PHYTOCHEMISTRY OF SELECTED GAMBIAN TRADITIONAL MEDICINAL PLANTS

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ABSTRACT

Traditional medicine has played a crucial role in the treatment and management of different human diseases since centuries ago in many African communities and traditions. Plants are a potent source of food and medicine in African communities. Malaria, diabetes, and parasitic diseases are common in Africa and cases can reach alarming levels occasionally. In this research, we studied the phytochemical constituents of popular plants in traditional medicine in The Gambia. The leaves of *Cassia tora* (Fabaceae), *Azadirachta indica* (Meliaceae) and *Vernonia amygdalina* (Asteraceae), the bark of *Khaya senegalensis* (Meliaceae), and roots of *Cassia sieberiana* (Fabaceae) respectively, were extracted by maceration in ethanol (90%). The samples (crude ethanol extract, n-hexane, and DCM fractions) were screened for phytochemical profile. The ethanol extract, n-hexane, and DCM fractions revealed Alkaloids, Saponins, Tannins, Phenol, Steroids, Flavonoids, Terpenoids, and Quinones. These phytochemicals are suggested to contribute to the efficacy of the plants in traditional medicinal application in The Gambia. It is hoped that the findings in this research will contribute to chemistry education through research on African medicinal plants and their healing properties. *[African Journal of Chemical Education—AJCE 13(1), January 2023]*

INTRODUCTION

Traditional medicine has existed since time immemorial to manage or treat various human ailments [1][2]. More than 60% of the world's population depends on plants for traditional or local treatment of infectious and inflammatory diseases [3]. Similarly, reports have indicated that traditional medicine is the first line of medication in many parts of Africa thus about 80% of the population sought traditional complementary medicine [4][5][6]. Disease prevalence is still a major problem in tropical and sub-tropical countries most especially malaria despite significant strides made in the past in malarial treatment and prevention[7][8][9]. Malaria is caused by infected mosquito bites which spread parasites through the human blood [10].

The Gambia is located in sub-Saharan Africa and the country is characterized by warm climatic conditions in several months of the year and a rainy season mostly from June to September annually [11]. The country is covered in part by forests with a variety of plant and animal species. An estimated 150 different plant species from a variety of plant families can be found in The Gambia [12]. As a result, plants are an important recipe in traditional medicine to treat diseases such as malaria, diarrhea, cough, and skin infections.

The West African Health Organization (WAHO) has identified *Ageratum conyzoides* L. (Asteraceae), *Cymbopogon citratus* (DC.) (Poaceae), *Sarcocephalus latifolius* (Rubiaceae), *Securidaca longepedunculata* Fres. (Polygalaceae), *Senna occidentalis* (L.) Link (Fabaceae) and *Senna podocarpa* (Fabaceae) as medicinal plants found in The Gambia and have been used in

traditional medicine to manage ailments [13]. The pharmacological properties and phytochemical constituents of these plants have been documented by WAHO. However, there are other plants used by traditional herbal medicinal practitioners in The Gambia and their secondary metabolite composition, chemical profile, and pharmacological effects are yet to be determined. *Cassia sieberiana* (Fabaceae), *Azadicrachta indica* (Meliaceae), *Vernonia amygdalina* (Asteraceae), *Khaya senegalensis* (Meliaceae), and *Cassia tora* (Fabaceae) are plants used in The Gambia for traditional and or local medicinal purposes [13].

Cassia sieberiania is known as West African laburnum and locally called "Sindian". It is a tropical deciduous woody shrub belonging to the Fabaceae family widely distributed in many parts of Africa [14]. The plant has significant therapeutic value. The root and stem bark formulation are effective against dysmenorrhea and gastric ulcer pain, leave infusion for stomach ache, ulcer, and diarrhea, and root powder for malarial treatment [15]. *Azadirachta indica* “Neem” is an evergreen tree of family Meliaceae cultivated in various parts of The Gambia. The leaves, fruits, flowers, and bark are attributed to anticancer, antihypertension, antidiabetic, antimalarial, and treatment of cardiac diseases [16]. *Vernonia amygdalina* “bitter leaf” is known for its bitter taste. Leaves of *V. amygdalina* are formulated and used in folkloric malarial treatment, cough, and dysentery. *Vernonia amygdalina* is a fast-growing plant with shrubs that extends to 2-3 m in height and leave growth is up to 20 cm [17]. *Khaya senegalensis* also called African mahogany, is a popular medicinal plant among the people of The Gambia. The stem bark is used in the treatment of malaria, headache, and

cough. Cassia tora on the other hand called “Jambanduro” is being used for food and medicinal purposes. Leave concoctions are an antidote for poison, normalizes cholesterol levels, and relieves hemorrhoids. The leaves are nerve tonic and a source of edible leafy food.

In this study, *Cassia sieberiana*, *Azadirachta indica* (Neem), *Vernonia amygdalina* (Bitter leaf), *Khaya senegalensis* (African mahogany), and *Cassia tora* plant parts were collected and extracted in ethanol by maceration. The extracts were fractionated in n-hexane and dichloromethane to isolate wide range of phytochemicals. The extracts and fractions were subjected to phytochemical screening. We report on the phytochemical profile of C. sieberiana, *A. indica, V. amygdalina, K. senegalensis* and *C. tora* and also suggest scientific bases for traditional medicinal uses of the plants in The Gambia.

EXPERIMENTAL

Materials

All chemicals and reagents used in this research are of analytical grade. They include ethanol, dichloromethane, n-hexane, methanol, and distilled water. The other chemicals used included chloroform, H_2SO_4, NaOH pallets, HCl, and anhydrous FeCl3. Standard solutions such as dilute NaOH, 5% and 10% ferric chloride, and Wagner's reagent (Iodine in Potassium Iodide) were prepared and used as required.

A set of glassware such as a distillation apparatus, Erlenmeyer flasks, test tubes, and beakers were also used.

Plant collection and preparation

The plant species (Figure 1) were collected at different locations in The Gambia in the month of January 2021. The leaves of Cassia tora, Azadirachta indica, and Vernonia amygdalina were collected from The Gambia College's experimental farm at Brikama Campus, West Coast Region (16° 49' 30" W). The bark of Khaya senegalensis and roots of Cassia sieberiana were collected from the Nyambai Forest in Brikama, West Coast Region (16° 49' 30" W). The collected plant parts were washed thoroughly with running water to remove sand and other particles attached. The leaves, root, and bark samples were air-dried under shade for three weeks. The dried samples were ground to fine powder using mortar and pestle. The powdered samples were placed in containers and stored at room temperature for extraction.

Figure 1. *Vernonia amygdalina* (A), *Khaya senegalensis* (B), *Cassia sieberiana* (C), *Cassia tora* (D), and *Azadicrachta indica* (E) Plants.

Extraction procedure

The extraction procedure followed a maceration method by [18] with modification. A 10 g of powdered plant samples were placed in beakers containing 100 mL of 90% ethanol (1:10 g/mL). The beakers were sealed with aluminum foil and allowed to stand for two weeks at room temperature in the laboratory to allow phytochemical extraction. After two weeks, the mixture was filtered using Whatman No. 1 filter paper placed in a separatory funnel to separate the ethanol extract from the residue.

The ethanol (90%) extract was further fractionated in n-hexane and DCM (solvents of increasing polarity). Fractionation was done by mixing the ethanol extract with n-hexane and DCM

respectively in a separatory funnel. The mixture was vigorously shaken intermittently, and phase separation was allowed to take place. The ethanol extract, n-hexane, and DCM fractions were then collected and evaporated by steam distillation. After evaporation, the ethanol extract, n-hexane, and DCM fractions were labelled and kept at room temperature. The same procedure was done for each of the plant samples. A total of five (5) ethanol extracts, five (5) n-hexane, and five (5) DCM fractions were subjected to phytochemical screening.

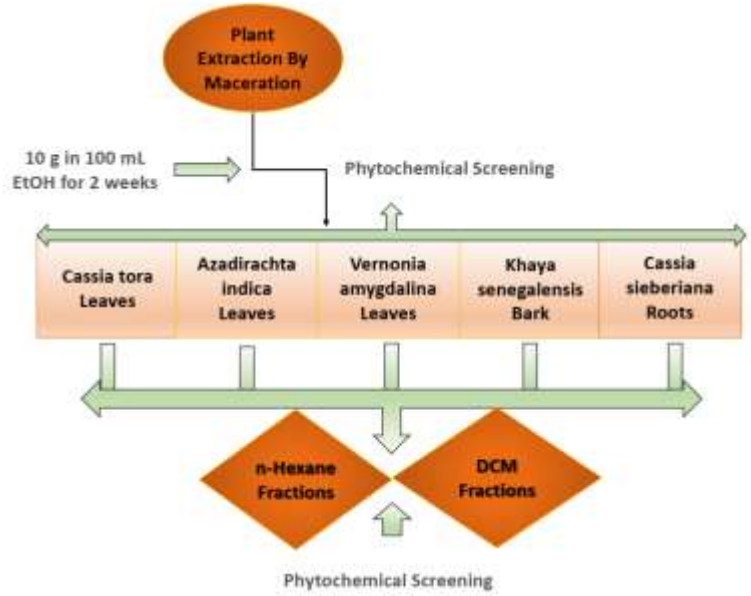

Figure 2. Plant Extraction Process

Phytochemical screening

The presence of eight (8) phytochemicals were determined in the ethanol leave extracts, n-hexane, and DCM fractions of *Cassia tora*, *Azadicrachta indica* and *Vernonia amygdalina* and bark and root extracts and fractions of *Khaya senegalensis* and *Cassia sieberiana* respectively. The

phytochemical screening for Alkaloids, Saponins, Tannins, Phenol, Steroids, Flavonoids, Terpenoids and Quinones was conducted as stated below using methods previously reported by [19].

Tannin Test

The extract was added to 1 ml of the prepared 5% $FeCl_3$ in a test tube. The formation of greenish precipitate was indicative of Tannin presence in the extract.

Saponin Test

The extract was mixed with 20 mL distilled water in a graduated cylinder. The mixture was vigorously shaken for about 5 mins. Foam formation showed the presence of Saponins in the extract.

Phenol Test

2 mL of distilled water was added to the extract. Few drops of the prepared 10% $FeCl_3$ were then added to the mixture. The formation of blue or green colour showed the presence of phenols in the extract.

Steroid Test

Few drops of the extract were mixed with 10 mL $CHCl_3$ in a test tube. 10 mL of concentrated H_2SO_4 was added dropwise to the side of the test tube. The formation of a red upper layer and a yellowish lower layer showed the presence of steroids in the extract.

Flavonoid Test

Few drops of dilute NaOH were added to the extract to form a yellow solution. The solution turned colourless with the gradual addition of dilute H_2SO_4. This showed Flavonoids were present in the extract.

Terpenoid Test

The extract was mixed with 2 mL of chloroform. The solution was then mixed with 3 mL of concentrated H_2SO_4 to form a ring layer. The formation of a red-brown precipitate shown Terpenoids was present.

Quinone Test

The extract was added to 1 mL of concentrated H_2SO_4 and the formation of a reddish colour showed Quinone presence in the extract.

Alkaloid Test

Extract with few drops of the Wagner's reagent (Iodine in Potassium Iodide). The formation of a reddish-brown precipitate showed Alkaloids were present.

RESULT AND DISCUSSION

Phytochemical screening of the ethanol, n-hexane, and dichloromethane root extracts of *Cassia sieberiana* (Table 1) revealed the presence of Saponins (**1**) in all solvent extracts. However, Steroids (**2**) were detected only in the DCM extract while Terpenoids (**3**) were detected in the ethanol

and DCM extracts. Tannins (**6**) and Phenols (**7**) were also detected in the ethanol and DCM extracts respectively. In contrast to a report by Macedo et al.[20] in which Flavonoids were detected in hydroethanolic (1:1) leave extract of Cassia sieberiana, we detect Flavonoids (**5**) in the n-hexane and DCM extracts alone. Therefore, ethanol/water solvent concentration might have influenced Flavonoid detection. Quinones (**4**) are also detected in the ethanol and DCM extracts. Alkaloids (**8**) are found in the ethanol extract only. It could be stated that Saponins, Quinones, Flavonoids, Alkaloids, and Terpenoids are present in *C.* sieberiana. Our results are in accordance with Ambadiang et al [21] and Manekeng et al. [22]. Ambadiang et al. isolated monobehenin, arachidic acid, *iso*-6-cassine, 3-O-methyl-chiro-inositol and sitosterol3-O-β-D-glucopyranoside from *C.* sieberiana and the plant extract showed significant antibacterial activity against *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* bacterial strains. This could be the reason for the efficacy of *C.* sieberiana in traditional medicine.

Table 1. Phytochemical Constituents of Root Extracts of *Cassia sieberiana*

Phytochemicals	**Ethanol Extract**	**n-Hexane Extract**	**DCM Extract**
Saponins	+++	+	++
Steroids	-	-	+++
Terpenoids	+++	-	+++
Quinones	+++	-	+++
Flavonoids	-	+++	++
Tannins	+++	-	+
Phenols	+++	-	+
Alkaloids	++	-	-

+++ = Highly detected, ++ = moderately detected, + = slightly detected, - = not detected

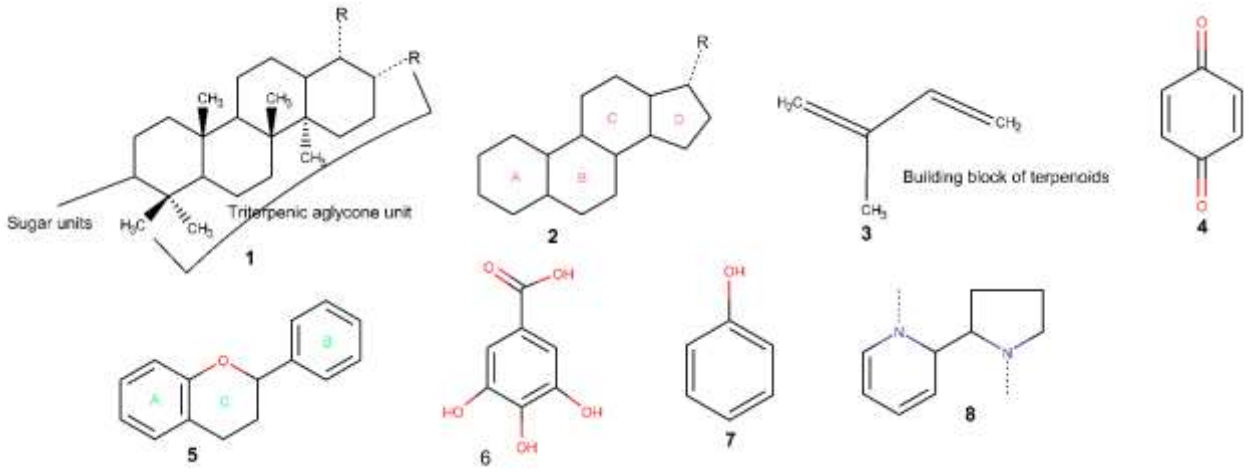

Figure 3. Structural Frameworks of Saponins (1), Steroids (2), Terpenoids (3), Quinones (4), Flavonoids (5), Tannins (6), Phenols (7), Alkaloids (8).

Table 2 shows the phytochemical constituents of bark extracts of *Khaya senegalensis*. Saponins, Steroids, Terpenoids, Quinones, Tannins, and Phenols are detected in the ethanol and n-hexane extracts while Flavonoids are absent. However, Flavonoids are found in the DCM extracts. *K*. senegalensis contains important phytochemicals. According to Dougnon et al.[23], the stem bark extract of *Khaya* senegalensis showed a strong minimum inhibitory concentration (25 mg/mL) against *Salmonella Typhimurium*, *Shigella spp.* and *Escherichia* coli disease-causing pathogenic strain growth. Kaur et al.[24] reported the antiplasmodial efficacy of *Khaya* senegalensis in which the ethanol bark extract showed moderate activity (IC_{50} 15-50 µg/mL) against P. falciparum. This could explain the folkloric use of the plant in malarial treatment.

Table 2. Phytochemical Constituents of Root Extracts of *Khaya senegalensis*

Phytochemical	Ethanol Extract	n-Hexane Extract	DCM Extract
Saponins	+++	++	+++
Steroids	++	+	+++
Terpenoids	+++	+++	+
Quinones	+++	+++	+++
Flavonoids	-	-	+
Tannins	+++	++	+++
Phenols	+++	++	+++
Alkaloids	+++	++	++

+++ = Highly detected, ++ = moderately detected, + = slightly detected, - = not detected

Phytochemical screening of leaf extracts of *Cassia tora* shows Tannins, Phenols, Quinones, and Alkaloids in all solvent extracts (Table 3). Saponins are absent in the DCM extract and Flavonoids are not detected in the ethanol extract. In a report by Aryal et al.[25], antioxidant evaluation of the plant extract by radical scavenging using DPPH showed a potency of 9.898 µg/mL. Antioxidant activity study of methanol leaf extracts of *C.* tora by Chethana et al.[26] showed IC_{50} between 86.48-215.62 µg/mL. The antioxidative property of the plant extracts might validate the therapeutic application of the plant in traditional medicine.

Table 3. Phytochemical Constituents of Leaves Extracts of *Cassia tora*

Phytochemical	Ethanol Extract	n-Hexane Extract	DCM Extract
Saponins	+++	++	-
Steroids	+++	++	++
Terpenoids	+++	+	+++
Quinones	+++	+++	++
Flavonoids	-	+	++
Tannins	+++	+++	+++
Phenols	+++	+++	++
Alkaloids	++	+	+++

+++ = Highly detected, ++ = moderately detected, + = slightly detected, - = not detected

In table 4, Steroids, Terpenoids, Quinones, Tannins, Phenols, and Alkaloids are detected in all solvent extracts of *Azadicrachta indica*. Flavonoids and Saponins are not detected in the ethanol and DCM extracts. However, the screened phytochemicals are observed to be present in Azadicrachta indica. Cen-Pacheco et al.[27] revealed from the bark extracts of *Azadicrachta* indica bioactive flavonoids 3-O-butyl-(-)-epicatechin and O-butyl-(-)-epigallocatechin. Another bioactive compound isolated from various plant parts of *Azadicrachta* indica is Azadirachtin. This compound is attributed to antimalarial, anticancer, and antifeedant activity according to Fernandes et al.[28].

Table 4. Phytochemical Constituents of Leave Extracts of *Azadicrachta indica*

Phytochemical	Ethanol Extract	n-Hexane Extract	DCM Extract
Saponins	++	+	-
Steroids	+++	++	+++
Terpenoids	+++	+	++
Quinones	+++	+++	+++
Flavonoids	-	+++	++
Tannins	+++	+++	+++
Phenols	+++	++	+
Alkaloids	+	+++	+

+++ = Highly detected, ++ = moderately detected, + = slightly detected, - = not detected

Finally, it is observed that Saponins, Steroids, Terpenoids, Quinones, Tannins, and Alkaloids are present in the extracts of *Vernonia amygdalina* except for Flavonoids which are detected in the n-hexane and DCM extract (Table 5). The anti-inflammatory, antimalarial, antioxidant, and antitumor properties of the plant have been determined in other investigations [29]. Unsurprisingly, “bitter leave” is popular among herbalists in many parts of West Africa including The Gambia [30].

The findings of this research suggest that more research should be carried out by African universities to document the traditional uses vis-à-vis the chemical profiling and therapeutic benefits of traditional medicinal plants used in the The Gambia and other African countries. Therefore, there is need for more funding in Chemistry education in The Gambia for effective research and innovation in traditional medicine.

Table 5. Phytochemical Constituents of Leave Extracts of *Vernonia* amygdalina

Phytochemical	Ethanol Extract	n-Hexane Extract	DCM Extract
Saponins	+++	++	+
Steroids	+++	++	+
Terpenoids	+++	++	++
Quinones	+++	+++	++
Flavonoids	-	++	+
Tannins	+++	+	+
Phenols	+++	++	+++
Alkaloids	+	+++	+

+++ = Highly detected, ++ = moderately detected, + = slightly detected, - = not detected

CONCLUSION

The leaves of Cassia tora, Azadirachta indica and Vernonia amygdalina, the bark of Khaya senegalensis and roots of Cassia sieberiana were collected from The Gambia College's experimental farm and Brikama Nyambai Forest, West Coast Region. The plant parts were extracted in ethanol (90%) for two weeks and the crude extracts were fractionated in n-hexane and dichloromethane. The crude ethanol extract and solvent fractions were subjected to phytochemical screening. Our investigation revealed that Saponins, Steroids, Terpenoids, Quinones, Flavonoids, Tannins, Phenols,

Alkaloids are major phytoconstituents of *Cassia sieberiana*, *Azadirachta indica* (Neem), *Vernonia amygdalina* (Bitter leaf), *Khaya senegalensis* (African mahogany), and *Cassia tora*. Literature have shown significant antioxidant, anti-inflammatory, antimalarial, and antibacterial activity of the studied plant extracts. Therefore, the traditional medicinal efficacy of *Cassia sieberiana*, *Azadirachta indica* (Neem), *Vernonia amygdalina* (Bitter leaf), *Khaya senegalensis* (African mahogany), and *Cassia tora* could be attributed to the presence of the detected phytochemical constituents. Chemistry education and research in traditional medicine could offer an alternative approach to health care delivery in The Gambia and Africa in general.

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