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Solvent Efficiency in Phytochemical Extraction: A Comparative Study of Methanol and Water in *Cassia siamea*

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Abstract: This study investigates the comparative solvent efficiency of methanol and water in the extraction of phytochemical constituents from the leaves and stem bark of *Cassia siamea*, a widely recognized medicinal plant used in traditional healing practices across Sierra Leone. As natural product research continues to garner global attention particularly in response to rising antimicrobial resistance and the search for safer alternatives to synthetic drugs there is an increasing demand for rigorous, evidence-based approaches to herbal drug development. Phytochemical extraction forms a foundational step in this process, with solvent selection playing a critical role in determining the yield, diversity, and concentration of bioactive compounds.

Using a cold maceration technique, powdered plant materials were extracted separately with methanol and distilled water under standardized laboratory conditions. The resultant crude extracts underwent qualitative phytochemical screening to detect the presence or absence of key secondary metabolites, including alkaloids, flavonoids, tannins, glycosides, saponins, steroids, phenols, anthraquinones, and terpenoids, following protocols established by Harborne and Sofowora. The results demonstrated that methanol was significantly more effective than water in extracting a broader and richer spectrum of phytochemicals. Notably, methanol extracts revealed a strong presence of phenols, glycosides, and steroids, all of which are known to possess potent pharmacological properties such as antimicrobial, antioxidant, anti-inflammatory, and cytoprotective effects.

In contrast, aqueous extracts were limited in their phytochemical diversity, detecting fewer compounds and showing reduced intensity for most metabolites. While water remains the solvent of choice in many traditional herbal preparations due to its safety and accessibility, these findings indicate that its extraction efficiency is relatively restricted, particularly for non-polar or moderately polar compounds. The absence of phenols and steroids in aqueous extracts is particularly noteworthy, as it underscores the importance of using more polar organic solvents like methanol when aiming to capture the full phytochemical potential of plant material.

This study not only validates the traditional medicinal relevance of *Cassia siamea* in Sierra Leone but also emphasizes the need for evidence-based optimization of extraction protocols in herbal pharmacognosy. The data presented herein contribute to the scientific foundation necessary for future work involving quantitative assays, bioactive compound isolation, pharmacodynamic studies, and eventually, the development of plant-based therapeutics. As the pharmaceutical industry increasingly turns to nature for novel drug leads, studies such as this are essential in bridging the gap between traditional knowledge and modern scientific innovation.

Keywords: *Cassia siamea, Phytochemical Screening, Solvent Polarity, Methanol Extract, Aqueous Extract, Secondary Metabolites, Herbal Medicine, Pharmacognosy, Sierra Leone.*

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I. INTRODUCTION

The exploration of bioactive compounds from medicinal plants has gained renewed scientific attention in the 21st century due to the global challenges posed by antibiotic resistance, emerging infectious diseases, and the limitations of synthetic pharmaceuticals. Medicinal plants, long used in traditional healthcare systems, are increasingly recognized as viable sources of therapeutic agents owing to their biochemical diversity and ethnopharmacological relevance. Central to unlocking the therapeutic potential of these plants is the process of **phytochemical extraction**, which isolates and identifies the active compounds responsible for observed pharmacological effects.

Phytochemicals, or secondary metabolites, such as alkaloids, flavonoids, glycosides, saponins, tannins, steroids, terpenoids, and phenolic compounds, play essential roles in plant defense mechanisms and exhibit a broad spectrum of bioactivities including antimicrobial, anti-inflammatory, antioxidant, antimalarial, and anticancer effects. However, the successful isolation of these compounds depends largely on the efficiency and selectivity of the extraction method employed particularly the choice of **solvent**, which profoundly influences the yield, purity, and profile of extracted constituents.

Solvent polarity is a key factor in phytochemical extraction. Polar solvents, such as **methanol** and **water**, are commonly used due to their ability to dissolve polar compounds like tannins, phenols, and glycosides. Methanol, a polar organic solvent, is widely acknowledged for its superior capacity to extract a wide range of both polar and slightly non-polar phytochemicals, while water though safer and more environmentally friendly is often less efficient in extracting compounds with intermediate or low polarity. The comparative effectiveness of these solvents has significant implications not only for laboratory analysis but also for traditional herbal formulations and the development of standardized plant-based pharmaceuticals.

Among the many plants of medicinal interest, *Cassia siamea* (syn. *Senna siamea*), belonging to the family Fabaceae, stands out as a species with demonstrated ethnomedical utility and promising pharmacological potential. Native to Southeast Asia and now widespread in tropical Africa including Sierra Leonen *C. siamea* is used extensively in folk medicine to treat a variety of ailments, including **malaria, fever, bacterial infections, inflammation, constipation, and insomnia**. Various parts of the plant leaves, stem bark, roots, and flowers are employed in decoctions, infusions, and poultices.

Numerous studies have affirmed the presence of secondary metabolites in *C. siamea*; however, **there is a paucity of solvent-specific phytochemical studies focusing on Sierra Leonean populations of the plant**. Given the influence of environmental factors such as climate, soil composition, altitude, and seasonality on phytoconstituent profiles, region-specific studies are necessary to understand the full biochemical potential and therapeutic relevance of local plant ecotypes.

Therefore, this study seeks to perform a **comparative analysis of methanol and aqueous extractions** from the leaves and stem bark of *Cassia siamea* collected in Sierra Leone. By evaluating the qualitative presence and distribution of phytochemicals in extracts prepared with these two commonly used solvents, this research aims to:

- Identify the more effective solvent for extracting pharmacologically important compounds,
- Provide empirical evidence to support traditional medicinal practices, and
- Contribute to the development of optimized extraction protocols for herbal drug standardization and further pharmacological investigations.

Ultimately, this study bridges the gap between traditional knowledge and modern phytochemical science, reinforcing the role of *Cassia siamea* as a potential source of natural bioactive compounds for addressing pressing healthcare needs.

II. MATERIALS AND METHODS

➢ *Study Area and Plant Collection*

Fresh samples of *Cassia siamea* leaves and stem bark were collected in March 2024 from the Eastern Region of Freetown, Sierra Leone, an area characterized by a tropical monsoon climate with high humidity and seasonal rainfall. Plant identification was carried out and authenticated by a botanist from the Department of Biological Sciences, Fourah Bay College, University of Sierra Leone. The plant material was assigned voucher specimens and deposited in the departmental herbarium for reference.

➢ *Preparation of Plant Material*

The collected leaves and stem bark were washed thoroughly under running water to remove soil and debris, followed by rinsing with distilled water. The cleaned samples were then shade-dried for 10 days at ambient room temperature (25–28°C) to preserve thermolabile compounds and minimize oxidative degradation. Dried samples were ground into fine powder using a clean electric grinder and stored in airtight containers away from light and moisture until further use.

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➢ *Solvent Extraction Procedure*

Two solvents **methanol (99.8% analytical grade)** and **distilled water** were selected for comparative extraction due to their widespread use in traditional and scientific herbal research. Extraction was carried out using the **cold maceration method**, suitable for preserving heat-sensitive compounds and widely accepted for qualitative phytochemical screening.

For each plant part (leaves and stem bark), **50 grams** of powdered material were soaked separately in **250 ml** of each solvent in conical flasks. The flasks were sealed with aluminum foil and kept on a rotary shaker at 150 rpm for 72 hours at room temperature. The mixtures were then filtered through Whatman No. 1 filter paper to remove plant residues.

The methanolic filtrates were concentrated using a rotary evaporator at 40°C under reduced pressure, while aqueous extracts were concentrated using a water bath at the same temperature. The resulting semi-solid extracts were weighed and stored in sterilized glass bottles at 4°C for further phytochemical analysis.

➢ *Phytochemical Screening*

The extracts obtained were subjected to **qualitative phytochemical screening** to detect the presence of the following bioactive compounds: **alkaloids, flavonoids, saponins, tannins, glycosides, steroids, terpenoids, phenols,** and **anthraquinones**. The tests were performed using standard procedures as described by Harborne (1998), Sofowora (1993), and Trease & Evans (2002), outlined below:

- Alkaloids: Detected using Mayer's and Wagner's reagents, which form cream or reddish-brown precipitates respectively.
- Flavonoids: Detected by the Shinoda test (formation of pink or red coloration after adding magnesium ribbon and concentrated HCl).
- Saponins: Identified through the frothing test, where persistent froth indicates saponin presence.
- Tannins: Detected using ferric chloride; blue-black or greenish-black coloration indicates presence.
- Glycosides: Detected by Keller-Kiliani test; a reddish-brown ring formation at the interface suggests cardiac glycosides.
- Steroids: Salkowski's test was used; the development of a red or reddish-brown ring indicates a positive result.
- Terpenoids: Libermann-Burchard reaction was used for detection.
- Phenols: Ferric chloride test was used; a deep bluish-green coloration indicates phenolic compounds.
- Anthraquinones: Borntrager's test was conducted; pink to red coloration indicates presence.

➢ *Data Analysis*

The results were recorded qualitatively as "++" (strongly present), "+" (present), or "–" (absent). Observations were tabulated for comparative analysis across both solvents and plant parts. Data interpretation focused on identifying trends in compound distribution, solvent extraction efficiency, and alignment with known pharmacological applications.

III. RESULTS

The phytochemical screening of the methanolic and aqueous extracts of *Cassia siamea* revealed significant differences in the types and intensities of secondary metabolites extracted from the leaves and stem bark. The outcomes affirm that solvent polarity plays a crucial role in the efficiency of compound extraction.

A. Overview of Phytochemical Composition

As shown in Table 1, the **methanolic extracts** of both leaves and stem bark exhibited a broader spectrum and stronger presence of phytochemicals compared to their **aqueous counterparts**. In the methanolic extracts:

- **Flavonoids**, **glycosides**, **tannins**, and **saponins** were present in both leaf and bark samples.
- **Phenols** and **steroids** were exclusively extracted using methanol, with phenols present only in the leaf extract.
- **Glycosides** were strongly present (++), particularly in the leaf methanolic extract.
- No presence of **alkaloids**, **terpenoids**, or **anthraquinones** was detected in any extract.

Aqueous extracts showed moderate extraction of flavonoids, saponins, and tannins, but lacked detectable levels of phenols and steroids. Glycosides were found in the aqueous leaf extract but absent in the stem bark extract.

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Table 1. Phytochemical Constituents Detected in Methanolic and Aqueous Extracts of *Cassia siamea* Leaves and Stem Bark

Phytochemical	Leaf (Methanol)	Leaf (Water)	Stem Bark (Methanol)	Stem Bark (Water)
Alkaloids	–	–	–	–
Anthraquinones	–	–	–	–
Flavonoids	+	+	+	+
Glycosides	++	+	+	–
Saponins	+	+	++	+
Tannins	++	+	++	+
Steroids	+	–	+	–
Terpenoids	–	–	–	–
Phenols	+	–	–	–

Legend:
"++" = Strongly Present, "+" = Present, "–" = Absent

B. Visual Representation of Findings

To aid understanding of extraction differences, visual comparisons of the plant parts and extracts are provided below.

Fig 1: Plant Parts Used in the Study

This image illustrates the various parts of the *Cassia siamea* plant, including the stem bark and leaves, which were utilized in the extraction process.

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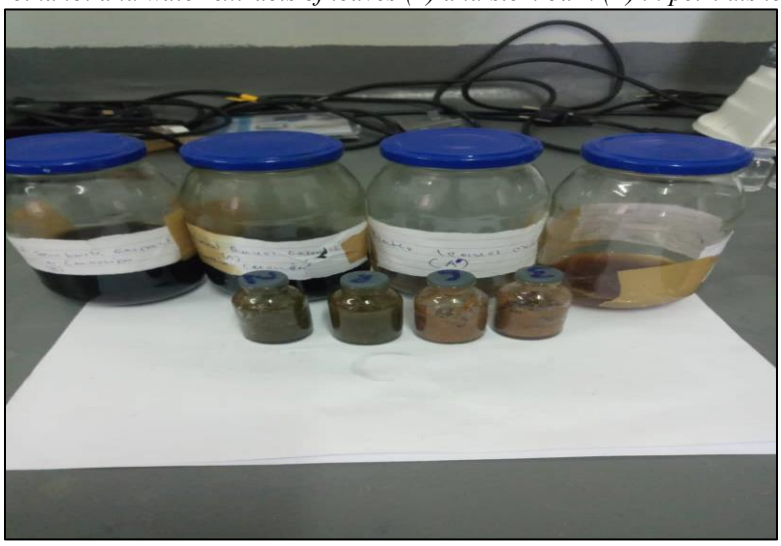
Fig 2: Crude Extracts of Leaf and Stem Bark

Methanol and water extracts of leaves (L) and stem bark (B) in petri dishes



C. Summary of Key Observations

- **Methanol consistently extracted more classes of phytochemicals**, suggesting its superior efficiency and broader solvating power.
- **Aqueous extracts were limited** to the more polar constituents like tannins and saponins but failed to extract phenols and steroids.
- **Glycosides and phenols**, which are known for potent biological activity, were more abundant in methanol extracts, indicating their lower solubility in water.
- The complete absence of **alkaloids, terpenoids, and anthraquinones** across all extracts suggests either their true absence in this chemotype or their presence below detectable thresholds in qualitative screening.

These observations collectively support the hypothesis that **methanol is a more efficient solvent** for extracting a diverse range of bioactive compounds from *Cassia siamea*, especially when the goal is to capture both polar and slightly non-polar phytochemicals.

IV. DISCUSSION

The present study provides a comparative analysis of methanol and aqueous solvents in the phytochemical extraction of *Cassia siamea* leaves and stem bark, shedding light on the significant role solvent polarity plays in influencing phytoconstituent yield and composition. The results corroborate earlier studies which emphasize that the solubility of phytochemicals varies across solvents of differing polarities, and that extraction efficiency is contingent on the compatibility between solvent type and the chemical nature of target compounds (Harborne, 1998; Tiwari et al., 2011).

A. Methanol as a Superior Extraction Solvent

Methanol emerged as a more effective solvent across both plant parts, successfully extracting a broader array of phytochemicals, including phenols and steroids, which were absent in aqueous extracts. Its intermediate polarity and low boiling point make it a versatile solvent capable of dissolving both polar and moderately non-polar compounds (Tiwari et al., 2011). Methanol's ability to extract **phenolic compounds**, known for their powerful antioxidant activity, is particularly important given the increasing global interest in natural antioxidants for disease prevention and therapeutic purposes. The exclusive detection of phenols in the methanolic leaf extract reinforces the necessity of using polar organic solvents in capturing compounds with lower water solubility.

Furthermore, methanol effectively extracted **glycosides**, which were strongly present (++), particularly in the leaves. Glycosides, especially cardiac and phenolic glycosides, are known for their antimicrobial, anti-inflammatory, and cardiotonic activities. Their extraction reinforces the use of *Cassia siamea* in traditional remedies for infections, chest ailments, and fever (Bukar et al., 2009). Similarly, **saponins** and **tannins**, also efficiently extracted by methanol, have been reported to possess immunostimulant, expectorant, and antimicrobial properties, validating the folk use of *Cassia siamea* in treating respiratory infections and gastrointestinal issues.

B. Limitations of Water as an Extractive Medium

Water, though traditionally favored for herbal preparations due to its safety and availability, demonstrated limited extraction capacity in this study. While aqueous extracts retained some phytochemicals such as flavonoids, tannins, and saponins, other valuable compounds like phenols, glycosides (in stem bark), and steroids were not detected. This

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supports the notion that **aqueous solvents, although beneficial for extracting highly polar constituents, are less effective for extracting semi-polar or non-polar compounds**, which often possess significant pharmacological activity (Edeoga et al., 2005).

The absence of **phenols** and **steroids** in aqueous extracts diminishes their therapeutic scope when used alone. Although traditional healers rely heavily on water-based decoctions, these may not harness the full medicinal potential of the plant unless complemented with other extraction techniques or solvents. As a result, this study suggests that hybrid approaches, such as using **hydroalcoholic mixtures**, may improve extraction efficiency in ethnomedicinal and pharmaceutical contexts.

C. Implications of Phytochemical Distribution by Plant Part

The differential distribution of phytochemicals between the leaves and stem bark further underscores the complexity of plant biochemistry. For instance, **phenols were exclusively present in the leaves**, while **saponins were more concentrated in the stem bark**, suggesting tissue-specific biosynthesis or accumulation. These variations are critical for determining which part of the plant should be used for targeted therapeutic purposes. For antioxidant effects, the leaf may be preferred, while the stem bark may be more suitable for respiratory ailments due to its higher saponin content.

D. Absence of Alkaloids, Terpenoids, and Anthraquinones

The complete absence of alkaloids, terpenoids, and anthraquinones in all extracts may be attributed to the chemical ecology of the Sierra Leonean variant of *Cassia siamea*. Previous studies from other regions, such as Nigeria and India, have reported the presence of these metabolites (Lemaire & Adosraku, 2002). This discrepancy highlights the importance of **geographical and ecological factors** including soil composition, climate, and altitude in shaping the phytochemical profiles of medicinal plants. Such regional chemotypic variation calls for localized pharmacognostic studies before broad generalizations are made.

E. Relevance to Ethnomedicine and Drug Discovery

The presence of multiple biologically active secondary metabolites in *Cassia siamea* supports its traditional use in treating a wide spectrum of ailments. Flavonoids and tannins contribute to its antimicrobial and wound healing properties, while saponins and glycosides offer anti-inflammatory and expectorant benefits. These bioactivities make the plant a strong candidate for **further pharmacological screening and drug development**. Given the growing crisis of antibiotic resistance and the search for affordable therapeutic alternatives in low-resource settings, such findings are timely and relevant.

V. CONCLUSION

This study has demonstrated that methanol is a more efficient solvent than water for the extraction of phytochemicals from the leaves and stem bark of *Cassia siamea*, a plant of significant ethnomedicinal importance in Sierra Leone. The methanolic extracts consistently yielded a broader and richer profile of secondary metabolites, including flavonoids, glycosides, tannins, saponins, steroids, and phenols several of which were absent or present in reduced concentrations in aqueous extracts.

These findings underscore the critical role of solvent polarity in phytochemical investigations and herbal drug standardization. While water remains a safer and traditionally preferred medium, its limited extraction range may overlook valuable phytoconstituents, reducing the therapeutic potential of aqueous herbal preparations. Methanol, by contrast, offers broader solubility and extraction efficacy, particularly for moderately polar compounds with known bioactivities.

The results also reaffirm the pharmacological relevance of *Cassia siamea*, supporting its traditional applications for treating infections, inflammation, and respiratory illnesses. In light of the absence of alkaloids and anthraquinones despite their detection in variants of *C. siamea* elsewhere this study highlights the need for geographically specific phytochemical profiling as an essential precursor to pharmacological validation.

Future studies should explore **quantitative phytochemical analysis**, **bioassay-guided isolation**, **toxicological assessment**, and **mechanistic studies** using both in vitro and in vivo models. Moreover, integrating solvent optimization strategies such as hydroalcoholic mixtures may provide a balance between safety and efficacy for both traditional healers and pharmaceutical researchers. In conclusion, *Cassia siamea* remains a promising source of bioactive compounds, and this study contributes to a growing body of knowledge aimed at bridging traditional herbal practices and evidence-based medicine.

REFERENCES

[1]. Bukar, A., Uba, A., & Oyeyi, T. I. (2009). Antimicrobial profile of *Cassia siamea* leaf extract on some selected clinical pathogens. *African Journal of Biotechnology*, 8(21), 5082–5086.
[2]. Edeoga, H. O., Okwu, D. E., & Mbaebie, B. O. (2005). Phytochemical constituents of some Nigerian medicinal plants. *African Journal of Biotechnology*, 4(7), 685–688.
[3]. Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis* (3rd ed.). Chapman and Hall.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may064

[4]. Lemaire, B., & Adosraku, R. K. (2002). Antibacterial activity and structural elucidation of compounds from *Cassia siamea*. *Journal of Natural Products*, 65(5), 784–789.
[5]. Sofowora, A. (1993). *Medicinal Plants and Traditional Medicine in Africa* (2nd ed.). Spectrum Books Ltd.
[6]. Tiwari, P., Kumar, B., Kaur, M., Kaur, G., & Kaur, H. (2011). Phytochemical screening and extraction: A review. *International Pharmaceutica Sciencia*, 1(1), 98–106.
[7]. Trease, G. E., & Evans, W. C. (2002). *Pharmacognosy* (15th ed.). Saunders Publishers.
[8]. World Health Organization (WHO). (2013). *WHO Traditional Medicine Strategy 2014–2023*. https://www.who.int/publications/i/item/9789241506096