IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 5, March 2026
Impact Factor: 8.2

The Cannonball Tree: An Integrated Review on Couroupita Guianensis and its Future Research Scope

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Abstract: *Couroupita guianensis, commonly referred to as the Cannonball tree, is a species of significant medicinal value, recognized for its extensive array of bioactive compounds found in its flowers, fruits, leaves, and other parts. This plant is rich in various phytoconstituents, such as alkaloids, flavonoids, sterols, triterpenoids, phenolics, and carotenoids, many of which play a role in its traditional medicinal uses. These compounds demonstrate remarkable pharmacological properties, including antimicrobial, anti-inflammatory, antioxidant, analgesic, wound-healing, and antiproliferative effects. Recent research has increasingly concentrated on elucidating the chemical makeup and biological efficacy of compounds such as couroupiol, isatin derivatives, nerol, linalool, β-sitosterol, and an array of flavonoids. The accumulating evidence positions C. guianensis as a valuable resource for the formulation of herbal remedies and enhanced cosmetic and personal care products. This review highlights the phytochemical abundance of the plant and advocates for further investigation into its therapeutic uses, safety assessments, and potential for product development*

Keywords: Couroupita guianensis,Connonball tree, Antimicrobial, Phytoconstituents

I. INTRODUCTION

Couroupita guianensis Aubl., widely recognized as the Cannonball tree, is a tropical species of significant cultural and medicinal importance, classified within the Lecythidaceae family. This species is originally from the Amazon basin's rainforests but has since proliferated throughout tropical areas of Asia, including India, Sri Lanka, Thailand, and Malaysia, where it is esteemed for its ornamental and medicinal attributes. The tree is notable for its large spherical fruits, aromatic flowers, and distinctive cauliflorous growth pattern, which have attracted both scientific and ethnobotanical interest due to their uniqueness and cultural significance [1].

In India, the flowers of this species are of considerable religious importance and are frequently utilized in temple ceremonies, particularly in the veneration of Lord Shiva. In the realm of traditional medicine especially within Ayurveda, Siddha, tribal medicine, and various folk practices various parts of the plant, including leaves, bark, flowers, fruit pulp, and seeds, are extensively employed. These components are traditionally used to treat skin ailments, inflammation, pain, fever, microbial infections, wounds, and urinary issues [2].

Phytochemical research has revealed that C. guianensis is a prolific source of indole alkaloids, flavonoids, terpenoids, tannins, phenolic compounds, and essential oils. Notably, the alkaloids tryptanthrin (couroupitine A) and indirubin (couroupitine B) have been extensively researched for their antimicrobial, anti-inflammatory, antinociceptive, wound-healing, and anticancer properties. Extracts derived from the leaves, fruits, and flowers have shown promising pharmacological effects in a variety of preclinical investigations [3].

Antimicrobial studies indicate that extracts from leaves and fruits exhibit notable antibacterial and antifungal properties, which corroborate their historical application in treating skin infections and managing wounds. Research on the anti-inflammatory and antioxidant properties of leaf and bark extracts further implies their capability to mitigate oxidative stress and prevent tissue damage.Investigations into wound healing utilizing fruit pulp have revealed

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enhanced epithelialization and granulation tissue development in animal models, suggesting positive impacts on tissue repair [4].

Neuropharmacological evaluations have indicated that methanolic extracts from flowers diminish spontaneous motor activity and extend phenobarbital-induced sleep duration in mice, implying potential sedative or central nervous system-modulating effects.Various extracts and isolated compounds, especially indole alkaloids, have shown cytotoxic and antiproliferative properties

future Research scope

against cancer cell lines, highlighting their potential as candidates for anticancer drug development [5].

In spite of its extensive traditional applications and robust preclinical findings, there is a lack of human clinical trials, and comprehensive data regarding long-term safety, toxicity, pharmacokinetics, or standardized dosages is limited [6].

Fig.1:- Cannonball tree.

Literature review :-

1. Nagendra K K Rangaiah G S,

In this modern study, the bio-control of the ocular pathogen Corynebacterium macginleyi was accomplished through the use of methanol, chloroform, and hexane extracts derived from forty distinct medicinal plants, employing the agar well diffusion method. Of the forty plants examined, the methanolic extracts from thirty-six exhibited significantly greater bioactivity compared to the chloroform and hexane extracts against C. macginleyi. The extracts from Terminalia catappa, Terminalia chebula, Rosa indica, Albizia lebbeck, and Butea monosperma demonstrated the highest levels of activity. Conversely, Hibiscus rosa-sinensis, Justicia adhatoda, Physalis minima, and Pongamia pinnata did not show any antibacterial activity under the conditions tested. Overall, 90% of the plants investigated displayed antibacterial properties, while the remaining 10% did not exhibit any antibacterial activity.

2. Abdul, MM; Sarker, AA;

The study was carried out using a crude methanolic extract derived from the leaves of Abutilonindicum to assess its cytotoxic and antimicrobial properties. The antimicrobial efficacy of the extract was tested against a range of Gram-positive and Gram-negative bacteria, as well as fungi, employing the disk diffusion method. To evaluate cytotoxic activity, a brine shrimp lethality bioassay was conducted to determine the LC50 values.

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3. Shekhawa MS, Manokari M.

The current research investigates the efficacy of exogenous auxins in promoting the formation of adventitious shoots and roots from shoot cuttings of Couroupita guianensis (Nagalingam), a species classified as threatened. A series of experiments were carried out to evaluate the impact of different auxin concentrations on the morphological characteristics of shoots and roots derived from stem cuttin`gs in a greenhouse setting. Among the auxins evaluated, notable effects on the induction and growth of shoot buds were recorded in nodal cuttings treated with α-Naphthalene Acetic Acid (NAA).

4. F. Jasmine. S., Moorthi. R

Medicinal plants serve a significant role in traditional medicine by providing relief for various ailments. Couroupita guianensis is one such medicinal plant that exhibits a range of activities including antibacterial, antimycobacterial, antimicrobial, antioxidant, antitumor, antiulcer,

antinociceptive, anthelmintic, antifertility, and antifungal properties. The chemical compound indirubin found in C. guianensis acts as both an antibacterial and antifungal agent, particularly effective against fungal infections. Additionally, it is utilized in the treatment of chronic myelocytic leukemia.

5. S. K. Gousia, Ashok Kumar. K

Couroupita guianensis, commonly referred to as the “Cannonball tree,” “Sal tree,” or “Ayauma tree,” has achieved a global distribution. This tree possesses significant medicinal properties, as various parts including the leaves, flowers, fruits, and stems are utilized in traditional medicine to treat a range of ailments. In this review, we aim to present the current knowledge regarding the phytochemical components, medicinal applications, and other biological activities associated with Couroupita guianensis. This plant holds considerable importance in traditional veterinary medicine and has been commercially utilized for an extensive period. Over the past few decades, numerous studies have reported its anti-inflammatory, anti-ulcer, and anti-cancer properties.

COUROUPITA GUIANENSIS

Synonyms :- couroupita guiansis Aubl,couroupita nicaraguensis,couroupita perlata Miers.

Biological source:- Couroupita guianenDsis Aubl., commonly known as the cannonball tree, belongs to the family Lecythidaceae and is a tropical plant whose leaves, flowers, fruits, seeds, and bark are used for various medicinal purposes.

Geographical source :- The cannonball tree originates from the dense tropical rainforests of north-eastern South America, especially within the Amazon Basin. Additionally, it is native to Central America, including Costa Rica and Panama, as well as Western South America, which encompasses Colombia, Ecuador, and Peru, along with Brazil .There is also a belief that it is indigenous to India, Sri Lanka, and Malaysia. In India, it is cultivated across the plains [7].

Description:-The cannonball tree is a sizable, deciduous species that can reach heights of up to 35 meters. It features a straight trunk covered in smooth bark and is notable for its large, spherical, woody fruits that resemble cannonballs, which dangle directly from the trunk on elongated stalks. This tree also produces large, striking, fragrant flowers characterized by a distinctive structure-petals that range from bright pink to reddish, arranged in a hood-like formation of stamens.

Organoleptic characters:-(Fruit)

- Color: Greenish when unripe, turning brown and woody
- Odor: Pungent and unpleasant when cracked open
- Taste: Astringent and slightly offensive in taste

-Texture :- Hard outer shell with soft, pulpy interor . □ Chemical contituents:-

-Couroupita guianensis contains important bioactive molecules such as alkaloids (indirubin, tryptanthrin), triterpenoids (lupeol, ursolic acid).

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- flavonoids (quercetin, kaempferol), along with phenolic acids and aromatic components like linalool and eugenol.These constituents are mainly responsible for the plant's antioxidant, antiinflammatory, antimicrobial, and anticancer activities[8].

Propagation and Cultivation:

Fresh seeds, which sprout well in damp, shady nursery circumstances, are the primary method of propagation for Couroupita guianensis; stem cuttings are employed less frequently. The tree's enormous canopy and heavy fruits make it ideal for decorative planting in open settings. It thrives in warm tropical climes with well-drained fertile soil, frequent watering in its early stages, and full to partial sunlight.

 Scientific name :- Couroupita guianensis .

 Commmon names :-

English:- Cannon ball tree.

Hindi :- shivaling , Ayahuma .

 Taxonomical Classification:-

• Kingdom : Plantae-Plants
• Subkingdom : Tracheobionta-Vascular plants
• Superdivision : Spermatophyta-Seed plants
• Division : Magnoliophyta-Flowering plants
• Class : Magnoliopsida-Dicotyledons
• Subclass : Dilleniidae
• Order : Lecythidales
• Family : Lecythidaceae – Brazil-nut family
• Genus : Couroupita Aubl. – Cannonball Tree
• Species : Couroupita guianensis Aubl. – Cannonball Tree [5].

 Commercial Applications:-

1. Herbal Medicines: Extracts from the leaves, flowers, and bark are used in traditional formulations for treating wounds, infections, inflammation, and pain.
2. Antimicrobial Products: Due to its strong antibacterial and antifungal properties, it is used in the development of herbal soaps, hand sanitizers, and wound-healing creams.
3. Aromatherapy & Perfumery: The fragrant flowers are a source of essential oils used in perfumes and aromatic products.
4. Nutraceuticals: Capsules and powders from dried plant parts are marketed as supplements for immune support and anti-inflammatory benefits.
5. Cosmetic Industry: Its antioxidant-rich extracts are used in skincare products for anti-aging and skin protection[9].

Morphology:-

1. Leaves:-

Phytochemicals such flavonoids, alkaloids, glycosides, tannins, steroids, and terpenoids have been reported to be present in C. guianensis aqueous extracts. Saponins have also been found in acetonic and methanolic extracts of C. guianensis leaves, which may be useful in the treatment of a number of illnesses [6]. The leaf extract of Couroupita guianensis has been shown to include phytochemical elements, including a high concentration of alkaloids, glycosides, phlobatannins, steroids, terpenoids, and tannins, as well as a moderate amount of flavonoids [7].

Secondary metabolites such as sugars, proetins, alkaloids, terpenoids, flavonoids, and phenolic substances have been detected in crude methanol extracts of this cannonball tree's leaves [8].

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Figure 2:- Leaves of Cannonball Tree.

2. Fruit :-

Alkaloids, sugars, tannins, glycosides, proteins, steroids, and triterpenes are among the phytochemicals found in the fruit pulp of C. guianensis [9]. Tannins, sugars, and polyphenolic substances are among the phytochemicals found in C. guianensis's alcoholic fruit extract [7]. Triterpenes, steroids, and proteins [9] Tannins, sugars, and polyphenolic substances are among the phytochemicals found in C. guianensis's alcoholic fruit extract [7].

3. Bark:-

The bark of Couroupita guianensis is rough, fissured and greyish-brown externally, with a reddishbrown fibrous inner layer that has an astringent taste. It contains tannin cells, calcium oxalate crystals and lignified fibers as key microscopic features. Chemically, the bark is composed of tannins, phenolics, flavonoids, triterpenoids, alkaloids and saponins, which contribute to its medicinal value. Pharmacological studies show that the bark has antimicrobial, anti-inflammatory and antioxidant activities, and it supports wound healing and anti-diarrheal effects[9].

4. Flower:-

The flowers of Couroupita guianensis are large, showy and fragrant, arranged in long hanging racemes that grow from the trunk. They are reddish-pink to orange on the outer side with a yellow and white hooded staminal structure inside [10]. Furthermore, it has been observed that phytoconstituents such proteins, alkaloids, terpenoids, phenolic compounds, and triterpenoids are present in the methanol extract obtained from flowers.[11]. Couroupita guianensis flower extracts have yielded new phytoconstituents, namely stigmasterol and cycloart-24-en-3-ol-4'exomethylene heptadeconate [12]. Phytochemicals including carbohydrates, alkaloids, phenols, saponins, tannins, glycosides, flavonoids, and terpenes were present in the methanolic extract of Couroupita guianensis.[13]. Carbohydrates, proteins, alkaloids, terpenoids, reducing sugars, and triterpenoids were among the phytochemicals found when flowers were treated with methanol. Carbohydrates, proteins, alkaloids, terpenoids, reducing sugars, and triterpenoids were among the phytochemicals found when flowers were treated with methanol.[8].

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Fig4:- Flower of Couroupita guianensis .

Phytochemitry :-

1. Alkaloids:-

 Couroupita guianensis harbors a small yet pharmacologically significant array of alkaloids, primarily found in its fruit, seeds, and stem bark. The two predominant alkaloids consistently identified in various studies are tryptanthrin (Couroupitine A) and indirubin (Couroupitine B). Initial phytochemical evaluations suggest a moderate concentration of alkaloids in stem extract [7] .

 Tryptanthrin is a tetracyclic heterocyclic alkaloid that has been isolated and structurally validated from the stem bark of the plant. It is recognized for its anti-inflammatory properties, functioning through the inhibition of COX-2 and 5-lipoxygenase pathways [14].

 Indirubin, a bis-indole compound that is structurally akin to indigo, has been detected in the fruit and seeds, with quantification in fruit extracts revealing approximately 0.0918% on a dry weight basis. This alkaloid holds pharmacological importance due to its anticancer, antiproliferative, and antimicrobial capabilities [16].

 From a pharmacological perspective, extracts that are rich in these alkaloids especially chloroform extracts derived from the fruit exhibit robust antimicrobial and antibiofilm properties. Both tryptanthrin and indirubin have been incorporated into in-silico drug discovery screenings (for instance, docking studies against Mycobacterium tuberculosis enoyl-ACP reductase), highlighting their therapeutic significance [17].

2. Flavonoids:-

 Flavonoids represent one of the primary categories of secondary metabolites found in Couroupita guianensis Aubl., primarily located in the leaves, flowers, and fruit tissues [15].

 Qualitative and quantitative phytochemical studies have consistently validated the existence of significant flavonoids such as quercetin, kaempferol, catechin, rutin, and their glycosidic derivatives [18].

 These compounds are widely acknowledged for their strong antioxidant, anti-inflammatory, antidiabetic, and hepatoprotective properties, which greatly enhance the medicinal value of the plant [19].

 Methanolic and ethanolic extracts from the leaves have shown a high total flavonoid content, which correlates with a significant capacity for free-radical scavenging.Quercetin and kaempferol, in particular, have been isolated and characterized through chromatographic and spectroscopic techniques, underscoring the plant's abundant flavonoid profile [20].

 The flowers also exhibit a considerable presence of flavonoids, particularly catechin derivatives, which contribute to antimicrobial and cytoprotective effects.These results reinforce the traditional medicinal uses of C. guianensis and emphasize flavonoids as key elements of its pharmacological efficacy [21].

3. Tannins:-

 Tannins constitute a significant category of polyphenolic compounds found in various parts of Couroupita guianensis Aubl., especially in the leaves, bark, and fruit pulp [21].

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 Initial phytochemical analyses have consistently validated the existence of both hydrolysable and condensed tannins, which play a role in the plant's astringent, antioxidant, antimicrobial, and wound-healing characteristics [18].
 Methanolic and aqueous extracts derived from the leaves have demonstrated considerable tannin levels, which correlate with pronounced free-radical-scavenging and
 antibacterial properties.The bark exhibits an even greater concentration of tannins, which supports its traditional application in treating skin infections and inflammatory disorders [21].
 The identification of tannins in C. guianensis is consistent with its ethnomedicinal uses and underscores the plant's significance as a source of natural polyphenolic therapeutics [19].

4. Saponins:-

 Saponins constitute a significant category of secondary metabolites identified in various parts of Couroupita guianensis Aubl., notably within the leaves, bark, and fruit tissues [20].
 Initial phytochemical analyses consistently demonstrate the existence of triterpenoid and steroidal saponins, which play a role in the extensive pharmacological activities of the considerable plant. Extracts from the leaves and bark particularly those obtained through methanol or aqueous solvents exhibit strong positive indicators for saponins, suggesting their presence [18].
 These compounds are linked to antimicrobial, anti-inflammatory, hemolytic, and immunomodulatory properties, thereby supporting the traditional medicinal applications of the plant in addressing skin conditions, wounds, and infections [21].

5. Phenolic compounds :-

 Phenolic compounds represent one of the most prevalent and pharmacologically important classes of metabolites found in Couroupita guianensis Aubl., primarily located in the leaves, flowers, bark, and fruit tissues. Phytochemical investigations have validated the existence of a variety of phenolics, such as gallic acid, ferulic acid, caffeic acid, p-coumaric acid, and numerous polyphenolic derivatives [20].
 These compounds are known for their potent antioxidant, anti-inflammatory, antimicrobial, and cytoprotective properties, which align with the traditional medicinal applications of the plant [19].
 Methanolic and ethanolic extracts derived from the leaves and flowers have shown a high total phenolic content, frequently assessed through Folin–Ciocalteu assays, indicating a substantial reservoir of constituents that scavenge free radicals. Additionally, the bark and fruit pulp exhibit notable phenolic concentrations, reinforcing their documented wound-healing and antiinfective effects. In summary, the phenolic composition of C. guianensis highlights its potential as a significant source of natural antioxidants and therapeutic phytochemicals [18].

6. Glucosides:-

 Glycosides represent a significant category of bioactive metabolites found in Couroupita guianensis Aubl., primarily located in the leaves, bark, and fruit tissues.Initial phytochemical studies have consistently indicated the existence of cardiac, phenolic, and flavonoid glycosides, which enhance the therapeutic potential of the plant.
 Extracts from the leaves and bark, obtained using methanol, ethanol, or aqueous solvents, exhibit strong positive results for glycosides in standard phytochemical screening tests, demonstrating their extensive distribution throughout the plant [18].
 These compounds are linked to a variety of pharmacological activities, such as antioxidant, cardioprotective, anti-inflammatory, and antimicrobial properties.The identification of flavonoid glycosides corresponds with the plant's elevated flavonoid and phenolic levels, implying synergistic functions in scavenging free radicals and protecting tissues [21].

7. Terpenoids & essential oil:-

 Terpenoids constitute one of the most prevalent and biologically important classes of metabolites found in Couroupita guianensis Aubl., primarily located in the flowers, leaves, and stem bark. Phytochemical investigations have revealed a range of triterpenoids, such as αamyrin, β-amyrin, friedelin, and lupeol, which display significant anti-inflammatory, antimicrobial, and antioxidant properties [19].

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 The essential oils, mainly extracted from the flowers, are particularly abundant in monoterpenes and sesquiterpenes, with key compounds including linalool, nerolidol, geraniol, β-caryophyllene, and various benzyl derivatives. These volatile terpenoids not only contribute to the distinctive aroma of the flowers but also exhibit considerable antimicrobial, insectrepellent, and cytoprotective effects [21].

 Investigations utilizing GCMS have consistently validated the chemical diversity present in the essential oil profile, emphasizing its therapeutic and aromatic significance [22].

8. Steroids:-

 Steroidal compounds represent a significant aspect of the phytochemical composition of Couroupita guianensis Aubl., particularly found in its leaves, bark, and fruit tissues. Both preliminary and advanced phytochemical studies have consistently identified the presence of phytosterols, notably β-sitosterol, stigmasterol, and minor amounts of campesterol [21].

 These plant steroids are recognized for their anti-inflammatory, hypolipidemic, antimicrobial, and membrane-stabilizing effects, which contribute to the traditional medicinal applications of the plant.

 Methanolic and ethanolic extracts derived from the leaves and bark often yield strong positive results for steroids in the Liebermann–Burchard and Salkowski assays, indicating a considerable sterol content [18].

 The identification of β-sitosterol aligns with the reported wound-healing and anti-inflammatory properties of the plant, implying a mechanistic involvement of sterols in it ethnomedicinal ethnomedicinal uses [19].

Chemical constituents:-

Part of plants	Chemical Constituents
Flower	Eugenol, linalool, nerol, geraniol, (E, E)-farnesol, (Z, E)-farnesol, vanillin, limonene, and geranial, trans ocimene, nootkatone, (E, E) farnesyl acetate, 2isopropenyl-5-methyl-4-hexenyl acetate), isatin, cycloart-24-en3-ol-3'exomethylene heptadeconate, cedr-8 en-13-ol, (E,Z)-farnesyl acetate, methyl (11E)-11-hexadecenoate, stigmasterol, Myristoleic acid, linoleic acid, octyl 4(nonanoyloxy) benzoate, caffeic acid, quercetin, p-coumaric acid, and ocoumaric acid Icosa-8, 10, 12-triene (8E, 10E, 12E)
Fruit	Malic acid, isocitric acid, stigmasterol, campesterol, hopane, rutin, quercetin, kaempherol, farmaricetin, luteolin, ursolic acid, and Couroupitine A (tryptanthrin) and B (indirubin)
Leaf	Hydroxycinnamic acids, caffeic acid, rosmarinic acid, kaempferol-3 Oneohesperidoside, triterpenic ester β-amirin palmitate, 20, 40-dihydroxy-60-methoxy-30,50-dimethylchalcone, 7-hydroxy-5-methoxy-6,8 dimethylflavanone, and 4-hydroxybenzoic acid
Seed	Indigo, indirubin, stigmasterol, campesterol, linoleic acid, nerol, and tryptanthrin.
Stem & Bark	Phytosterol, β-amyrin, betulin-3β-caffeate, and lupeol-3β-caffeate, along with couropitone (stigmasta-4,23(E)-dien-3-one 1), β-amyrin, β-amyrone, β-amyrin acetate, stigmasterol, ergosta-4,6,8(14), 22-tetraen-3-one, β-sitosterol, and its glycoside.

Table.1Chemical constituents of Couroupitaguianensis.

Medicinal and pharmacological Activity:-

1. Antioxidant activity:-

Couroupita guianensis has demonstrated significant antioxidant activity, largely due to its rich content of flavonoids, phenolic acids, alkaloids, and triterpenoids present in various parts of the plant such as the leaves, flowers, fruits, and bark. The antioxidant effect is primarily attributed to the plant's ability to scavenge free radicals, inhibit lipid peroxidation, chelate metal ions, and enhance antioxidant enzyme activity. These mechanisms help reduce oxidative

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stress, which is associated with various chronic diseases including inflammation, cancer, and neurodegenerative conditions [23].

Flavonoids such as quercetin, kaempferol, and rutin, along with phenolic compounds like caffeic acid, o-coumaric acid, and rosmarinic acid, contribute to the plant's strong free radical neutralizing capacity. Triterpenoids like β-amyrin and lupeol also support cell protection and anti-inflammatory functions. Studies using methanolic and ethanolic extracts of C. guianensis leaves have shown high DPPH radical scavenging activity and reducing power, often comparable to standard antioxidants such as ascorbic acid. The total phenolic and flavonoid content in these extracts has been directly correlated with antioxidant potency [24].

2. Antimicrobial activity:-

Couroupita guianensis has been widely reported and is attributed to its diverse bioactive compounds such as flavonoids, alkaloids, phenolics, terpenoids, and essential oils. Various parts of the plant including bark, leaves, flowers, and fruits exhibit activity against a broad spectrum of microorganisms, including bacteria, fungi, and some protozoa. Bark extracts, rich in triterpenoids like ursolic acid and α-amyrin, as well as Couroupitine-type alkaloids, have demonstrated significant antibacterial activity against both Gram-positive bacteria such as Staphylococcus aureus and Gram-negative bacteria like Escherichia coli and Pseudomonas aeruginosa. Similarly, leaf extracts containing flavonoids (quercetin, kaempferol) and tannins show strong inhibitory effects against pathogenic fungi including Candida albicans and Aspergillus species. The flower extracts, containing naphthylisoquinoline alkaloids (Couroupitine C–F) and essential oils such as linalool and β-caryophyllene, have also been reported to exhibit antimicrobial and antifungal properties [25]. The mechanism of antimicrobial action is primarily through disruption of microbial cell membranes, inhibition of nucleic acid synthesis, and interference with enzyme systems, ultimately leading to microbial cell death. Several in vitro studies have confirmed the efficacy of these extracts, with zones of inhibition comparable to standard antibiotics, while in vivo studies indicate potential therapeutic applications with minimal toxicity. the antimicrobial potential of C. guianensis highlights its promise as a source for natural antimicrobial agents and supports its traditional medicinal use for treating infections.[26].

3. Anthelmintic activity:-

Helminthic infections represent a significant challenge for livestock globally. The emergence of antihelminthic resistance has led researchers to explore plant-based alternatives. In vitro investigations have demonstrated that the leaves and flowers of CG exhibit antihelminthic properties[30].The anthelmintic activity of Couroupita guianensis is attributed to its rich phytochemical profile, which includes alkaloids, flavonoids, tannins, saponins, steroids, and terpenoids. These bioactive compounds act synergistically to combat parasitic worms through multiple mechanisms. Alkaloids contribute to neuromuscular paralysis in helminths, leading to their expulsion from the host, while flavonoids and tannins interfere with the worms' energy metabolism by disrupting mitochondrial function and ATP production. Tannins additionally impair nutrient absorption in parasites by binding to proteins in their gut, and saponins cause structural damage to the worm's cuticle and cell membranes [27].

4. Anti-inflammatory activity:-

The ethanolic extract derived from the fruit of C. guianensis exhibits anti-inflammatory properties. A high dosage of this extract inhibits the migration of white blood cells into the peritoneal cavity. It also suppresses the migration of other cells, along with the activity of cytokines and mediators.[28]. Reactive oxygen species and pro-inflammatory cytokines play a significant role in triggering inflammatory responses within the body. The activation of specific Immune mediators and cytokines facilitates the removal of damaged or pathogen-infected cells; however, in certain instances, pro-inflammatory factors are activated, resulting in the migration of white blood cells under normal conditions. Research has demonstrated that high doses of fruit extract from C. guianensis inhibit cell migration and also modulate interleukins. The anti-inflammatory properties of this plant extract can serve as an effective therapeutic option in wound healing.[29].

Couroupita guianensis, commonly known as the Cannonball tree, exhibits significant antiinflammatory activity attributed to its rich array of bioactive compounds present in the bark, flowers, leaves, and fruits. The anti-

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inflammatory effects are primarily mediated through the inhibition of key pro-inflammatory enzymes such as cyclooxygenase (COX-1 and COX-2) and lipoxygenase (LOX), which suppress the synthesis of prostaglandins and leukotrienes, important mediators of inflammation. Additionally, the plant extracts have been shown to reduce the levels of pro-inflammatory cytokines, including TNF-α, IL-1β, and IL-6, thereby modulating chronic inflammatory responses. Flavonoids, phenolic acids, triterpenoids, and saponins found in various parts of the plant contribute both directly and indirectly by scavenging free radicals, reducing oxidative stress, and stabilizing cellular membranes, all of which further mitigate inflammation [30].

5. Neuropharmacological activity:-

Studies have shown that extracts from the leaves, flowers, and bark possess anxiolytic and sedative effects, which are largely attributed to modulation of the GABAergic system, enhancing inhibitory neurotransmission, and possibly interacting with serotonergic receptors to stabilize mood. The plant also demonstrates antidepressant-like activity, likely through regulation of monoamine neurotransmitters including serotonin, norepinephrine, and dopamine, with flavonoids and phenolic compounds playing a key role [31]. In addition, C. guianensis exhibits anticonvulsant properties, protecting against chemically induced seizures by enhancing GABA-A receptor activity and stabilizing neuronal membranes. Its analgesic effects are observed in both central and peripheral models of pain, mediated through modulation of opioid receptors and inhibition of proinflammatory mediators such as prostaglandins. Furthermore, the plant possesses neuroprotective activity, largely due to its antioxidant properties; bioactive compounds such as flavonoids, naphthoquinones, and phenolic acids scavenge reactive oxygen species and enhance endogenous antioxidant enzymes, reducing oxidative stress and preventing neuronal damage[32]. the neuropharmacological potential of Couroupita guianensis is attributed to its rich composition of naphthoquinones, flavonoids, alkaloids, tannins, and phenolic compounds, which together contribute to its anxiolytic, antidepressant, anticonvulsant, analgesic, and neuroprotective effects, highlighting its promise as a natural therapeutic agent for central nervous system disorders [33].

6. Anti diabetic activity:-

A 50% ethanol extract of C. guianensis significantly reduced blood sugar levels after meals. On the fourteenth day, when glucose and the C. guianensis extract were given, the postprandial blood sugar (PPBS) levels after 120 minutes fell within the reference range, in contrast to the control group that received only water. The extract effectively halted hyperglycemia [34]. Supplementing

C. guianensis flower aqueous and methanolic extracts (100 mg/kg)Effectively reduced blood glucose levels in diabetic rats induced by Alloxan, demonstrating their antidiabetic properties. Furthermore, daily oral administration Of both extracts (100 mg/kg body weight) in conjunction with metformin (100 mg/Kg body weight) led to significant enhancements in diabetic mice [35].

7. Antinociceptive activity:

The antinociceptive potential is mainly attributed to its bioactive constituents, including flavonoids, alkaloids, terpenoids, and phenolic compounds, which interact with the peripheral and central pain pathways. Studies have demonstrated that extracts from the leaves, flowers, and bark exhibit both central and peripheral analgesic effects. The peripheral antinociceptive effect is believed to be mediated through inhibition of prostaglandin synthesis, thereby reducing inflammation-induced pain. This has been observed in models such as acetic acid-induced writhing in mice, where the extract significantly decreased the number of writhes, indicating peripheral analgesia [36]. the central antinociceptive effect is associated with modulation of the opioid system, which was evident in hot plate and tail-flick tests in experimental animals. In these models, pre-treatment with Couroupita guianensis extracts increased the latency to pain response, suggesting activation of central pain inhibitory mechanisms. Additionally, the analgesic activity is dose-dependent and varies with the plant part used, with bark and flower extracts often showing more potent effects. Mechanistic studies also indicate the involvement of antioxidant and antiinflammatory pathways, which synergistically contribute to the overall pain-relieving properties of the plant. These findings suggest that Couroupita guianensis could

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International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 5, March 2026
Impact Factor: 8.2

be a promising candidate for the development of novel analgesic agents with potentially fewer side effects compared to conventional drugs [37].

8. Anti bacterial activity:-

The antibacterial properties of the ethyl alcohol extract from Couroupita guianensis were examined against gram-positive microorganisms such as Staphylococcus aureus and Bacillus subtilis, as well as gram-negative bacteria including Escherichia coli and Pseudomonas aeruginosa. In comparison to doxycycline, ciprofloxacin, and fluconazole, significant activity was observed against B. subtilis at a concentration of 4 mg when compared to the other tested organisms. This research also revealed the presence of various phytoconstituents, including tannins, sugars, and polyphenols. collectively demonstrated the antibacterial properties of the ethanolic extract of Couroupita guianensis oil.[36].

9. Anticancer activity:-

Studies have shown that extracts from the leaves, flowers, and bark can inhibit the proliferation of different cancer cell lines, including breast, liver, colon, and lung cancer cells. The mechanism of action is multifaceted: it involves induction of apoptosis (programmed cell death) through both intrinsic and extrinsic pathways, modulation of cell cycle regulators to arrest cancer cell proliferation, and inhibition of angiogenesis, thereby preventing tumor growth and metastasis. the antioxidant properties of Couroupita guianensis reduce oxidative stress, which is a key factor in cancer initiation and progression. Certain compounds such as couroupitine and naphthylisoquinoline derivatives have been reported to trigger apoptosis by upregulating proapoptotic proteins (e.g. Bax) and downregulating anti-apoptotic proteins (e.g., Bcl-2), activating caspase cascades, and causing mitochondrial membrane depolarization. In vitro studies also suggest that these extracts can sensitize resistant cancer cells to chemotherapeutic agents, enhancing their effectiveness while potentially reducing side effects [37].

10. Anti-ulcer activity:-

The ethanolic extract of Couroupita guianensis demonstrated notable anti-ulcer activity at doses of 150 and 300 mg/kg, resulting in significant reduction of gastric lesions caused by pylorus ligation and ethanol-induced ulcers. The formation of gastric lesions induced by ethanol may be attributed to stagnation in gastric blood flow, which plays a role in the progression of hemorrhagic and narcotic characteristics of tissue damage [38].

11. Immunomodulatory activity:-

The study of the flowers from C. guianensis revealed notable immunomodulatory effects. PMNs displayed a marked increase in phagocytic activity in vitro when exposed to the SME. The SME effectively boosts the non-specific immune response, as evidenced by an improved phagocytic index and a higher proportion of PMN cells participating in phagocytosis relative to the control group [39]. Enhanced hypersensitivity reactions to SRBCs were observed in vivo Following SME treatment, suggesting a potential enhancement of cellular Immunity. At doses of 100 and 200 mg/kg, the extract had a significant Impact on both early and delayed hypersensitivity responses. This Indicates that SME promotes leukocyte migration and activation, thereby Bolstering the body's cellular immune functions [40]. elevated antibody titers against SRBCs Demonstrated that SME bolstered the humoral immune response. This indicates that the extract plays a role enhancing the humoral Immune response by augmenting antibody production and Stimulating lymphocyte activity [41].

12. Wound healing activity :-

The wound healing activity of Couroupita guianensis has been widely studied due to its rich phytochemical profile, which contributes to tissue repair and regeneration. Extracts from various parts of the plant, particularly the leaves, flowers, and bark, have shown significant efficacy in promoting wound healing [42]. The presence of bioactive compounds such as flavonoids, tannins, alkaloids, saponins, and phenolic compounds plays a pivotal role in this process. Flavonoids and tannins exhibit strong antioxidant and antimicrobial activities, which help reduce oxidative stress and prevent microbial infections at the wound site, thereby accelerating healing. Alkaloids and saponins stimulate cellular proliferation and collagen synthesis, crucial for tissue regeneration and the formation of new extracellular matrix. Studies using in vivo models, such as excision and incision wound models in rats, have demonstrated that

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Volume 6, Issue 5, March 2026
Impact Factor: 8.2

topical application or oral administration of C. guianensis extracts significantly enhances wound contraction, increases hydroxyproline content (indicative of collagen formation), and shortens the epithelialization period. Additionally, the anti-inflammatory properties of the plant help modulate cytokine activity and reduce edema, further supporting efficient wound repair [43].

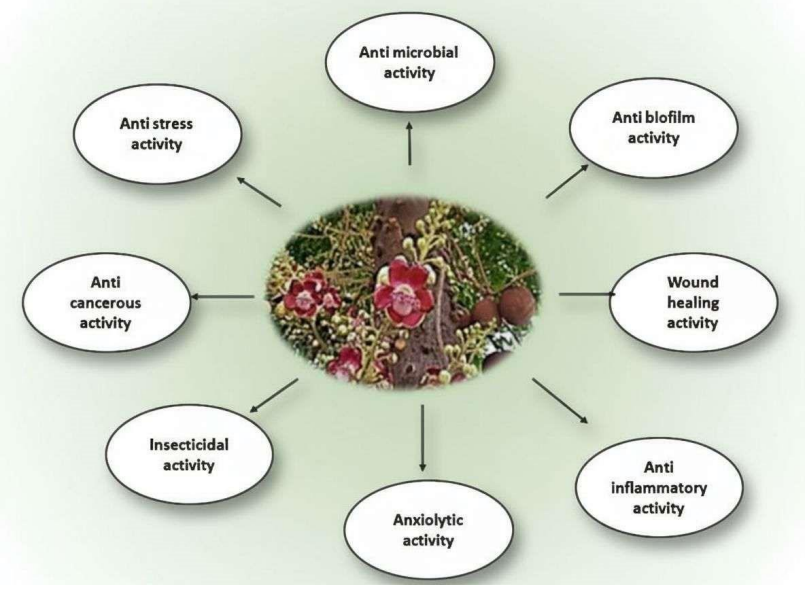

Fig.6 Pharmacological activity of Couroupita guianensis.

Market products of couroupita guianensis:-

1)Harbal oil:-

Fig .7Ayahuma Harbal oil

Uses:-

- The oil has antimicrobial and anti-inflammatory properties, aiding in faster healing of cuts, sores, and skin infections.
- Applied topically, it helps reduce joint and muscle pain due to its analgesic and antiinflammatory effects.
- Used to treat acne, rashes, and other skin disorders thanks to its antifungal and antibacterial compounds.

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 The aromatic compounds in the oil have calming effects, useful in aromatherapy for stress and anxiety relief.
 Contains natural insecticidal agents that help deter mosquitoes and other insects.
 Antiseptic Massage Oil: Often used in traditional medicine for massaging inflamed or infected areas to promote circulation and reduce infection[44].

2) Soap:

Fig 8:- Hoeki soaps bar.

Uses:-

 The soap helps eliminate bacteria from the skin due to the plant's natural antimicrobial compounds.
 Useful for people with skin conditions like eczema, dermatitis, or rashes, thanks to its soothing, anti-inflammatory properties.
 Helps reduce acne by cleansing excess oil and fighting acne-causing bacteria.
 Aids minor cuts or scrapes by preventing infection and supporting healing.
 Its antifungal and cleansing properties help control body odor naturally.
 Regular use may improve skin tone and texture due to the presence of natural antioxidants and flavonoids.
 Suitable for sensitive skin, especially in herbal or ayurvedic formulations without synthetic chemical.

3) Extract capsule or powder:-

Fig.9 Extract powder

Uses:-

 Capsules or powders may help fight bacterial and fungal infections due to natural compounds like indirubin and tryptanthrin .

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- Used traditionally to reduce swelling and inflammation, especially in joint or skin-related conditions .
- Rich in antioxidants and phytochemicals that support immune function and general wellness.
- Taken orally, it may support faster healing of skin lesions and ulcers due to internal antiinflammatory effects.
- Traditionally used to relieve digestive disorders like diarrhea, ulcers, or gastrointestinal infections
- Natural analgesic properties can help manage mild pain and discomfort.
- In Ayurveda and folk medicine, it's believed to purify blood and detoxify the body [44].

Toxicology:-

1. Cytotoxic and anticancer activity:-

Numerous studies indicate a dose-dependent cytotoxic effect of particular fractions and constituents (especially tryptanthrin and various indolic alkaloids) on cancer cell lines; certain bark and fruit fractions exhibit antiproliferative properties and induce apoptosis in vitro.Concurrently, some researchers have noted minimal cytotoxicity in non-target cell assays for specific fractions, implying the possibility of therapeutic windows that vary based on preparation and dosage.These underscore pharmacological interest while also indicating that certain extracts or components possess sufficient biological activity to induce cellular damage at adequate doses.

2. Clinical & human safety report:-

Currently, there is a significant absence of published clinical safety data pertaining to humans. While there exist ethnobotanical applications and topical or traditional uses, comprehensive clinical studies, including randomized trials and controlled safety assessments, are notably missing. Consequently, the safety of human use remains ambiguous, particularly concerning internal administration, elevated dosages, or extended usage.

Current Research and Future Directions:-

1. Future prospectives

- C. guianensis extracts exhibit a range of effects in the treatment of various disorders; they hold the promise of significantly influencing society by serving as alternatives to conventional pharmaceuticals utilized in the medical sector.
- Recent studies have unveiled the pharmacological characteristics of extracts primarily sourced from leaves, stems, bark, and flowers. Consequently, further investigation is essential to pinpoint phytochemicals that influence metabolism in animal models.
- C. guianensis is a robust tree that yields phytochemicals including alkaloids, phenolic compounds, hydrocarbons, and terpenoids, which have predominantly demonstrated antimicrobial, anti-depressant, and anti-cancer properties. However, the precise mechanisms through which secondary metabolites like saponins function as anti-cancer agents and glycosides modulate blood glucose levels in diabetes mellitus remain largely elusive.
- This overview examines the phytochemical and physiological functions employed by plants, along with their biological targets in addressing various health issues. Presently, researchers encounter a considerable challenge in elucidating the mechanisms of action of phytochemicals that are not yet understood.

II. CONCLUSION

Couroupita guianensis extract, in capsule or powder form, demonstrates significant medicinal potential backed by both traditional use and scientific studies. Its antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties support its use in managing infections, skin disorders, pain, and digestive issues. Active compounds like indirubin and tryptanthrin contribute to its therapeutic effects, including early evidence of anti-cancer activity. While promising, further clinical research is needed to confirm its safety, dosage, and long-term benefits. Overall, Couroupita guianensis stands out as a valuable herbal resource in natural medicine.Introduction:

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Volume 6, Issue 5, March 2026
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International Journal of Advanced Research in Science, Communication and Technology
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