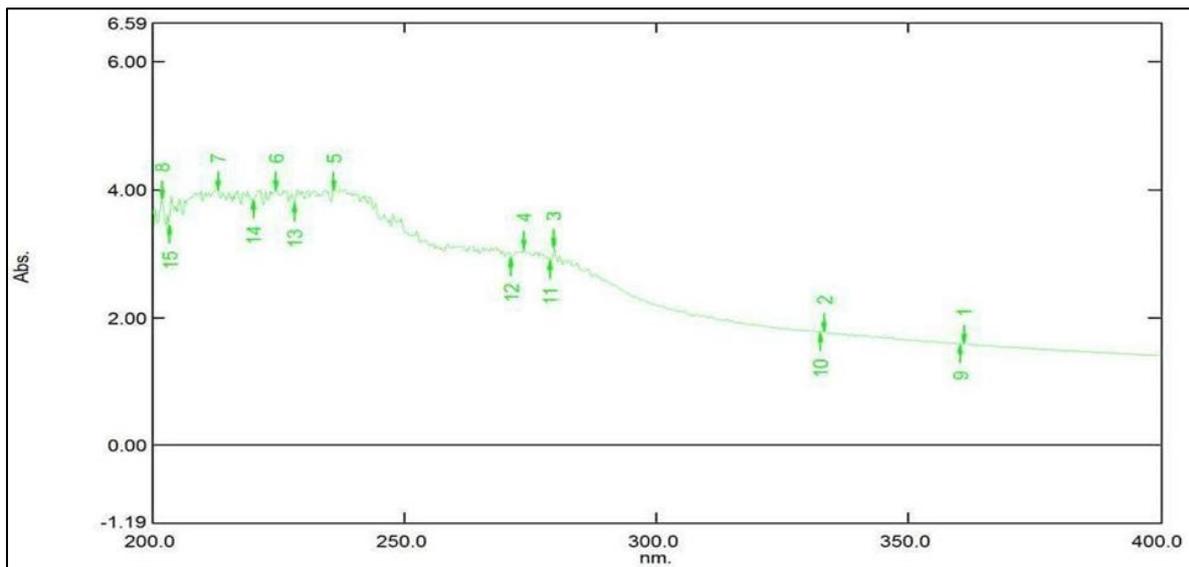
- Phenols/ Flavonoids
- Alkaloids
- Proteins
- Glycosides
- Fatty acids<sup>[40]</sup>

These are consistent with the known phytochemical constituents of *Caesalpinia Bonducella*, which has pharmacological activities like antioxidant, anti-inflammatory, antimicrobial, and anticancer <sup>[41, 42]</sup>.

#### 4.1.1. UV Visible Spectroscopy



**Figure 4** UV-VIS spectroscopy using water as a solvent



**Figure 5** UV-VIS spectroscopy using methanol as a solvent

**Table 4** Observations of UV-VIS using water as a solvent

Peak Region (approx.)	Possible Compounds / Groups
200–240 nm	Aromatic rings, flavonoids, conjugated dienes
240–280 nm	Phenolic –OH, carbonyl groups, alkaloids, flavonoids
~300–350 nm	Flavonoids, flavanols, phenolic acids (less intense here)

- Flavonoids (like quercetin, kaempferol)
- Phenolic acids
- Glycosides
- Alkaloids<sup>[43]</sup>

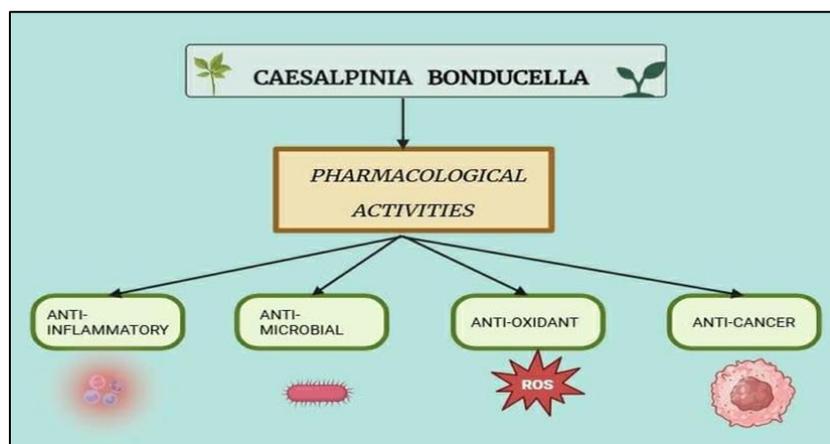
**Table 5** Observations of UV-VIS using methanol as a solvent

Peak Region (approx.)	Possible Functional Groups / Compounds
200–240 nm	Aromatic rings, conjugated double bonds, phenolics
240–280 nm	Carbonyl compounds, flavonoids, alkaloids
280–310 nm	Flavonoids, extended conjugated systems
~330–350 nm (weak)	Trace levels of extended conjugated flavonoids

#### 4.2. Pharmacological Activities

The *C. Bonducella* possesses flowers antipyretic and analgesic qualities. The phytochemical analyses of ethanolic bark extracts from the two new homoisoflavonoids that *C. bonducella* produced, in addition to five well-known natural products <sup>[44]</sup>. Each of these

Compounds showed varying glutathione levels. Potential inhibitory and antifungal effects of S-transferase (GST), CNS depressant, antinociceant, and diarrheal activities of the *C. bonducella* stem ethanolic extract were also noted <sup>[45]</sup>. Recently, it was discovered that the plant root extract was found to contain anti-inflammatory and antimicrobial properties, whereas the root Bark has anti-fertility properties. The plant's leaves demonstrate anti-inflammatory, analgesic, and antipyretic properties <sup>[46]</sup>. CNS depressant, anti-proliferative, anti-psoriatic. Amyloidogenic, hepatoprotective, antioxidant, and antitumor. Mosquito repellent, anti-asthmatic, and muscle relaxant Properties <sup>[47]</sup>. Ahsan et al. discovered the antibacterial and cytotoxic effects of methanolic leaf and bark extracts of the plant. A polymethylene compound, which is in charge of antimicrobial activity, was isolated. From an ethyl acetate extract of *C. bonducella* leaves <sup>[48, 49, 50]</sup>.

**Figure 6** Pharmacological Activity of *C. bonducella*

### 4.3. Examination of Toxicity

Using the Miller and Tainter (1944) protocol, a dried extract of *C. bonducella* was diluted in water and given orally to various groups of rats at dosages ranging from 100 to 1000 mg/kg body weight for the LD50 investigation. After seven days of treatment, none of the groups experienced any mortality [51, 52].

### 4.4. In Vivo Immunomodulatory

*C. bonduc* extract has been demonstrated to have anti-inflammatory effects in multiple studies [53]. Among published studies, one found that an ethanolic extract *C. bonduc* seeds has immunomodulatory properties. This study studied the immunomodulatory efficacy of *C. bonduc* ethanolic seed extract (200-500 mg/kg) [54, 55]. The experiment found that the percentage of neutrophils adhering to nylon fibers increased considerably. The study discovered that sheep red blood cells enhanced the delayed-type hypersensitivity reaction by boosting antibody titers in a dose-dependent manner. In vivo tests demonstrated neutrophil adherence, haemagglutinating, antibody titre, delayed type hypersensitivity reaction, phagocytic activity, and cyclophosphamide-induced myelo-suppression [56].

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## 5. Conclusion

The current study provides a thorough pharmacogenetic, phytochemical, and pharmacological overview of *Caesalpinia Bonducella*, a medicinally significant plant in the Fabaceae/Caesalpinaceae family. This plant, also known as Kuberakshi or Bonduc Nut, has long been used in the Ayurvedic, Siddha, and Unani medical systems to treat fever, inflammation, skin diseases, diabetes, and nervous disorders. Pharmacognostic analysis showed distinctive macroscopic characteristics such as hard-coated greyish seeds that are rich in fixed oils, bipinnate compound leaves, prickly petioles, and yellow prickles on stems. Tannins, flavonoids, alkaloids, phenols, coumarins, quinones, and saponins are among the bioactive secondary metabolites that were confirmed to be present by the methodical extraction and qualitative analysis of the plant's seed and shell extracts. Functional groups corresponding to phenolics, carbonyls, aromatic rings, and glycosides were found in FTIR and UV-VIS spectroscopic analyses, which further supported these compounds and suggested the plant's rich phytochemical profile. Important components including proteins, carbohydrates, phytosterols, fatty acids, and bonducin were found by phytochemical screening; these components all support the plant's wide range of pharmacological effects. Numerous therapeutic properties, such as anti-inflammatory, antipyretic, analgesic, antioxidant, antimicrobial, antidiabetic, hepatoprotective, CNS depressant, and immunomodulatory activities, are demonstrated by *C. Bonducella*, according to pharmacological studies and literature data. According to toxicity studies, both the ethanolic and aqueous extracts are safe at moderate dosages and do not cause death in experimental models. Overall, the results demonstrate *Caesalpinia Bonducella* potential as a source of new bioactive compounds for drug development and support its traditional use. Standardized quality control procedures and sophisticated pharmacological and clinical research are still scarce, though, despite its lengthy history of use. Future studies should concentrate on identifying particular active ingredients, clarifying how they work, and using cutting-edge clinical trials to confirm therapeutic efficacy.

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## Compliance with ethical standards

### *Acknowledgments*

We would like to take this time to thank our esteemed mentor, Mr. Unmesh Bhamare, for his important advice, unwavering support, and encouragement during the project's completion. His astute advice, helpful critiques, and knowledgeable oversight have been a continual source of encouragement and inspiration, helping us to overcome a variety of obstacles we have faced while working. We really appreciate his generous sharing of his time, patience, and knowledge, all of which have been crucial to the successful completion of this project. In addition to helping us improve our academic and research abilities, his mentoring has given us a feeling of discipline, commitment, and scientific curiosity.

### *Disclosure of conflict of interest*

The authors declare that there is no conflict of interest regarding the publication of this research work.

### *Statement of ethical approval*

The present research work does not contain any studies performed on animals or human subjects by any of the authors.

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