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Research Article

Qualitative and Quantitative Phytochemical Screening of Aqueous, Methanol, and Hexane Leaf Extracts of *Senna siamea*

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ABSTRACT

Senna siamea is a remarkable plant traditionally recognized for its potent antimicrobial, antifungal, and antimalarial properties. This study was conducted to identify the phytochemical compounds responsible for these therapeutic effects. Fresh leaves were collected and subjected to extraction using water (aqueous), methanol, and hexane solvents. These extracts were then analyzed for phytochemical constituents employing standard methodologies. The phytochemical screening of all crude extracts indicated the presence of saponins, tannins, steroids, phenols, alkaloids, and flavonoids. In the aqueous extract, saponins were the most abundant, comprising 9.90%, followed by alkaloids at 6.47%. The methanolic extract exhibited a higher glycoside content of 2.81%, while the hexane extract had the highest terpenoid content at 2.40%. Based on this study, it can be concluded that *Senna siamea* extracts are rich in phytochemicals, with saponins being the most prevalent. This abundance of saponins may contribute to the plant's pharmacological activities, supporting its traditional use as an alternative treatment for various health conditions.

Keywords: Aqueous; Hexane; Methanol; Phytochemical; *Senna siamea*

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INTRODUCTION

Senna siamea (S, siame), also known as kassod tree, Malga or marke **(**Hausa), ewe kasia (Yuroba) is an angiosperme native of Southeast Asia (Kamagaté *et al.,* 2014). Firstly classified in the Caesalpiniacae family, then in those of Leguminoseae, *S. siamea* is now classified among the Fabaceae (Kamagaté *et al.,* 2014). *S. siamea* is better known by the tropical populations for its various medicinal value (Shivjeet *et al.,* 2013). It is also known for its various common uses in cattle rearing, agriculture, and furniture (Rojas-Sandoval and Acevedo-Rodríguez, 2022). The synonym *Cassia siamea* is, however, still widely used today (Rojas-Sandoval and Acevedo-Rodríguez, 2013). *Senna* species are annual shrub that grows all over tropical countries throughout India, Pakistan, Bangladesh and West China and grows well in the wasteland as a rainy season weed (Shivjeet *et al.,* 2013). This plant is a shrub with medium-size, 10-12 m tall, occasionally reaching 20 m (Veerachari and Bopaiah 2011). The bole is short; the crown is dense and rounded at first, later becoming irregular and spreading (Kamagaté *et al.,* 2014).

The young bark is grey and smooth, and later with longitudinal fissures; the leaves are alternate, 15-30 cm long, compound, with 6-14 leaflets, each ending in a tiny bristle (Kamagaté *et al.,* 2014). The flowers are bright yellow, large, up to 60 cm long, upright, with pyramid-shaped panicles (Kamagaté *et al.,* 2014). The fruits are flat with an indehiscent pod, 5-30 cm long, and constricted between the seeds, it contains about 20 seeds per pod. The seeds are

bean-shaped, greenish-brown, and 8-15 mm long (Kamagaté *et al.,* 2014).

The leaves, stems, roots, flowers and seeds of *S. siamea* regardless of subspecies have been used for the treatment of several illnesses including mostly malaria, a tropical endemic disease that causes high morbidity and mortality (Kamagaté *et al.,* 2014).

Pharmacological investigations have revealed the presence of several activities, and is a mixture of various groups of chemicals, it is of no surprise that it exhibits different modes of action. Its major actions include, antimalarial, antidiabetic, antitumoral or anticancer, hypotensive, diuretic, antioxidant, laxative, anti-inflammatory, analgesic, antipyretic, anxiolytic, antidepressant, sedative, and antimicrobial activitie (Kamagaté *et al.,* 2014). *Senna siamea* was identified from the southwest Nigerian ethnobotany as a remedy for febrile illness (Ajaiyeoba *et al.,* 2008). Study reveals *Senna siamea* at doses of 100, 200 and 400 mg/kg have shown significant antiplasmodial activity with parasite reduction of 50%. No mortality of rats was observed at the tested doses (Javeres *et al.,* 2019). Ethanolic, ethyl acetate and hexane extracts of *C. siamea's* leaves at doses of 150 and 300 mg/kg were effective against the antidiabetic-alloxan-induced diabetes model (Kamagaté *et al.,* 2014). The methanol and aqueous extracts of bark (800 and 1000 µg/mL) inhibited 60.5% and 51.34% of free radicals, respectively, compared to rutin, which exhibited 62.56% inhibition. Meanwhile, at 1000 µg/mL, the hexane, chloroform, and ethyl acetate extracts of leaves demonstrated moderate antioxidant activities (Kaur and Arora, 2011). Ethanol and aqueous extracts of *Cassia siamea* leaves and stem bark (100–400 mg/kg, orally, for 4 hours) exhibited significant dose-dependent anti-inflammatory, analgesic, and antipyretic activities in experimental rat models (Nsonde-Ntandou *et al.,* 2010). The methanol leaf extract exhibited strong antibacterial activity against *Bacillus cereus* and *Listeria monocytogenes*, with IC_{50} values of 5.2 mg/mL and 20.8 mg/mL, respectively, after 24 hours of exposure at 37°C. Under the same conditions, it showed low activity against *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas fluorescens*, *Salmonella risen*, *Salmonella typhimurium*, *Staphylococcus aureus*, *Yersinia enterocolitica*, and *Lactobacillus plantarum*, with IC_{50} values reaching up to 166.7 mg/mL (Nanasombat and Teckchuen, 2009). Various fungal species were found to be sensitive to the hexane, ethanol, methanol, and aqueous extracts of *Cassia siamea*. The ethanol and aqueous bark extracts (100 mg/mL) exhibited activity against six *Candida* strains (*C. albicans, C. glabrata, C. tropicalis, C. krusei, C. parapsilosis,* and *C. guilliermondii*), with effects comparable to fluconazole (25 µL/mL) after 24 hours of exposure (Prabhakar *et al.,* 2009). *Senna siamea* is a rich source of drugs for various applications, including traditional and modern medicine, nutraceuticals, and food supplements, due to its phytochemicals (Esievo *et al.,* 2016). The objective of this study was to screen the phytochemical constituents of aqueous, methanol and hexane leaves extracts of *S. siamea* and relate them to some of its traditional uses.

MATERIALS AND METHODS

Collection, Identification and Authentication of Plant Samples

Fresh and mature leaves of *Senna siamea* were obtained at Jiddari polo Maiduguri, Borno State. The samples were collected in a clean sterile polythene bag and brought to the herbarium of the Department of Biological Sciences, Nigerian Defence Academy Kaduna, for identification and authentification with Voucher specimen number issued NDA/BIOH/2023/51 (*Senna siamea).* Three different solvent extraction methods were used for the plant material—polar, intermediate polar, and non-polar—to determine the extract with the highest phytochemical yield. Aqueous extraction was used for polar compounds, methanol for intermediate polar compounds, and hexane for non-polar compounds.

Sample Preparation

The fresh plant samples were rinsed with water and air-dried in the shade for three weeks. The dried samples were then milled into powder using a grinding machine and stored in sterilized polythene bags until use.

Extraction

Preparation of aqueous crude extracts

Fifty grams (50 g) of *Senna siamea* sample was separately extracted with 1500 mL of distilled water in a 2000 mL beaker. The soaked samples were stirred, covered with aluminium foil, and left for 24 hours. The resulting extracts were filtered using muslin cloth, and each filtrate was evaporated to dryness using a hot plate set at 40°C to obtain the crude extract. The crude extracts were then weighed and stored in a refrigerator until use (Patil and Gaikwad, 2010).

Preparation of methanol crude extracts

The powdered samples (50 g) were extracted with 500 mL of methanol using a Soxhlet extractor for 72 hours. After complete extraction, the methanol solvent was evaporated under reduced pressure using a rotary evaporator (Yamato, Rotary Evaporator, and Model RE-801) to obtain the methanol crude extract. Each methanol crude extract was then suspended in 60 mL of water and separately filtered through Whatman filter paper to

remove any remaining particles. The particle-free crude extract was completely evaporated under reduced pressure using a rotary evaporator to obtain dry crude extracts. The residue left in the separatory funnel was re-extracted twice following the same procedure and then filtered (Patil and Gaikwad, 2010).

Preparation of Hexane Crude Extracts

The leaves were shade-dried and then milled into a fine powder using a Willye-type mill. The powdered sample was stored at 28°C, protected from light and moisture, until use. The extract was prepared using a Soxhlet apparatus with 50 g of powdered leaves and 1 L of *n*-hexane. The solvent was evaporated at 75 rpm and 64.4°C using an HB10 rotary evaporator. The resulting material after solvent evaporation was the crude extract (Costa Cordeiro *et al.,* 2018).

Qualitative Phytochemical Screening of Leaf Extracts *S. siamea*

The leaves extracts of the plant were screened for metabolites such as alkaloids, tannins, flavonoids, saponins, terpenoids, steroids, anthraquinones, glycosides, cardiac glycosides, saponins glycosides, volatile oils, and balsams.

Test for Alkaloids (Dragendoff's Test)

About 0.2 g of each plant sample was added to 3 mL of *n*-hexane in a test tube, mixed, shaken, and filtered. Then, 5 mL of 2% HCl was added to the test tube containing the plant extract and *n*-hexane mixture. The mixture was heated and then filtered. A few drops of picric acid were added to the filtrate, and the formation of a yellow precipitate indicated the presence of alkaloids (Wadood *et al.,* 2013)

Test for Tannins (Ferric Chloride Test)

Two millilitres (2 mL) of each extract was mixed with 2 mL of water, followed by the addition of 1 to 2 drops of diluted ferric chloride solution. The appearance of a dark green or blue-green coloration indicated the presence of tannins (Wadood *et al.,* 2013).

Test for Flavonoids (H_2SO_4 Test)

About 0.5 g of each plant extract was added to a test tube containing 10 mL of distilled water. Then, 5 mL of dilute ammonia solution was added to a portion of the filtrate, followed by the addition of 1 mL of concentrated H_2SO_4. The appearance of a yellow coloration indicated the presence of flavonoids in each extract (Wadood *et al.,* 2013).

Test for Saponins (Frothing Test)

A small volume of distilled water was added to 1 mg of each plant extract in a test tube. The solution was then shaken vigorously and observed for a stable, persistent froth for 20 minutes. The formation of a layer of foam indicated the presence of saponins (Sabri *et al.,* 2012).

Test for terpenoid Steroids (Liebermann Burchard's Test)

Ten millilitres (10 mL) of each extract were evaporated, and the residue was dissolved in 0.5 mL of hot acetic anhydride. Then, 0.5 mL of chloroform filtrate was added, followed by treatment with Liebermann-Burchard's reagent. The appearance of a blue-green colour at the interphase confirmed the presence of steroids. (Wadood *et al.,* 2013).

Test for Anthraquinones (Borntrager's Test)

Two millilitres of 10% hydrochloric acid were added to each extract in a test tube and boiled for 2 minutes. An equal amount of chloroform was then added to the test tube and vortexed twice. The chloroform layer was pipetted out, and an equal volume of ammonia was added to it. The appearance of a pinkish layer indicated the presence of anthraquinones (Efe *et al.,* 2016).

Test for Glycosides (Fehling's Test)

About 2.5 of 50% sulphuric acid was added to 5ml of the extract each in a test tube. The mixture was heated in boiled water for 15 minutes, cooled, and neutralized with 10% NaOH, and 15mL of Fehling's reagent was added, and the mixture was boiled. A brick-red precipitate was observed, which indicated the presence of glycocides (Ayoola *et al.,* 2008).

Test for Cardiac Glycosides (Keller-Kiliani's Test)

About 2 mL of 0.5% ferric chloride solution was added to 1 mL of each extract in a test tube and allowed to stand for 1 minute. Then, 1 mL of 10% H_2SO_4 was carefully poured down the inner wall of the test tube. The formation of a reddish-brown ring at the interface between the two layers indicated the presence of cardiac glycosides (Gul *et al.,* 2017**).**

Test for Saponins Glycosides (Fehling's Test)

About 2.5 mL of Fehling's reagent was added to 2.5 mL of each extract in a test tube. The formation of a bluish-green precipitate indicated the presence of saponin glycosides. (Gul *et al.,* 2017).

Test for Volatile oils (HCl Test)

Ninety percent (90%) of HCl was mixed with each plant extract. A white precipitate confirms the presence of volatile oils (Efe *et al.,* 2016).

Test for Balsams: (Ferric Chloride Test)

About 2.5 mL of each plant extract was mixed with an equal volume of 90% ethanol. Two drops of alcoholic ferric chloride solution were then added to the mixture. The appearance of a dark green colour indicated the presence of balsams. (Gul *et al.,* 2017).

Quantitative Determination of Phytochemicals Components

Quantitative Estimation of Alkaloids

One milligram (1 mg) of each plant extract was dissolved in dimethyl sulfoxide (DMSO), followed by the addition of 1 mL of 2N HCl and subsequent

filtration. The resulting solution was transferred to a separating funnel, where 5 mL of bromocresol green solution and 5 mL of phosphate buffer were added. The mixture was shaken vigorously with 1, 2, 3, and 4 mL of chloroform, and the chloroform layer was collected in a 10 mL volumetric flask and diluted to volume with chloroform.

A set of reference standard solutions of atropine (20, 40, 60, 80, and 100 µg/mL) was prepared using the same procedure. The absorbance of both the standard and test solutions was measured against a reagent blank at 470 nm using a UV/visible spectrophotometer. The alkaloid content was expressed as mg of AE per gram of plant extract (Selvakumar *et al.,* 2019).

Quantitative Estimation of Tannins

The tannin content was determined using the Folin-Denis reagent. A stock solution was prepared by dissolving the extract in distilled water in a calibrated flask (1:1 ratio). Standard solutions were obtained by appropriately diluting the stock solution with distilled water. Suitable aliquots of the tannin-containing extract (0.05, 0.2, and 0.5 mL) were pipetted into test tubes, and the volume was adjusted to 1.00 mL with distilled water. Then, 2.5 mL of sodium carbonate reagent was added to each tube. The tubes were shaken, and absorbance was recorded at 725 nm after 40 minutes. The total tannin content was calculated as tannic acid equivalent (TAE) from the standard curve (Suleiman *et al.,* 2017).

Quantitative Estimation of flavonoids

A colorimetric assay was used to determine the total flavonoid content using aluminium chloride as the reactive agent. Each plant extract (1 mL) was mixed with 4 mL of distilled water in a 10 mL flask. Then, 0.30 mL of 5% sodium nitrite was added, and after 5 minutes, 0.30 mL of 10% aluminium chloride was introduced into the flask. After another 5 minutes, 2 mL of 1M NaOH was added, and the solution was diluted to 10 mL with distilled water. A set of standard quercetin solutions (20, 40, 60, 80, and 100 µg/mL) was prepared using the same procedure. The absorbance of both the test and standard solutions was measured against a reagent blank at 510 nm using a UV-visible spectrophotometer. The total flavonoid content was expressed as mg of quercetin equivalent (QE) per gram of extract (Selvakumar *et al.,* 2019).

Quantitative Estimation of Saponins

The test extract was dissolved in 80% methanol, followed by the addition of 2 mL of vanillin in ethanol. The mixture was well mixed, and then 2 mL of 72% sulfuric acid (H_2SO_4) solution was added, mixed thoroughly, and heated in a water bath at 60°C for 10 minutes. The absorbance was measured at 544 nm using a UV/visible spectrophotometer against a reagent blank. Saponin concentrations were calculated using the standard curve (R^2 = *0.992*) and expressed as mg of diosgenin equivalents (DE) per mg of crude extract. (Madhu, 2016).

Quantitative Estimation Terpenoid

About 100 mg of the plant material was placed in screw-capped tubes and frozen in liquid nitrogen at -80°C for one month. The frozen sample tissue was then homogenized with 95% (v/v) methanol in pre-cooled Teflon adaptors for 5 minutes at 30 Hz. Tungsten carbide was removed using a magnet, and the sample was incubated at room temperature in the dark for 48 hours. Following incubation, the sample was centrifuged at room temperature for 15 minutes, and the supernatant was collected into a clean 2 mL microtube. Then, 1.5 mL of chloroform was added to each micro centrifuge tube. A standard curve was prepared using 200 µL of a linalool solution in methanol, with serial dilutions ranging from 12.965 to 1.296 µM. The total volume of 200 µL was made up by adding 95% (v/v) methanol. The sample mixture was vortexed thoroughly and left to stand for 3 minutes. Then, 100 µL of sulfuric acid (H_2SO_4) was added to each microcentrifuge tube, and the assay tubes were incubated at room temperature in the dark for 2 hours. At the end of the incubation period, a reddish-brown precipitate formed in each assay tube. The supernatant was carefully removed without disturbing the precipitate. The reddish-brown precipitate was partially soluble in the reaction mixture. To dissolve it completely, 1.5 mL of 95% methanol was added to each tube and vortexed thoroughly. The resulting solution was transferred to a colorimetric cuvette, and absorbance was measured at 538 nm using a UV/visible spectrophotometer, with 95% (v/v) methanol as the blank (Ghorai *et al.,* 2017).

Quantitative Estimation of Anthraquinones

Each extract (1.00 g) was accurately weighed and added to 30 mL of distilled water. The mixture was thoroughly mixed, weighed, and refluxed in a water bath for 15 minutes. After cooling, the flask was reweighed, adjusted to its original weight with water, and centrifuged at 4000 rpm for 10 minutes. Twenty millilitres of the supernatant liquid was transferred to a separatory funnel and acidified with 2 M hydrochloric acid. Fifteen millilitres of chloroform was added, and the mixture was extracted. The chloroform layer was discarded, and the extraction was repeated three times. The aqueous layer was separated, and 0.10 g of sodium bicarbonate was added. The mixture was shaken for 3 minutes and centrifuged again at 4000 rpm for 10 minutes. Next, 10 mL of the supernatant liquid was transferred to a 100 mL flask, followed by the

addition of 20 mL of a 10.5% (w/v) ferric chloride hexahydrate solution. The mixture was refluxed in a boiling water bath for 20 minutes. After that, 1 mL of concentrated hydrochloric acid was added, and the mixture was heated for another 20 minutes with frequent shaking to dissolve the precipitate. After cooling, the mixture was transferred to a separatory funnel and shaken with 25 mL of diethyl ether. The partitioning process was repeated until anthraquinones were completely extracted, confirmed using the Borntrager's reaction. The combined diethyl ether extracts were washed twice with 15 mL of distilled water. The purified diethyl ether extract was then transferred to a 100 mL volumetric flask and adjusted to volume. A 25 mL portion of this solution was evaporated to dryness, and the residue was dissolved in 10 mL of 0.5% (w/v) magnesium acetate in methanol, yielding a red solution. The UV absorbance of this solution was measured at 515 nm. (Sakulpanich and Gritsanapan, 2008).

Quantitative Estimation of Glycosides

Eight millilitres (8 mL) of each plant extract was transferred into a 100 mL volumetric flask. Then, 60 mL of distilled water and 8 mL of 12.5% lead acetate were added, mixed thoroughly, and filtered. Fifty millilitres (50 mL) of the filtrate was then transferred into another 100 mL flask, where 8 mL of 47% sodium hydrogen phosphate (Na_2HPO_4) was added to precipitate excess Pb^{2+} ions. The mixture was stirred, adjusted to volume with distilled water, and filtered twice using the same filter paper to ensure complete removal of lead phosphate. Next, 10 mL of the purified filtrate was transferred into a clean Erlenmeyer flask and treated with 10 mL of Baljet reagent. A blank titration was conducted using 10 ml of distilled water and 10 mL of Baljet reagent. The solutions were allowed to stand for one hour to ensure complete color development. Finally, the color intensity was measured colorimetrically at 495 nm using a UV/visible spectrophotometer (Muhammad and Abubakar, 2016).

Data Analysis

The data obtained from the study were analyzed statistically using the Statistical Package for the Social Sciences (SPSS) version 25.0. Analysis of Variance (ANOVA) was conducted to determine significant differences between groups at a 95% confidence level. Mean values generated from the study were compared and separated using the Least Significant Difference (LSD) test.

RESULTS

The percentage yields of the leaf extracts in aqueous, methanol, and hexane solvents indicate that the aqueous extract had the highest yield at 29.61%, followed by the methanol extract at 23.30%, while the hexane extract had the lowest yield at 8.20%. The results are presented in Table 1. The results of the qualitative analysis of *Senna siamea* are presented in Table 2. The analysis revealed the presence of tannins, saponins, alkaloids, glycosides, flavonoids, balsams, steroids, saponin glycosides, and cardiac glycosides in the aqueous extract. The methanol extract showed the presence of tannins, saponins, alkaloids, glycosides, flavonoids, balsams, steroids, saponin glycosides, cardiac glycosides, and volatile oils. In contrast, the hexane extract indicated the presence of steroids, terpenoids, tannins, flavonoids, cardiac glycosides, and volatile oils.

The result of the quantitative phytochemical analysis of *S. siamea* aqueous, methanol and hexane leaves extracts are presented in Table 3. The result showed a significant amount of Alkaloids in aqueous and methanol, Terpenoids in all three solvents, flavonoids in aqueous and methanol, Saponins in aqueous, Anthraquinones in aqueous and methanol leaves extracts, and Tannins in aqueous extract.

Table 1: Percentage Yields of the Leaf Extracts of *S siamea*

Extracts	Plant material (g)	Aqueous Yield (%)	Methanol Yield (%)	Hexane Yield (%)
S siamea	50	29.61	23.30	8.20

Table 2: Qualitative Phytochemical Components of Aqueous, Methanol and Hexane Leaf Extracts of *Senna siamea*

Phytochemical Components	Aqueous	Methanol	Hexane
Alkaloids	+	+	-
Saponin glycocides	+	+	-
Steroids	+	+	+
Tannins	+	+	-
Terpenoids	+	+	+
Cardiac Glycosides	+	+	+
Flavonoid	+	+	-
Balsams	+	+	-
Volatile Oils	-	+	+
Saponins	+	+	-
Anthraquinones	+	+	-

Key: - Absent. + Present

Table 3: Quantitative Phytochemical Components of Aqueous, Methanol and Hexane Leaf Extracts of *Senna siamea*.

Phytochemical Component (%)	Aqueous	Methanol	Hexane
Alkaloids	6.47±0.15^{c}	1.06±0.00^{b}	0.00±0.00^{a}
Terpenoids	2.46±0.02^{b}	2.50±0.01^{b}	2.40±0.00^{a}
Flavonoid	3.13±0.27^{c}	2.14±0.19^{b}	0.59±0.14^{a}
Saponins	9.90±0.60^{c}	0.79±0.01^{b}	0.00±0.00^{a}
Glycosides	4.07±0.12^{c}	2.81±0.14^{b}	0.50±0.01^{a}
Anthraquinones	1.39±0.09^{b}	1.42±0.28^{b}	0.00±0.00^{a}
Tannins	4.55±0.15^{b}	0.51±0.33^{b}	0.23±0.02^{a}

Values are mean ± standard deviation of 3 replications; means in a column with different superscripts are significantly different (P<0.05)

DISCUSSION

In this study, the percentage yield of aqueous, methanolic, and hexane leaf extracts of *S. siamea* indicated that the aqueous extract (29.61%) had the highest yield compared to methanol and hexane extracts, despite using the same quantity of plant material. This difference in the total yield could be attributed to the nature and amount of secondary metabolites extracted, which may be due to the solubility of polar secondary metabolites in these solvents such as carbohydrates, alkaloids and Polar flavonoids. This is finding is in agreement with the work of Dirar *et al.* (2019) who reported aqueous extracts showed higher extracts yield than ethanol, acetone and dichloromethane that was tested on six plants.

The qualitative phytochemical analysis of aqueous and methanol leaf extracts revealed the presence of tannins, saponins, alkaloids, glycosides, flavonoids, balsams, steroids, saponin glycosides, and cardiac glycosides in the aqueous extract. Similarly, the methanol extract showed the presence of tannins, saponins, alkaloids, glycosides, flavonoids, balsams, steroids, saponin glycosides, cardiac glycosides, and volatile oils. In contrast, the hexane extract indicated the presence of steroids, terpenoids, tannins, flavonoids, cardiac glycosides, and volatile oils. The differences in the phytochemical composition of the aqueous, methanol, and hexane extracts can be attributed to the polarity of the solvents used in the extraction process. Different solvents have varying abilities to dissolve specific phytochemicals based on their polarity. Water is a highly polar solvent, which makes it effective at extracting polar compounds such as tannins, saponins, alkaloids, glycosides, flavonoids, and cardiac glycosides. The findings suggest that these plants are rich sources of phytochemical compounds. Similar components were previously observed in the whole plant of *S. occidentalis* (Egharevba *et al.,* 2010). Egharevba *et al.* (2013) also reported the presence of carbohydrates, saponins, sterols, flavonoids, resins, alkaloids, terpenes, anthraquinones, glycosides, and balsams in *S. occidentalis*, as well as in the seeds, bark, and leaves of *Azadirachta indica* (Niyi, 2011; Padal *et al.,* 2013; Susmitha *et al.,* 2013; Abdulrazaq *et al.,* 2020).

Among the most significant phytochemical constituents found in these plants are alkaloids, tannins, flavonoids, anthraquinones, and phenolic compounds (Okwu, 2001). *S. siamea* was observed to contain alkaloids, anthraquinones, cardiac glycosides, flavonoids, phlobatannins, polyphenols, saponins, steroids, tannins, and terpenoids (Kendeson *et al.,* 2018). However, some studies, such as that by Bukar (2009), did not detect alkaloids, flavonoids, or resins in the aqueous leaf extract of *S. siamea*. This variation may be attributed to differences in the location and timing of plant collection.

Other studies, including those by Odeja *et al.* (2015), Ronan *et al.* (2009), and Sheeba *et al.* (2009), have also reported similar phytochemical compositions in *A. indica*, *S. occidentalis*, and *S. siamea*. These findings align with those of Tamasi *et al.* (2021), who identified terpenoids in *S. occidentalis*, and Oyun and Oyetayo (2020), who observed them in *A. indica*. However, they contradict the findings of Daskum *et al.* (2020), who reported the absence of terpenoids in hexane leaf extracts, which may be due to variations in plant collection sites and timing.

The presence of bioactive compounds in *S. siamea* indicates its medicinal potential, as each identified bioactive compound is known to have one or more therapeutic applications (Garba *et al.,* 2012).

The quantitative phytochemical screening of *S. siamea* leaf extracts revealed a significant presence of saponins, with the highest concentration found in the aqueous extract (9.90%), while the methanol extract contained a considerably lower amount (0.79%). Alkaloids were also present in notable quantities, with 6.47% in the aqueous extract and 1.06% in the methanol extract. Tannins were recorded at 4.55% in the aqueous extract, while the methanol and hexane extracts contained significantly lower amounts, at 0.51% and 0.23%, respectively. Glycosides were detected at 4.07% in the aqueous extract, 2.81% in the methanol extract, and only 0.50% in the hexane extract. Flavonoids showed a low concentration of 0.59% in the hexane extract, while the aqueous (3.13%) and methanol

(2.14%) extracts contained relatively higher amounts.

Terpenoids were present in significant amounts across all solvents, with methanol (2.50%), aqueous (2.46%), and hexane (2.40%) extracts displaying comparable concentrations. Anthraquinones were also observed, with the aqueous extract containing 1.39% and the methanol extract 1.42%. These variations in phytochemical content could be attributed to differences in the extractability of compounds with varying polarities.

These findings align with the study by Kwada and Tella (2009), which reported a phenol content of 17.49%, higher than that of alkaloids (0.06%), flavonoids (0.06%), and saponins (0.19%). Similarly, a study by Ekeke *et al.* (2019) using HPLC analysis identified 39 flavonoids, 46 alkaloids, 18 glucosides, and 45 phenolic compounds in varying amounts. Other supporting studies include those by Veerachari and Bopaiah (2013) and Mohammed *et al.* (2013).

However, these results contrast with those of Bukar (2009), who reported that alkaloids, flavonoids, and resins were absent in the aqueous leaf extract of *S. siamea*. This discrepancy may be attributed to differences in the plant's location and the timing of sample collection.

CONCLUSION

The study demonstrated that *S. siamea* leaf extracts contain diverse phytochemical compounds with varying concentrations depending on the extraction solvent. The aqueous extract yielded the highest percentage (29.61%) and was rich in polar compounds such as tannins, saponins, alkaloids, and glycosides, while methanol and hexane extracts also contained significant amounts of bioactive compounds, including terpenoids and flavonoids. These variations emphasize the influence of solvent polarity on phytochemical extraction.

Quantitative analysis further confirmed the presence of saponins, alkaloids, flavonoids, glycosides, tannins, and anthraquinones, with notable differences in their concentrations across solvent extracts. The results align with previous studies, highlighting *S. siamea* as a potential source of medicinally valuable bioactive compounds.

Overall, the findings reinforce the therapeutic potential of *S. siamea* and support its traditional medicinal applications. Future research should focus on isolating and characterizing the bioactive compounds, assessing their pharmacological properties, and evaluating their safety and efficacy for medicinal use.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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