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Research Paper

Phytochemical and Proximate Studies of Leaf, Stem and Root of *Cassia mimosoides* L

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Abstract— *Cassia mimosoides* L. is an annual or a short-lived perennial herb or diffuse shrub, commonly known as Japanese tea or tea senna. Studies of ethnobotanical uses of this *Cassia* species, especially in Nigeria, are still few and far between. The sample extracts of the different parts of *C. mimosoides* were investigated for phytochemical and proximate composition using the standard laboratory procedures. The test of significance was measure using Duncan's Multiple Range Test (DMRT). There were presence of tannins, flavonoids, alkaloids, steroids, phenols, saponins, anthraquinone and cardiac glycosides; and absent of terpenes in this *Cassia* species parts. The leaf of this plant contained low concentrations of anthraquinone glycosides at 5.70±0.14%, flavonoids at 5.70±0.14% and tannins at 4.85±0.07%. Only alkaloids and saponins were present in the stem and root, and the values of these compounds were highly detected in all the parts. The highest percentage moisture content at 34.90±0.14, crude protein at 1.10±0.14 and crude fibre at 32.15±0.07 were found in the root, with the exception of ash and carbohydrate. Fat was absent in the stem and root. A wide range of therapeutic and nutritional compounds were found in *C. mimosoides* parts. Therefore, this study suggests that this species of *Cassia* is a good source of pharmacological active compounds and nutrients; hence, its pharmaceutical application in formulation of new drugs is encouraged, as well as its use in ethnobotany as healthy food and drug.

Keywords— Fabaceae, Plant-Based Chemicals, Alkaloids, Saponins, Cardiac Glycosides, Steroids, Crude Fibre

1. Introduction

Cassia mimosoides L. belongs to the genus, *Cassia*, a member of the family, Fabaceae (Leguminosae). *Cassia* and *Senna* are synonyms but *Senna* is predominantly used. There are 692 species of *Cassia* [1]. They are herbs or shrubs growing up to 1.7m high or diffuse; and the flowers are yellow [2]. Moreover, the species is a variable plant, locally common on sandy soil and is widespread in tropical Africa and Asia. The species possesses a pithy stem that is woody at the base and hairless or minutely hairy [3]. In addition, the common name of this plant is Japanese tea or tea senna.

The knowledge of the application of herbal drugs is an age long practice that has been handed down to us by our forefathers. Plants are resourcefully rich in ingredients that are utilised in formulation of drugs used in therapy [4]. Moreover, herbal drugs serve as traditional treatments of diseases in various parts of the world and their application rose in the past two decades. Medicinal plants play vital role in economy in the areas of pharmaceutical, perfume, food and cosmetic industries [5]. Traditional medicine is particularly the primary healthcare system in the developing countries. A wide array of the biological active ingredients is present in several parts of plant species, which, in turn, determines their medicinal properties. Hence, a surge in search of edible and medicinal plant species, in order to benefit largely from the bounty of nature God gave us. The plant-based chemicals are not nutritious but possess disease preventive and healing qualities. They do so in synergy with a range of nutrients present in plant-derived foods.

Cassia mimosoides is one of the plants that are used by traditional medicinal practitioners. In India, the root of *C. mimosoides* is used in treatment of diarrhoea and spasm of stomach [6]; the pulverised leaves are used for dressing wounds and sores [7]; mouth ulcers [8] and spasm of stomach and headache [9]. However, very few available literatures on the scientific medicinal investigation and documentation of this plant indicated that it is underutilised [6]. Hence, there is a dearth of information on the phytochemical and nutrient values of this species of *Cassia* as well as its ethnobotanical applications, especially in Nigeria. This therefore, presents this plant as one of the underutilised species of *Cassia*. As a result, the objectives of this study were to determine the phytochemical and proximate contents of *C. mimosoides* parts.

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2. Related Work

Presence of bioactive compounds and pharmacological activities of various *Cassia* species parts have been extensively reported. *Senna italic* Mill. aqueous and ethanolic leaf extracts contained alkaloids, favones, total phenols, tannins and quinone derivatives [10]. Arachidyl arachidate and luteolin were found in the pod aqueous, ethyl acetate, methanol and n-hexane extracts of *Cassia grandis* L.f. while β-sitosterol, stigmasterol, cinnamic acid, 4-hydroxycinnamic acid and hydroxymethylfural were detected in *C. timoriensis* DC flowers [11]. Methanol extract and purified fractions of *C. glauca* Lam leaves, showed antimicrobial, antioxidant and hemolytic actions [12]. Petroleum ether, chloroform and ethanol extracts of *C. glauca* L. leaf and stem showed antimicrobial activities against *Staphylococcus aureus, Enterococcus faecalis*, *Klebsiella, Escherichia coli*, *Aspergilus fumigata* and *Candida albicans* [13]. Anthroquinone, alkaloids, flavonoids, glycosides, reducing sugars, phenolics, proteins, tannins and sterols were detected in leaf, stem bark and root ethanolic and aqueous of *C. abbreviata* Oliv. [14]. Alkaloids, phenols and terpenoids from leaves of *C. didymobotrya* (Fresen.) Irwin & Barneby, exhibited antimicrobial activities against *Bacillus subtilis*, *S. aureus*, *Micrococcus leteus*, *Esherichia coli*, *Enterobacter aerogenes*, *A. niger* and *C. albicans* [15].

Moreover, *Cassia* species are useful in traditional treatment of various diseases in Nigeria [16]. *Cassia alata* L. is used for treatment of ringworm, eczema, malaria and sexually transmitted diseases. *Cassia angustifolia* Vahl. serves *as* a laxative. *Cassia occidentalis* L. is traditionally used for the treatment of guinea worm and stomach problems. *Cassia sieberiana* DC. is used for treatment of hernia. *Cassia tora* L. is used as a snake repellent. The leaves are also boiled and taken as an analgesic for the treatment of rheumatism and arthritis. It is clear from the literature data that *C. mimosoides* is a neglected species of *Cassia*. Therefore, there is great need to study *C. mimosoides* parts for presence of biologically important compounds, hence, this study.

3. Materials and Method

2.1 Sources of Materials

Leaves, stems and roots of *C. mimosoides* were collected in June, from Nnamdi Azikiwe University, Awka, Nigeria. The voucher specimen was authenticated and deposited in Department of Botany herbarium of the same institution.

2.2 Preparation of Plant Samples

The plant samples were dried under room temperature for five days and ground into coarse powder with the use of electric blender (Moulinex, France). Exactly 100g of each sample was weighed into Soxhlet extractor and extracted for 30 minutes using ethanol as extraction solvent. The extract was transferred into a 250 ml conical flask and stored in a refrigerator at 20^{o} C prior to analyses.

2.3. Qualitative Analysis of Phytochemical Constituents

The standard laboratory procedures for qualitative phytochemical determination of alkaloids, anthraquinone glycosides, cardiac glycosides, flavonoids, phenols, saponins, steroids, tannins and terpenes were conducted [17]. The negative sign '-' was used to denote the absence of phytochemicals.

2.3.1. Test for Tannins (Ferric Chloride Test)

A measured 2ml 5% ferric chloride ($FeCl_3$) solution was poured into 2ml of the plant extracts. A dark blue colouration indicated the presence of tannins.

2.3.2. Testfor Flavonoids

Exactly 4ml of the plant extract was measured out and 2ml of 50% methanol was added. The solution was warmed in a GFL water bath (1083; GFL) to 37^{o} C and a pinch of metal magnesium powder was added. Five drops of concentrated hydrochloric acid was added subsequently. Red colouration confirmed the presence of flavonoids.

2.3.3. Test for Phenols

A total of 5ml of the plant extract were poured into a test tube and three drops of diluted $FeCl_3$ solution were added. Phenols are present when a red colouration was formed.

2.3.4. Test for Alkaloids

A measured 5ml of the plant extract was poured into a test tube and the filtrate was carefully tested with Mayer's reagent (potassium mercuric). Formation of a yellow coloured precipitate pointed out that alkaloids are present.

2.3.5. Cardiac Glycosides (Keller-Killani Test)

Two drops of glacial acetic acid were added into 5ml of the plant extract. Moreover, there was addition of two drops of 10% $FeCl_3$ and concentrated tetraoxosulphate (vi) acid (H_2SO_4). Presence of cardiac glycosides was confirmed, when a reddish-brown colour appeared at the junction of the two liquid layers.

2.3.6. Anthraquinone Glycosides (Borntrager's Test)

Diluted sulphuric acid was poured into 5ml of the plant extract, brought to boiling and then filtered. Subsequently, the filtrate was allowed to cool and an equal volume of chloroform was added. Separation of the organic layer followed and then ammonia was added. The ammonia layer turned pink and signified the presence of anthraquinone glycosides.

2.3.7. Test for Saponins

Exactly 5ml of the plant extract was measured into a test tube; 2ml of distilled water was poured in and shaken energetically. The persistent froth volume or bubbles produced, demonstrated the presence of saponins.

2.3.8. Test for Steroids and Terpenes (Liebermann-Burchard Reaction)

A measured 2ml of acetic anhydride and three drops of concentrated sulphuric acid were poured into 5ml extract of the samples in a test tube. Presence of steroids was confirmed, when a blue-green ring appeared between the layers, whereas the appearance of pink-purple ring, showed the presence of terpenes.

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2.4. Quantitative Determinations of Phytochemical composition

2.4.1. Determination of Alkaloids

The alkaline precipitation gravimetric method of Harborne [17] was applied for alkaloid determination. Exactly 0.5g of each sample was scattered in 50ml 10% acetic acid solution in ethanol. The mixture was shaken and allowed to stand for 4h, then filtered. Evaporation of the filtrate to 1/4 of its original volume was carried out. Concentrated ammonium hydroxide (NH_4OH) was then added in drops, in order to precipitate the alkaloids. Filtration of the precipitate was done with a weighed filter paper, and then washed with 1% NH_4OH solution. The precipitate in filter paper was dried in the oven (Labtron Equipment Ltd.) at 60^o C for 30 min and then re-weighed. The weight of the alkaloids was determined by the weight difference and presented as a percentage of the sample weight.

2.4.2. Flavonoid Determination

The determination of flavonoids was performed using the gravimetric method described by Harborne [17]. A total of 50ml water and 2ml HCl solution were added into 5g of the powdered sample in a conical flask. The solution was boiled for 30 min, allowed to cool to 25^o C and subsequently filtered through a Whatman's filter paper [no. 42; Mettler-Toledo Instruments (Shanghai) Ltd.]. A measured 10ml ethyl acetate extract with presence of flavonoids was regained, whereas the aqueous layer was thrown away. The second (ethyl-acetate layer) was filtered with a pre-weighed Whatman's filter paper; the residue was then placed in an oven (Labtron Equipment Ltd.) to dry at 60^o C. The residue was weighed after being cooled in a dessicator (Bioevopeak Co., Ltd.). The flavonoid weight was determined by the weight difference and as a percentage of the sample weight.

2.4.3. Determination of Phenols

The determination of the phenol percentage in the sample was conducted with the methods of Harborne [18]. Exactly 2g of each sample was used and the absorbance of the extracts was measured using spectrophotometer (Bioevopeak Co., Ltd.) at 505nm wavelength.

2.4.4. Determination of Terpenoids

Terpenoid determination was conducted with the method outlined by Ferguson [19]. Exactly 10g of the sample granules was measured and immersed in alcohol for 24 h. After filtering the sample, the filtrate was extracted with petroleum ether and this ether extract was then recorded as the measure of the total terpenoids.

2.4.5. Determination of Saponins

Saponin determination was conducted using the method of Obadoni and Ochuko [20]. A measured 20g of each sample was placed into a conical flask and 100 cm^3 of 20% aqueous ethanol was added. Heating of the samples was done with continuous stirring, over a hot GFL water bath (1083; GFL) for 4 h at ~55^o C. Filtration of the mixture was also done and the residue was re-extracted with 200ml 20% ethanol. The combined extracts were boiled in a GFL water bath (1083; GFL) at ~90^o C in order to reduce the quantity to 40ml. The concentrate was poured into a 250ml separatory funnel and 20ml diethyl ether was added and energetically shaken. The aqueous layer was regained whereas the ether layer was poured away.

The purification process was done repeatedly, 60ml n-butanol was added and the combined n-butanol extracts were washed with 10ml 5% aqueous sodium chloride twice. The remaining solution was boiled in a GFL water bath (1083; GFL) for 30 min and then cooled in ice for 15 min. The saponin content was then calculated after the samples were dried in an oven (Labtron Equipment Ltd.) to a constant weight. The level of saponins was analysed by the difference and evaluated as a percentage of the original sample.

2.4.6. Determination of Anthraquinone Glycosides

This analysis adopted the extraction method of Sakulpanich and Gritsanapan [21] as modified by Khoomsab and Khoomsam [22]. The absorbance of the samples were read at 515nm in an UV-Vis spectrophotometer (Jenway 7305), and recorded accordingly.

2.4.7. Determination of Cardiac Glycosides

The quantitative evaluation of cardiac glucosides was done using the method described by Muhammad and Abubakar [23]. A measured 8ml of plant extract was poured into a 100ml volumetric, subsequently, addition and mixing of the 60ml of H_2O and 8ml of 12.5% lead acetate was done, followed by filtration. Exactly 50ml of the filtrate was poured into another 100ml flask and addition of 8ml of 47% Na_2HPO_4 was carried out, in order to precipitate the excess Pb^{2+} ion. This was further mixed and completed to the volume with water. In order to remove excess lead phosphate, filtration of the mixture was done twice through the same Whatman's filter paper [no. 4; Mettler-Toledo Instruments (Shanghai) Ltd.]. Exactly 10ml of the purified filtrate was poured into clean Erlyn – Meyer flask and treated with 10ml Baljet reagent. A total of 10ml distilled water and 10ml Baljet reagent were used for a blank titration. For complete colour development, this mixture was allowed to stand for 1 hr and the intensity of the colour was measured with a Colorimeter (Mettler-Toledo Instruments (Shanghai) Ltd.) at 495nm.

2.4.8. Determination of Steroids

Steroids were determined using the method of Okeke and Elekwa [24]. In 100ml freshly distilled water, 5g of the sample was dispersed and homogenised in a laboratory blender (8010 G, MRC). The homogenates were filtered and the filtrate was eluted with normal ammonium hydroxide solution (pH 9). Subsequently, 2 ml of the eluents were placed in test tubes and mixed with 2ml chloroform. An amount of 3ml ice-cold acetic anhydride was then poured into the mixture in the flask and two drops of concentrated sulfuric acid (H_2SO_4) were added carefully and preparation and treatment of standard sterol solution were conducted. The absorbance of the standard and prepared samples was measured with a spectrophotometer (Bioevopeak Co., Ltd.) at 420nm.

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2.4.9. Determination of Tannins

The level of tannins was evaluated using the Folin-Denis colorimetric method of Kirk and Sawyer [25]. Exactly 5g of the sample was sprayed in 50mls of distilled water and shaken. The mixture was filtered through a Whatman's filter paper [No. 42; -Toledo Instruments (Shanghai) Ltd.] after it was kept to stand for 30min at 28^{o} C. A total of 2 ml of the extract was scattered in a 50ml volumetric flask. Subsequently, 2ml standard tannin solution (tannic acid) and 2ml of distilled water were poured in separate volumetric flasks to serve as standard. Addition of reagent and 2.5ml of saturated Na_2C03 solution into each of the flask was done. The content of each flask was increased to 50mls with distilled water and incubation was allowed at 28^{o} C for 90 min. Their respective absorbance was measured at 260 nm using the reagent blank to calibrate the spectrophotometer (Bioevopeak Co., Ltd.) at zero.

2.5 Proximate Determination

The gravimetric and furnace incineration gravimetric methods respectively were used to evaluate the moisture and ash values of the samples as outlined by James [26]. In addition, the Weende, solvent extraction and Kjeldahl methods were used to determine the crude fibre, fat and crude protein contents respectively [26], while the carbohydrate content was calculated using the difference method, as the nitrogen free extractive (NFE) [24].

2.5.1. Moisture Content Determination

Thorough washing of the dishes was carried out, and subsequently dried in the oven (Labtron Equipment Ltd.). They were later placed inside a dessicator (Bioevopeak Co., Ltd.) for cooling and were then weighed. The weight of the samples was obtained by placing it in a weighed dish. The samples were subsequently dried in the oven (Labtron Equipment Ltd.) at 70^{o} C for 2 h and further at 105^{o} C for 4 h. They were cooled in the dessicator (Bioevopeak Co., Ltd.). Then the dry weight of the sample and the dish was obtained. The percentage moisture level was then computed by the difference of the weight of the sample.

2.5.2. Determination of Ash Content

A measured 5g of the sample was poured in a muffle furnace at 550^{o} C and burnt to ashes. It was later cooled in a dessiccator (Bioevopeak Co., Ltd.) and weighed, when it was completely burnt to ashes. The weight of the ash procured was calculated by the difference and recorded as the percentage of the weight of sample analysed.

2.5.3. Content Determination of Crude Protein

Exactly 2g of sample was poured into a 250ml beaker. Addition of 75ml hot water was done and subsequently boiled. The mixture was stirred energetically and 25ml 6% copper sulphate solution were added. Further boiling and vigorous stirring of the mixture was done and 25ml 1.25% sodium hydroxide solution were added. The mixture was vigorously stirred again, took away from the flame and allowed to settle. It was later filtered in a Whatman's filter paper [no. 4 Mettler-Toledo Instruments (Shanghai) Ltd.]. Cleaning off of the precipitate from the sides of the beaker was carried out and the sulphate was washed off from the paper 6 times with very hot water. The paper was allowed to drain properly, and then taken to a Kjeldahl flask (Labtron Equipment Ltd.) containing ~10g anhydrous sodium hydroxide and a trace of selenium. Subsequently, addition of exactly 30ml H_2SO_4 was done, the nitrogen content was estimated and thus, the crude protein content of the sample was then calculated.

2.5.4. Determination of Fat Content

This method is based on the guiding belief that non-polar components of the samples are easily extracted into organic solvents. Exactly 3g of each sample were placed into marked fat-free thimbles and weighed, plugged with glass wool and poured into Soxhlet extractors (Labtron Equipment Ltd.) containing 160ml petroleum ether with a boiling point of 75^{o} C. In addition, weighed clean dry receiver flasks were fitted to the extractors. Assembling of the extraction units was then done and circulation of cold water was allowed, while the temperature of the water bath was maintained at 60^{o} C. The extraction was conducted for 8 h, after which the removal of the thimbles containing the samples were done and placed in an oven (Labtron Equipment Ltd.), at 70^{o} C for 3 h and dried to constant weight. The level of fat was then determined by the difference and estimated as a percentage of the original sample.

2.5.5. Determination of Crude Fibre Content

The water reflux with 200ml of a solution comprising 1.25 g of H_2SO_4 per 100ml of solution was boiled for 30 min. Two folds of cheese cloth were used to filter the solution on a fluted funnel. The residue was thoroughly washed with boiling water and then placed in a beaker and boiled for 30 min with 200ml of a solution containing 1.25 g of carbonate-free Sodium hydroxide (NaOH) per 100ml. The final residue was filtered through a thin but closed pad of washed and ignited asbestos in a Gooch crucible (Bioevopeak Co., Ltd.). It was then weighed after drying in an electric oven (Labtron Equipment Ltd.). It was finally burnt, cooled and weighed again. The loss in weight after the incineration x100, therefore, was the percentage of crude fibre.

2.5.6. Carbohydrate Content Determination

The carbohydrate level was estimated using the difference method as calculated as follows: Percentage carbohydrate = 100 - (% moisture + % ash + % crude fibre + % crude protein + % fat).

2.6 Statistical Analysis

The statistical analysis was done using SPSS software version 21. The data obtained were subjected to one-way analysis of variance (ANOVA) and the test of significant was measured with Duncan's Multiple Range Test (DMRT). The data were expressed as mean ± standard deviation of triplicate determinations.

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4. Results and Discussion

Cassia mimosoides is an annual or a perennial erect, sometimes diffuse herb or low shrub (Figure 1).The result of qualitative and quantitative phytochemical investigations revealed that alkaloids, anthraquinone and cardiac glycosides, flavonoids, phenols, saponins, steroids and tannins were detected in the leaves with the exception of terpenes. Only saponins and alkaloids were present in the stem and root (Table 1). High percentages of alkaloids were found in this plant leaf at 15.65±0.07, stem at 15.20±0.14 and root at 17.00±0.14. This differs from findings of earlier studies, where the levels of alkaloids in plant parts were usually low and the greatest concentrations were mainly detected in the leaves. This was evident in the alkaloid percentages in parts of *Stachytarpheta angustifolia* (Mill.) Vahl. (leaf at 2.79±0.31, stem at 1.15±0.2 and root at 0.80±0.18) [27]; *S. cayannensis* (L.C. Rich.) Schau (leaf at 3.46±0.02 and stem at 2.36±0.00) *and S. indica* (L.) Vahl. (leaf at 2.81±0.03 and stem at 1.94±0.02) [28]; *Mimosa invisa* Mart. (leaf at 5.77±2.55, stem at 3.63±2.05 and root at 0.71±0.02) and *M. pudica* L. (leaf at 6.32±0.71, stem at 3.79±1.06 and root at 0.76±0.02) [29], and *Boerhavia diffusa* L. (leaf at 1.79±0.01, stem at 1.53±0.01 and root at 1.31±0.01) and *B. erecta* L. (leaf at 1.86±0.00, stem at 1.64±0.00 and root at 1.24±0.01 [30]. Alkaloids provide important pharmacological activities for the human therapeutic arsenal, such as anti tumoral drugs, stimulants, analgesics, anti-inflammatory and antioxidant compound [31].

Moreover, *C. mimosoides* seems to possess spiritual powers. Some South African diviners (Sotho, Tsonga and Zulu) regard *C. mimosoides* as a dream-inducing plant that is thought to produce 'true visions' that evoke instinctive powers that usually emerge only while sleeping [32]. This ethnobotanical application of this *Cassia* species is presumably due to the hallucinogenic, muscle relaxant, sedative and stimulating activities of plant-derived alkaloids. The levels of saponins followed a pattern that stem>leaf>root. They occurred in the levels of 45.85±0.07%, 23.40±0.14% and 13.65±0.07% respectively. Saponins reduce blood fatty acids, cancer, and blood glucose reaction [33].

Considerable high value of cardiac glycosides at 19.15±0.07% was present in the leaf. Cardiac glycosides are associated with the regulation of several important cellular processes by hindering the modes of action of Na^+/K^+-ATPase [34]. In addition, *C. mimosoides* leaf possesses anti-ulcer potential [35] that could be as a result of the antimicrobial and gastro-protective abilities of flavonoids, as well as the wound healing potential of tannins. Moreover, *C. mimosoides* fresh leaf is used to treat paediatric cough in Uganda [36] and typhoid fever in southern Benin [37]. These pharmaceutical utilisations of *C. mimosoides* are most likely caused by the analgesic and sedative properties of alkaloids as well as the antimicrobial activity of flavonoids, tannins and phenols. Furthermore, anthraquinone glycosides at 5.70±0.14%, flavonoids at 4.65±0.07% and tannins at 4.85±0.07% were present in low quantities; indicating that the leaves of this species synthesise and accumulate them in low concentrations. In an earlier work, both ethanolic and aqueous leaf extracts of *C. mimosoides* had antimicrobial activity against *Escherichia coli*, *Salmonella* spp and *Shigella* spp [38]. This suggests that the *C. mimosoides* leaf possesses an antidiarrhoeal effect. The usefulness of this plant leaves in Africa is presumptively due to the presence of majority of the phytochemicals in them. Moreover, the roots are used for treatment of diarrhoea, colic and spasms for stomach, dysentery and the whole plant is used as a remedy for eruption in the faeces [39]. This could be attributed to the antimicrobial property of high percentages of alkaloids at 17.00±0.14 and saponins at 13.65±0.07 present in the root of this plant. Some plants exhibit antidiarrhoeal quality through their antimicrobial activity [40].

Anthraquinone glycosides were only present in the leaves. This disagrees with a claim, where the root of *C. mimosoides* was reported to contain a physcion, an anthraquinone derivative [41],[42]. Anthraquinones provide a wide array of health benefits including inhibition of cancer growth by inducing apoptosis [43],[44] and relieving constipation [45],[46]. However, over consumption of anthraquinones may lead to a number of health issues. The low level of anthraquinones in the leaves of this plant and its absence in the stem and root, therefore, denote that the consumption of *C. mimosoides* leaves, stems and roots is safe. Presence of anthraquinones was also detected in *Cassia siamea* Lam. (cassod tree) leaves and *Cassia fistula* L. (golden shower) pods [22]. In addition, the low concentration of flavonoids found in the leaves could exert some pharmacological actions. Moreover, levels of phenols and steroids at 11.10±0.14% and 11.85±0.07% respectively occurred in a closer range in the leaf. The presence of steroids in the ethanol leaf extract of this plant disagrees with earlier findings, where steroids were absent in the methanol leaf extract of *C. mimosoides* [47]. In another previous work, steroids were also absent in the leaf of *Dissotis rotundifolia* (Sm.) Triana [48]. Moreover, relatively lesser percentages of alkaloids, cardiac glycosides and saponins at 4.85±0.49, 5.65±0.44 and 3.45±1.48 respectively were detected in the *D. rotundifolia* leaf, in contrast to the higher levels present in *C. mimosoides* leaf. Flavonoids, saponins, steroids [49] and tannins have antioxidant potentials, hence, may affect anti-inflammatory mechanisms. Flavonoids may affect anti-inflammatory mechanisms due to their ability to inhibit reactive oxygen or nitrogen compounds [50].The leaf is the most useful part of *C. mimosoides* because the majority of the phytochemicals investigated were detected in it.

In the proximate investigation, the levels of nutrients were highest in the root with the exception of ash, carbohydrate and fat (Table 2). The presence of highest moisture content in the root at 34.90±0.14% indicated that maximal level of water occurs in the root of *C. mimosoides*. Highest ash content was detected in the leaf at 66.95±0.07%, followed by the stem at 60.10±0.14%; while the least was found in the root at 25.25±0.07%. Ash represents the mineral values of plant parts; hence, the highest levels of minerals are most likely present in the leaves. The minerals help in boosting the immunity of the human body and also aid in general body

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maintenance. The highest percentage of protein was found in the root at 1.10±0.14. Fat was only present in the leaves in low amount (3.65±0.07%). This implied that fat is not synthesised in the stem and root of this plant. Aqueous extracts of *C. mimosoides* young leaves and stem are taken as tea in Japan [39],[51]. This application is most likely as a result of the health-giving constituents of this *C. mimosoides* part. Therefore, *C. mimosoides* is edible and nutritious; hence, the leaf could be used as vegetable.

Figure 1. Habit of *C. mimosoides*

Table 1. Phytochemical composition of *C. mimosoides* leaf, stem and root

Composition (%)	**Leaf**	**Stem**	**Root**	***P-value***
Alkaloids	15.65±0.07^{b}	15.20±0.14^{a}	17.00±0.14^{c}	0.001
Anthraquinone glycosides	5.70±0.14	_	_	
Cardiac glycosides	19.15±0.07	_	_	
Flavonoids	4.65±0.07	_	_	
Phenols	11.10±0.14	_	_	
Saponins	23.40±0.14^{b}	45.85±0.07^{c}	13.65±0.07^{a}	0.000
Steroids	11.85±0.07	_	_	
Tannins	4.85±0.07	_	_	
Terpenes	_	_	_	

Values are mean+Standard Deviation. Means with different letters in a row are significantly different (p>0.05).

Table 2. Proximate composition of *C. mimosoides* leaf, stem and root

Composition %	**Leaf**	**Stem**	**Root**
Moisture content	7.10±0.14^{a}	9.25±0.70^{b}	34.90±0.14^{c}
Ash	66.95±0.07^{c}	60.10±0.14^{b}	25.25±0.07^{a}
Crude protein	0.90±0.14^{b}	0.19±0.07^{a}	1.10±0.14^{b}
Crude fibre	1.70±0.14^{a}	2.90±0.14^{b}	32.15±0.07^{c}
Carbohydrate	19.65±0.07^{b}	27.55±0.07^{c}	5.45±0.07^{a}
Fat	3.65±0.07	_	_

Results are mean+Standard Deviation. Means with the same letters are not significantly different (p>0.05).

5. Conclusion and Future Scope

The findings of this work revealed that a lot of safe health-promoting phytochemicals and nutrients are available in the leaf of *C. mimosoides*, hence, presenting it as the most useful part of this plant. In addition, the leaf, stem and root of this species could be regarded as excellent sources of alkaloids and saponins. Therefore, *C. mimosoides* leaves could be used ethnobotanically as food and drugs, as well as in pharmaceutical development of novel drugs.

Moreover, the phytocompounds contained in the leaf, stem and root of *C. mimosoides* presumably possess antimicrobial property against the causative agents of cough, typhoid fever, ulcer and diarrhoea; hence, further research is recommended in this area.

Conflict of Interest

Authors declare that there was no any conflict of interest.

Authors' Contributions

Chinelo A. Ezeabara wrote the first draft of the manuscript, did the literature search and conceived the study. She was also involved in experimental research and data analysis. Linda N. Umeka and Wisdom C. Anyanele were involved in experimental research and data analysis. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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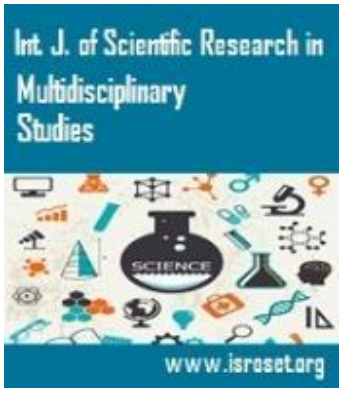

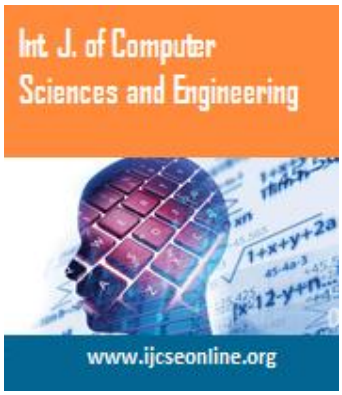

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