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Physicochemical profiling and bioactive potential of *swietenia macrophylla* king seed in natural mosquito repellent development

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Abstract
Background: Traditional medicine has long utilized plant-based therapies for various health conditions. In India, medicinal plants continue to play a vital role in healthcare practices, necessitating scientific validation of their therapeutic properties. *Swietenia macrophylla* King seeds have been recognized for their medicinal potential, prompting an investigation into their pharmacognostical assessment, physicochemical characteristics, and phytochemical profiling. Additionally, the research explores the development of herbal mosquito repellent cones using natural binders to provide a sustainable alternative to synthetic repellents.
Results: The phytochemical investigation of *S. macrophylla* King Seed showed that most of secondary metabolites extracted more successfully using polar solvents than non-polar ones. Additionally, an analysis of extractive values, moisture content, and ash composition including microscopic examination was conducted. The study identified significant antibacterial activity, particularly in the methanolic extract of *Swietenia macrophylla* King Seeds, demonstrating promising efficacy against *Staphylococcus aureus* and *Escherichia coli*. The bioactive compounds contributing to antimicrobial properties are revealed by the phytochemical analysis. Furthermore, the formulated mosquito repellent cones exhibited prolonged burning time, minimal ash content, and effective mosquito repellency, reinforcing their potential as a viable natural alternative.
Conclusion: The findings highlight the pharmacological potential of *Swietenia macrophylla* King Seeds, emphasizing their antibacterial efficacy and suitability for natural insect-repellent formulations. The study reinforces the viability of plant-based solutions in tackling drug-resistant bacteria and mosquito control. Building on this current research concept, researchers have the capability to create herbal mosquito repellents that are environmentally friendly, affordable, and sustainable medical applications in the future.

Keywords: *Swietenia macrophylla* King Seed, pharmacognostical evaluation, anti-bacterial activity, herbal-based, mosquito repellent

1. Introduction
In many regions of the world, traditional medicine has been applied for generations to treat a wide range of human illnss.80% of people worldwide rely on medicinal plants, and in India, using plants as therapeutic agents is still a significant part of the country's traditional medical system. Utilizing locally available medicinal plants for disease treatment and control continues to play a key factor in healthcare delivery in developing nations. Advances in chemical, pharmacological, and microbiological research have now enabled effective screening of higher plants for active compounds [1, 2]. Antibiotic drugs are to reduce bacteria, which can lead to severe illnesses and disorders. They have significantly improved human health, as antibiotics are now able to control a wide range of illnesses. However, certain bacteria developed resistance to popular antibiotics as a result of the inappropriate and irrational use of medicines. As a result, finding novel, natural, and effective antimicrobials from various sources is crucial for treatment. New medications have been largely derived from natural ingredients [3, 4].
Vector-borne diseases are most prevalent in tropical and sub-tropical regions of worldwide. The chief vector for the global transmission of dengue, chikungunya, and malaria, which impact over 750 million people annually, is the mosquito. At the moment, the major strategies for preventing diseases spread by mosquitoes are still controlling the formation of mosquito larvae and protecting oneself from mosquito bites by using mosquito nets and repellent.

The mosquito repellents are those that make the surface unpleasant to the mosquitoes. Better repellents can offer longer-lasting (> 1 hour) protection from bites with just one application. Mosquito repellents function by disrupting the insect's ability to navigate effectively [5, 6]. People's perspiration releases lactic acid and carbon dioxide, which attracts female Anopheles mosquitoes. In humans, lactic acid stimulates the chemical receptors that inhabit mosquitoes. By blocking lactic acid receptors, the mosquito repellent antagonist provides protection from insects and the mosquitoes [7]. Numerous commercial brands of insect repellent based on N, N-diethyl-meta-toluamide (DEET), Lcaridin, IR3535, or chemicals extracted from various medicinal plants have overtaken the market. These synthetic marketed preparations contain a significant number of hazardous component materials that are classified as carcinogenic chemicals having the potential to harm the environment. The need for natural mosquito repellents that are affordable, effective, non-toxic, environmentally friendly, and biodegradable is growing as a result of these circumstances [8].

Swietenia macrophylla King seeds (commonly known as big-leaf mahogany) belonging to the family Meliaceae, is an evergreen timber tree found in Southern Asia and the Pacific, grow up to approximately 30-45 metre. The seeds serve various purposes as multi ingredients dietary product. There are usually about 35-45 winged seeds per fruit. Seeds are chestnut colored and 7.5-12 cm in length [9, 10]. There are many therapeutic benefits of antimicrobial, antiviral, antimalarial, antidiabetic properties. Additionally, it is used for managing of heart failure, anorexia-related issues, asthma, and bronchitis. Beyond its medicinal benefits, it serves as a spice and is also incorporated into culinary preparations and confectionery [11, 12].

The current study focused on examining the pharmacognostic evaluation, along with the physicochemical and phytochemical analysis of seed extract of *Swietenia macrophylla* King. The recent work has also been performed to screen its antibacterial activity against multiple-drug-resistance bacteria strains, to formulate and evaluate the herbal-based mosquito repellent cone using natural binder.

2. Materials and Methods

The present section deals with the detailed description methods to conduct different studies categorized into following headings.

2.1 Materials

Plant materials: The seeds of *Swietenia macrophylla* King.

2.2 Methods

2.2.1 Collection, identification and authentication of plant sample

The mature, healthy *Swietenia macrophylla* King Seedpods were collected from Harisinghpur, Ghatal, West Bengal, India, in the month of September'24. The plant part has been identified and authenticated from Central National Herbarium, Botanical Survey of India, Howrah, bearing the access number CNH/Tech. II/2024/131, on dated 24th of October 2024.

2.2.2 Preparation of plant sample

The fresh plant materials (seedpods) underwent a shade-drying process in the Himalayan Pharmacy Institute's laboratory until achieving a crispy texture. Subsequently, the dried parts were chopped with a grinder to obtain a coarse powder for successive solvent extraction.

2.3 Pharmacognostical evaluation [13, 14]

2.3.1 Macroscopical evaluation

The macroscopical evaluation was carried out as per the established methods to determine the shape, size, color, taste, odour and texture of the crude drug.

2.3.2 Microscopical evaluation

A) Transverse section (TS) of seeds of *Swietenia macrophylla* King

The seeds of the fruit were sectioned by using a blade and then first observed in distilled water to locate crystal system. Next, glycerine was applied, followed by staining with Phloroglucinol and concentrated Hydrochloric acid to identify lignified components. Other staining reagents like safranin, iodine etc. were also used but the better result has shown only by phloroglucinol HCl.

B) Powder microscopy

The powder analysis of the crude drug was performed by collecting and then well-cleaned with water to remove any undesired material, and allowed to air-dry in a shaded area. After complete drying, it was powdered and passed through sieve no 60. Finely powdered drug was prepared observed for different tissue and cell components. Then, by using the brush with any fine tiny particles of each powdered drug was taken and dipped in the stain of Safranin, Sudan IV and Iodine individually. Then the particles again washed with distilled water and mounted in a glass slides after this cover slip was placed and then it was observed in an electron microscope. The microscopic character was noted.

2.4 Physicochemical Analysis

The physicochemical parameters such as pH, extractive values, ash values, moisture content were determined according to official methods prescribed in Indian Pharmacopoeia 1996 and WHO guidelines on quality control methods for medicinal plant materials.

2.4.1 pH value

The pH was determined by using pH papers and pH meter, while dipping it in the extract solution.
Then calculated the values separately for all the extracts.

2.4.2 Moisture Content

In a tarred watch glass, around 5 grams of the air-dried crude medication was precisely weighed. The plant material was dried for a while at 105°C in a hot air oven until a constant weight was achieved. The drug's moisture content is determined by the weight differential [15].

Moisture content (%) = $(W_2-W_3)/(W_2-W_1)$ *100

Where, W_1=weight of container with lid, W_2= weight of container with lid and sample before drying; W_3=weight of container with lid and sample after drying.

2.4.3 Ash value detection: [16]

A) Total ash detection

3grams of the powdered drug was weighed accurately in a silica crucible. The powdered drug was incinerated by increasing the heat sequentially not more than 700^{0}C until the sample was free from carbon. On ashless paper, the residue

was burned together with the filter paper until the ash turns to white. Upon the evaporation of filtrate, it was kept in a desiccator. The ash percentage was calculated by weighing the overall content in contrast to sample.

B) Acid insoluble ash

After boiling the resulting total ash for five minutes as described above, it was combined with 25ml of diluted hydrochloric acid. After filtering and collecting the insoluble material on ash-free filter paper, the paper was cleaned with hot water, burned in a tared crucible, cooled, and stored in a desiccator. With reference to the air-dried drug, the resulting residue was weighed and the acid-insoluble ash of the crude drug was estimated. The drug's unpeeled form cannot have more than 2.5% acid-insoluble ash and 10% total ash.

C) Water soluble ash

To the total ash obtained, twenty-five mL of water was added and boiled for five minutes. The insoluble matters were collected on Gooch crucible or an ashless filter paper, washed with luke warm water and fired in a crucible for 15minutes at a temperature that not exceeding 450^0C.The weight of this residue was subtracted from the weight of total ash. The content of water-soluble ash with reference to dried drug was calculated.

2.4.4 Extractive value [17]

Extractive values are useful for the evaluation of drugs, giving the insights about the nature of the chemical constituents present in it. Extracts obtained by exhaustive processing of crude drugs provide an approximate measure of their chemical constituents. The variation in the chemical nature and properties of drug components, different solvents are given and employed to determine extractive values.

A) Water soluble extractive

In a stoppered flask, 5 g of coarsely ground, air-dried seed was macerated in 100 mL of chloroform water for 24 hours (2.5 ml in 1000 ml of water). For six hours, the material shook a lot. Filter paper was used to filter to avoid the risk of excessive solvent loss. In a shallow dish with a tarred bottom, 25 milliliters of water extract were evaporated until completely dry. It was weighed after being dried at 105 °C. Using the air-dried substances as a reference, the water-soluble extractive value as a percentage w/w, was determined.

B) Alcohol soluble extractive [18]

In a stopper flask, mix five grams of the coarsely crushed seed, air-dried combined with 100 ml of 95% ethanol for 24 hours. For six hours, the material was shaking a lot. It was filtered via filter paper to prevent too much alcohol loss. In a pre-weighed, shallow flat-bottomed dish, 25 milliliters of water extract were evaporated until completely dry. It was weighed after being dried at 105 °C. The air-dried drug was utilised as a particular standard to assess the extractive value of alcohol-soluble components as a percentage w/w, was determined.

2.4.5 Loss on drying

Loss on drying is a parameter to keep the moisture content under check as the large amounts of moisture can promote hydrolytic reactions and microbial growth.2grams of powder drug was placed in a weighed preheated porcelain dish and then kept in a hot air oven and dried at 105°C till constant weight was observed. Weight was taken after drying and was transferred to desiccator to cool, again porcelain dish was reweighed [19]. The moisture content percentage was calculated using the specified formula;

% moisture content = $[(W_1-W_2)/W] *100$, Where, W = weight of sample, W_1 = weight of sample before drying, W_2 = weight of the sample after drying.

2.5 Qualitative analysis

2.5.1 Extraction of phytoconstituents

The resulting extracts are used to identify all the distinct phytocontituents included in the seed extract of *S. macrophylla* King was subjected to qualitative phytochemical analysis in accordance with the established protocols.

About 72gm of the air dried coarse powdered seed was extracted by Soxhlet apparatus (hot continuous extraction) with 400ml of various solvents successively according to their polarity, starting from Petroleum ether followed by chloroform, ethyl acetate, methanol for 7hours.After each extraction, it was filtered through muslin cloth carefully, separating the solvent from extract, and was recovered in rotary evaporator. Each time before extracting with the next solvent, the powdered material was air dried at room temperature. The each concentrated extract was completely evaporated until dry on water bath [20]. The color, consistency and extractive values were noted.

2.5.2 Preliminary assessment for phytochemicals

The extracts were reported to chemical analysis as per different standard methods for identification of various phytoconstituents. The various identification screenings aid in understanding the medicinal potential of plants [21].

2.6 *In-vitro* antibacterial activity by Disc diffusion method

2.6.1 Test microorganisms used

In this study, two bacterial species, *Staphylococcus aureus* (gram positive) and *E. coli* (gram negative), were used as test microbes. These microorganisms were taken from the Microbiology Laboratory, Himalayan Pharmacy Institute. *S. aureus* and *E coli* were cultured overnight at 37°C on nutrient agar medium. Bacterial isolates from the agar plates were transferred to nutrient broth for culturing. The test strains were maintained on separate agar media, subcultured every 30 days, and stored in a refrigerator following standard procedures.

2.6.2 Preparation of bacteria culture media

The required amounts of nutrient agar and nutrient broth were dissolved in distilled water and transferred into conical flasks. Approximately 20 ml of nutrient broth was distributed into conical flasks. All media-containing flasks and test tubes were sealed with cotton wool and sterilized in an autoclave at 1.5 pounds of pressure and 121°C for 15 minutes. Post-sterilization, nutrient agar was aseptically poured into sterilized petri dishes within a laminar flow hood to prevent contamination. The media in the petri plates were left to solidify for about an hour and then placed in an inverted position in an incubator that was set at 37°C for 24 hours to minimize water evaporation. After this incubation period, uncontaminated plates were selected for culturing bacteria. The nutrient broth in flasks (approximately 20 ml per flask) was utilized for shaking incubation of microorganisms, whereas nutrient broth in test tubes was used for standardizing microbial cultures [22].

2.6.3 Disc diffusion method

The disc diffusion method for antimicrobial susceptibility testing was performed following the standard procedure outlined by Bauer *et al*. (1966) to evaluate the antibacterial activity of plant extracts [23]. A bacterial culture, was evenly spread onto previously prepared agar plates using a sterile swab. The plates were left to dry naturally for 15 minutes before being used for the sensitivity test. Discs impregnated with various plant extracts were placed on the surface of the prepared agar. Each test plate contained three discs: one positive control (a standard commercial antibiotic disc), one negative control, and one disc treated with plant extracts. The standard antibiotic discs used included Streptomycin (10mg/ml) and for *S. aureus* and *E. coli*. DMSO (100%) served as the negative control. The discs were positioned equidistantly on each plate. Depending on the bacterial species, the plates were kept at 37 °C for an incubation period of 18 to 24 hours. After incubation, the inhibition zones were examined, measured with calipers, and recorded. The tests were performed in triplicate to ensure reliability [24].

2.7 Methodology for formulating mosquito repellent cones

Ten-twelve cones of varying weights and component proportions were prepared. The wet weight of each cone was recorded, and to determine the dry weight, the cones were sun-dried for 72 hours before measurement. A natural binder, comprising wood powder, was purchased from a local market. Natural gum was incorporated, obtained from locally sourced market, was utilized as an adhesive to make repellant cones more effective. The various ingredients involved in the preparation serve distinct purposes [16]

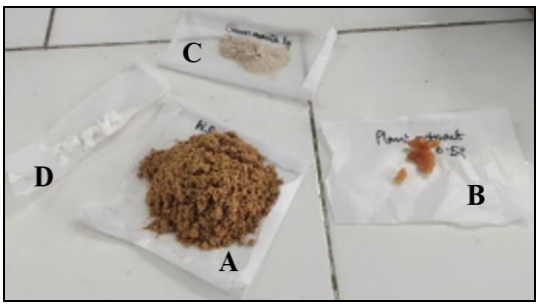

Fig 1: A-D; showing the ingredients are (A) wood powder, (B) seed extract, (C) gum acacia, (D) starch powder

2.7.1 Formulation of mahogany seed cones in combination with a natural binder

The dried powder of each ingredients was individually weighed and transferred to a mortar and pestle for thorough mixing. After that, it was sieved to get fine powder. Water was gradually added to the fine powder, mixing continuously until a damp mass with the right consistency was achieved. The mixture should be well-blended and not overly watery to avoid complications during cone formation. Cones were shaped using the hand-rolling method, and the same procedure was followed for all formulations. The cones were initially dried for a few hours in the shade [26].

2.7.2 Evaluation parameters of mahogany seed cones

The effectiveness of prepared mahogony seed cones was assessed based on several parameters like flammability, smoke visibility, odor, burning duration, irritation test and mosquito repellence [27-30].

- **Smoke visibility:** Each mosquito repellent cone was burned individually. Subsequently, the smoke generated and its adverse effects, including irritation, difficulty breathing, and nasal and eye discharge, were examined and documented.
- **Odor and irritation test:** Each mosquito repellent cone was burned separately, and its odor was evaluated including any irritation happened or not in a room (10 feet * 12 feet).
- **Flammability test & burning time (min):** The combustible nature of the cones was checked by burning them with candles. The test aimed to evaluate their consistent combustibility, burning efficiency in relation to burning duration, and comparatively their effectiveness as repellents.
- **Ash content (gm):** The ashes from each formulation were individually collected and accurately weighed on a weighing machine using butter paper. The ash weights of each combination, along with their respective burning times, were recorded.

  Mosquito repellent cones were burnt in the room for one hour. A decrease in the mosquito count was observed. The repellency test was also carried out by targeting mosquito-prone areas during the evening and nighttime, such as classrooms, college premises, laboratory corners and hostel. Public feedback was collected after allowing the cones to burn.

3. Results

3.1 Macroscopic examination of seed

- **Colour:** Brown to reddish.
- **Odor:** Distinctive smell.
- **Shape:** Samaroid.
- **Taste:** Bitter.
- **Texture:** Hard outer shell.

3.2 Microscopic evaluation

Transverse section of the seed displayed various parts of the Parenchymatous cells, cotyledons, cells of testa, endosperm, perisperm, plumule, marginal parenchyma band, with various types of stains like Safranin, Phloroglucinol with concentrated HCl. The finely powdered drugs were observed under a Carl Zeiss binocular microscope. Distilled water and glycerin served as mounting media to prepare multiple slides, which were analyzed for various tissue and cell components (Figure 2). Additionally, powder microscopy of the seed showed different parts of the cells of testa with brownish contents including exotesta, mesotesta, longitudinally elongated calcium oxalate cells, and pitted vessels, stone cells, and oil globules with starch grains, with various types of stains like Iodine, and Phloroglucinol with HCl (Figure 3).

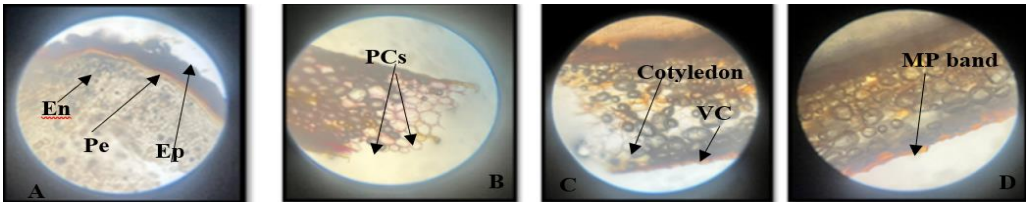

Fig 2: A-E Microscopical study of *Swietenia macrophylla* King Seed

Where En=Endosperm, Pe=Perisperm, Ep=Epidermis, Pcs = Parenchymatous cells, Vc = Vasicentric, MP band = Marginal Parenchyma band

A: T.S. of *Swietenia macrophylla* King Seed by Iodine water, B: T.S of *Swietenia macrophylla* King seed by Phloroglucinol with HCl, C: T.S. of *Swietenia macrophylla* King seed by Iodine water, D: T.S. of *Swietenia macrophylla* King seed by Saffranin, E: T.S. of *Swietenia macrophylla* King seed by Iodine water

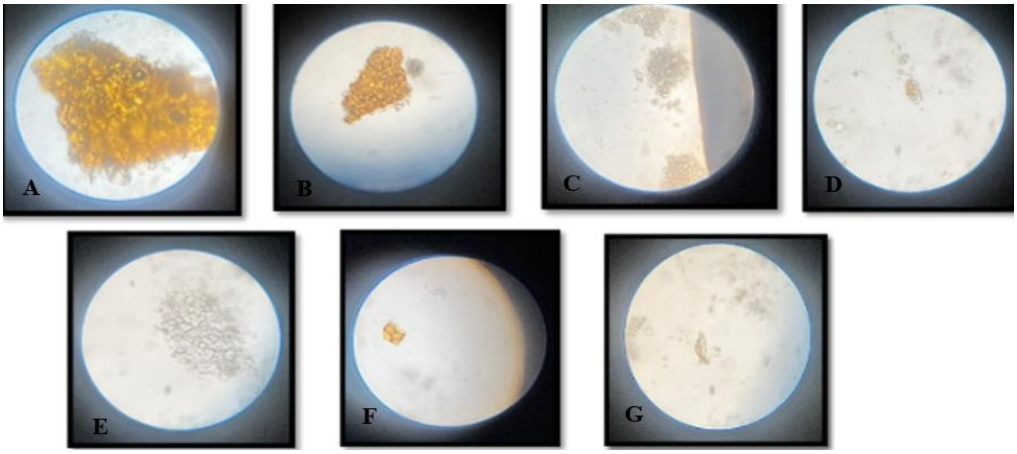

Fig 3: A-H Powder microscopy of *Swietenia macrophylla* King Seed

A: cells of testa; B: Exotesta; C: cells of mesotesta; D: oil globules; E: oil globules with starch grains, F: calcium oxalate crystals; G: stone cells.

3.3 Physico-chemical evaluation: Different values obtained from the physicochemical analysis such as percentage yields, moisture content, ash values, extractive values, lod of the present seed extract are recorded as follows:

Table 1: Physicochemical parameters of seed extract of *Swietenia macrophylla* King of different solvent

Percentage yield		Ash values(%w/w)		Moisture content	Extractive value		Loss on drying (dry basis)
Petroleum ether (Yellow)	5.84%	Total ash	3.66	6.52%	Alcohol extractive vale	~ 0.562	23.33%
Chloroform (Light brown)	4.02%	Acid insoluble ash	3		Water extractive value	~ 0.485	
Ethyl acetate (Orange)	2.64%	Water soluble ash	0.63				
Methanol (Orange to dark brown)	36%						
Aqueous (Dark brown)	19.82%						

3.3 Phytochemical Screening

Table 2: The result of phytochemical screening of different solvent extracts of *Swietenia macrophylla* King Seed

Phytochemicals	Performed chemical test	Solvents				
		PE	CH	EA	ME	AQ
Alkaloids	Mayer's test	-	-	-	+	+
	Wagner's test	-	+	+	+	+
	Hager's test	-	-	+	+	+
	Dragendorff's test	-	-	-	-	-
Carbohydrates	Molish's test	-	-	+	+	+
	Fehling's test	-	+	+	+	+
	Benedict's test	-	-	-	+	+
	Barfoed's test	--	+	+	-	-
Saponins	Foam test	-	-	+	+	+
	Froath test	-	-	+	+	+
Phenolic compounds	Ferric chloride test	-	+	+	+	+
	Gelatine test	-	-	-	+	+
	Lead acetate test	-	-	+	+	+
Glycosides	Aq. NaOH test	-	+	+	+	+
	Conc.H_2SO_4	-	+	+	+	+
	Keller-killani test	-	-	-	+	+
	Brontrager's test	-	-	-	+	-
Flavonoids	Shinoda test	-	-	-	-	-
	Alkaline reagent test	-	+	+	+	+
Protein and Amino acid test	Millon's test	-	+	-	+	+
	Biuret test	-	-	-	+	+
	Ninhydrin test	-	-	-	-	-
Phytosterols & triterpenoids	Salkowski test	-	+	+	+	+
Fixed oil & fats	Spot test	-	+	+	+	+
	Saponification test	-	+	+	+	+
Gum & mucilage		-	-	-	-	-

"+"ve indicates Presence and "-" indicates Absence

3.4 *In vitro* anti-bacterial activity

The antimicrobial properties of the seed extract against the two bacterial strains were evaluated based on the presence or absence of inhibition zones. Table presents the inhibition zones for the seed extracts tested for antibacterial activity. The antibacterial activity demonstrated a broad spectrum, effectively inhibiting both Gram-positive and Gram-negative bacteria. Moreover, no clear zones were observed in the negative controls (DMSO), indicating that the appearance of the clear zones resulted from the bioactive compounds present in the extract.

Table 3: *In vitro* Antibacterial study of *Swietenia macrophylla* King seeds methanolic extract:

Bacterial strains	Concentration of each disc			Standard antibiotic (10mg/ml streptomycine), (Positive control)
	50mg/ml	80mg/ml	90mg/ml	
	Inhibition zone(mm)			
S. aureus	14±0.577	16±1.154	5.66±0.666	15.33±0.88
E. coli	10±0.577	15±0.333	7±1.452	14±0.57

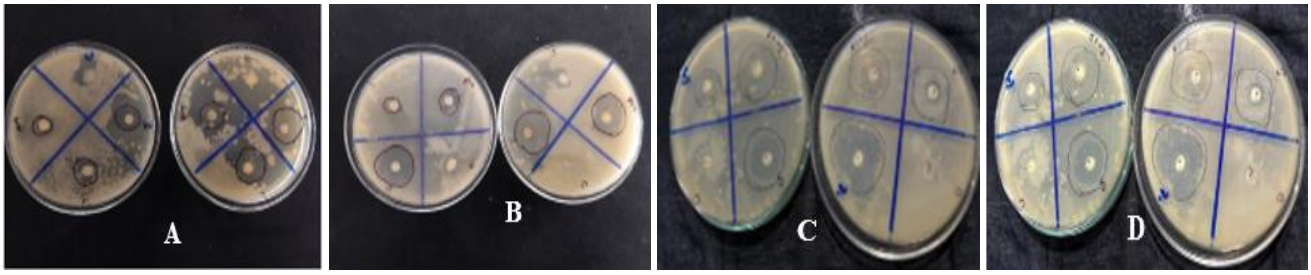

Fig 4: A-D, showing the inhibition zone against the selected bacteria *Staphylococcus aureus* (gram positive) and *E. coli* (gram negative) along with the different concentrations (50mg/ml, 80mg/ml, 90mg/ml) of *Swietenia macrophylla* King seed extract

3.5 Formulation of mosquito repellent cones

Table 4: For 5gm of repellent cones were formulated by adding desired amounts of ingredients:

Formulation	Ingredients			
	Wood powder	Gum acacia	*S. macrophylla* King seed extract	Starch powder
F1	3	1	1	0.5
F2	3.5	1	0.5	0.5
F3	2	1.5	1.5	0.5
F4	2.5	0.5	2	0.5
F5	1	2	2	0.5

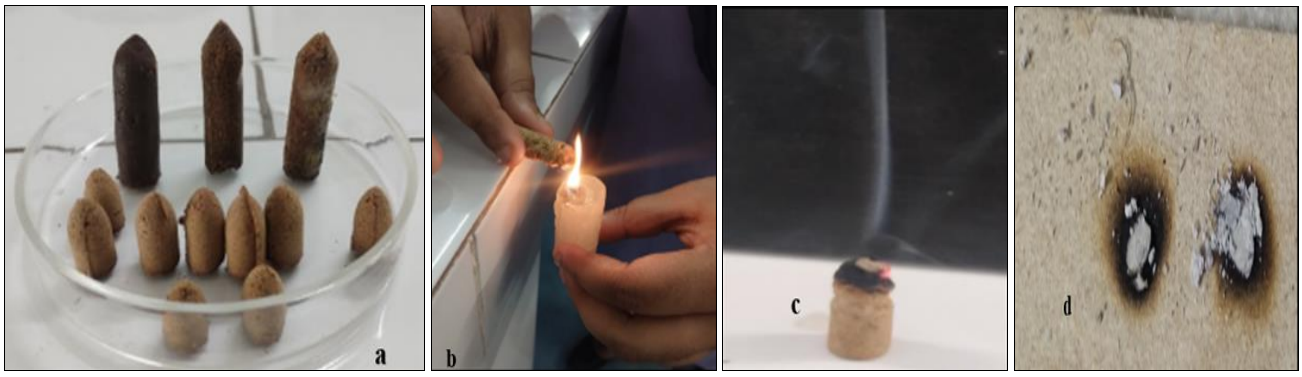

Fig 5: include (a) repellent cones, (b) burning of cones, (c) smoke visibility, (d) ash content

Table 5: Sensory evaluation of effectiveness of mosquito repellent

SL No.	Formulation	Burning time (min)	Ash content (g)	Odour	Smoke visibility	Irritability	Mosquito repellent activity (number)
1	F1	6	1.4	Good	Low	No	0
2	F2	12	0.86	Satisfactory	High	No	2
3	F3	15	0.59	Satisfactory	High	No	2
4	F4	2	1.9	Not so good	Very low	No	0
5	F5	18	0.17	Most satisfactory	Highest	No	4

Table 6: Mosquito repellency test in different mosquito-prone areas:

SL No	Mosquito-prone areas	Remarks given by volunteers	Remarks
1	Home	Smoke does not casuse any irritation and mosquitoes are escaped	Mosquitoes are removed from room
2	Laboratory premises	No irritation caused to mosquito-escaped	Mosquitoes are removed
3	Classroom corners	Smoke does not cause any discomfort, mosquitoes removed outside	Mosquitoes are repelled

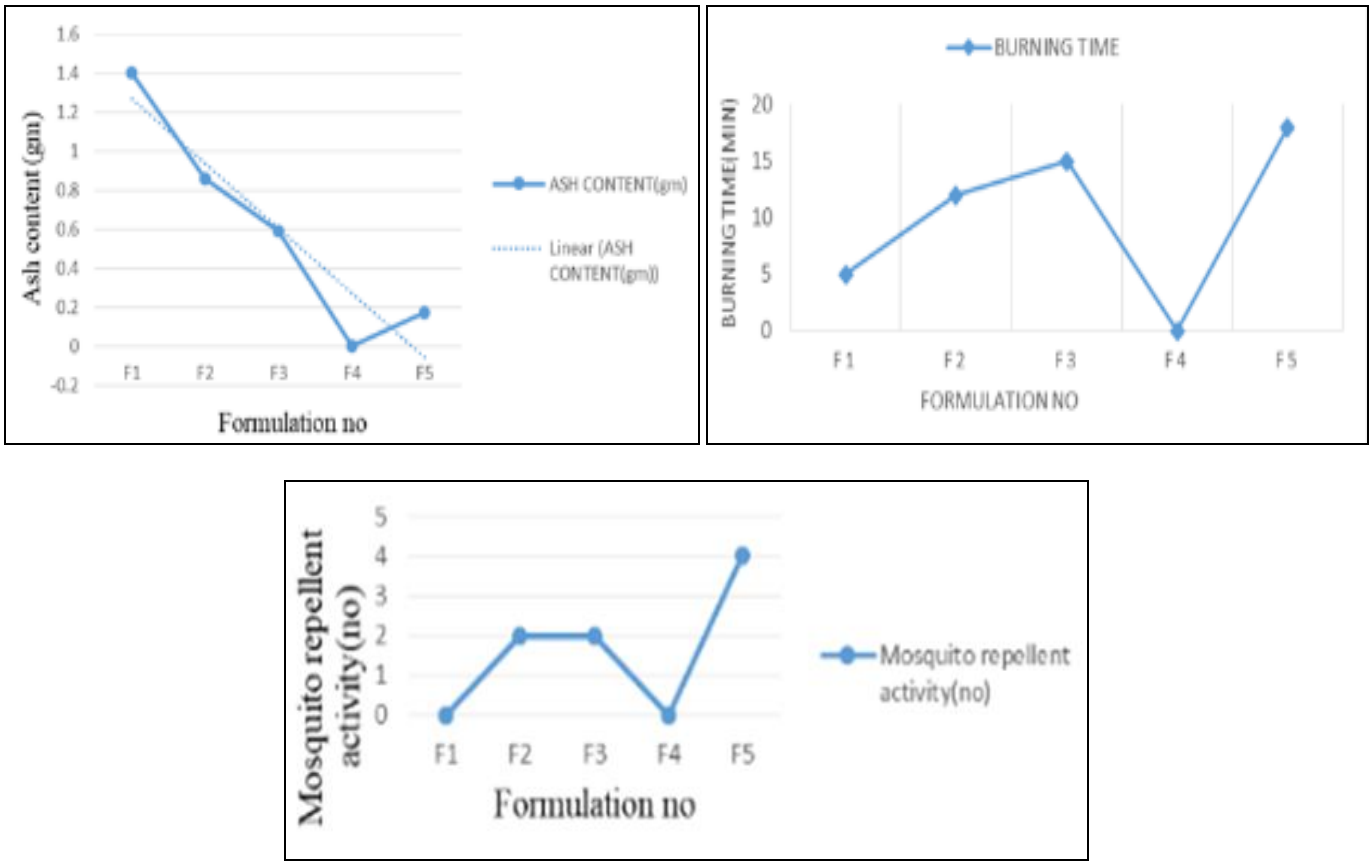

Fig 6: (A-C) includes;(A) Ash content (gm) of formulations F1-F5, (B) Burning time(min)of formulations F1-F5, (C) Mosquito repellent activity(no) of formulations F1-F5

4. Discussions

These current studies help to verify the drug's identification, quality, purity and safety for human use. Significant morphological and anatomical traits of *Swietenia macrophylla* King were discovered during the pharmacognostic investigation, which helped with its identification and verification. TS phloroglucinol sections are clarified using HCL. Initial phytochemical screenings are a widely used method for detecting bioactive compounds. Insects are infamous for their troublesome behaviors, including biting, stinging, contaminating, and spreading diseases, leading people to seek methods to control their populations. It is not necessary to eliminate all insect species, as they provide food for birds, reptiles, and mammals, and many also assist in pollinating plants. Health stores offer a variety of bug repellents made from essential oils that are diluted enough to prevent skin irritation [31]. Extractive value is essential for assessing crude drugs because it reveals the type of chemical constituents that are present. During storage, drug moisture levels should be maintained at minimum to inhibit bacterial, yeast, or fungal growth. Ash values help to assess crude drug composition and purity. To evaluate the quantity of inorganic substances present in pharmaceuticals, water soluble ash is utilized. The experimental tests indicated that herbal-based mosquito repellents demonstrated better results with their steady burning capacity, reduced ash content, and absence of irritation, suffocation to the incorporation of wood powder, natural gum, starch powder and a blend of natural components.

Various herbal powder combinations have been tested as mosquito repellent cones, with some demonstrating excellent results. Smoke visibility indicates that natural mosquito repellents and pesticides exceed synthetic alternatives. The five tested formulations demonstrated significant effectiveness in mosquito-prone areas, reducing mosquito numbers during burning. Among them, the F5 comprising mahogany seed extract, wood powder, starch powder and gum acacia proved to be the most efficient, offering maximum reduction in mosquito presence while providing the most pleasant aroma. Similarly, the F3 and F2 showed strong repellent properties. The F1exhibited good mosquito-repelling capability. The formulation four (F4) incorporating above mentioned ingredients exhibited structural fragility, indicating that their ratio does not significantly contribute to improving integrity. This suggests that the selected combination lacks the necessary binding properties required for a stable structure. Though, these findings highlight that natural mosquito repellent cones are a superior choice compared to synthetic alternatives, being both more effective and environmentally friendly.

5. Conclusion

Using powdered plant material and extracts, the prevailing physicochemical and phytochemical screening procedure revealed useful information on plant identity to this research paper. The World Health Organization (WHO) encourages the use of safe and effective traditional medicine in public and private health services, as people become more aware of its benefits. The current research findings indicate that the chosen plant possesses alkaloids, saponins, phenolic compounds, flavonoids, glycosides, alkaloids, phytosterols and triterpenoids, and fixed oils. Consequently, pharmacognostical studies were conducted to identify and validate the crude drug, providing valuable insights for developing additional formulations based on the original medication. These combinations will contribute to the treatment of various diseases and health conditions. This study recorded the anti-bacterial activity of *S. macrophylla*

King Seed extracts using various solvents (PE, CH, EA, MeOH, and AQ). The findings revealed high anti-bacterial activity in the methanolic extract of the plant. Encouraging the widespread use of natural mosquito repellents like cream, candle, sticks, roll-on, spray and cones can help mitigate the harmful effects of synthetic alternatives on human health and the environment. Herb-based repellents are cost-effective, convenient, readily available, and demonstrate strong mosquito-repelling properties. Compared to commercially produce synthetic coils, handmade mosquito repellent cones pose fewer health risks. Recent research has shown that formulation five exhibits excellent mosquito-repellent activity, whether used alone or in combination with other herbal powders. The results received positive feedback when evaluated by panels of individuals. Additionally, the cones were tested for potential allergic reactions, and the findings indicated that no symptoms such as coughing or sneezing were reported. However, further rigorous testing and trials are necessary for the successful commercialization of mosquito repellent cones.

6. Conflict of interest

The author declares that there is no conflicts of interest regarding the publication of this paper.

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