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Comparative Chemical Constituents of some *Cassia* Species and their Pharmacognistic Importance in South Eastern Nigeria

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Abstract: An assessment and investigation into three species of *Cassia* namely *Cassia alata* Linn., *Cassia occidentalis* Linn. and *Cassia sieberiana* DC. belonging to the family of Fabaceae (subfamily Caesalpinoideae) was carried out with the aim of identifying and quantifying the bioactive components of these ornamental shrubs. The alkaloid, flavonoid, saponin, steroid, phenol and tannin contents of the vegetative and reproductive parts of these plants viz. the leaves, stems, roots and pods were screened and compared. All the plant parts investigated contained appreciable amount of alkaloids, flavonoids and saponins ranging from (1.24 ± 0.06% - 4.06 ± 0.51%), (1.18 ± 0.0% - 2.68 ± 0%) and (2.20 ± 0.03% - 4.28 ± 0%) respectively. Tannin contents on the plant parts were equally high (1.12 ± 0.01% - 1.54 ± 0.01%), while the phenol contents ranged from (0.13 ± 0% - 0.36 ± 0%) respectively. These analytical results suggest the plants have a significant role in phyto-medicine. The importance of these plants was discussed in line with the role they play in ethno-medicinal life of the people.

Keywords: *Cassia* Species, Phytochemical Constituents, Medicinal Properties

1. Introduction

The genus "*Cassia*" is a member of the Fabaceae family (Leguminosae family) in the major group angiosperms (flowering plants). The Fabaceae or Leguminosae, commonly known as the legume, pea or bean family, is a large and economic important family of flowering plants. Plants of this family are found throughout the world, growing in many different environments and climates (Stevens, 200l).The plants range in habit from giant trees to small annual herbs, with the majority being herbaceous perennials. The plants have indeterminate inflorescences, which are sometimes reduced to a single flower. The flowers have a short hypanthium and a single carpel with a short gynophore, and after fertilization produce fruits that are legumes (Schrire *et al*., 2005). The leaves are usually alternate compound, and are even - or odd-pinnately compound. The name "Cassia" means "Cinnamon-like bark". In addition, the genus *Cassia* was for long ill-delimited with regards to the related Cassiinae - especially *Senna* (which has many medicinal important species). (Frodin, 2004).

The medicinal value of these plants lies on some chemical substances that produces a definite physiological effect of these substances are, alkaloids, flavonoids, glycosides, tannin oils, phenols and many others (Omaye, 2004). According to Kapur and Atal (1982), there is need that the local herbs be evaluated for phytochemistry so as to determine the potential of indigenous sources of medicines.Many plants in this genus are used extensively in traditional medicine in tropical and warm subs tropical countries (Robber and Speedie, 1996). It is believed to possess a laxative effect. Its extract is reported to be beneficial in treating many skin diseases like eczema, rashes, ringworm etc, the seeds are roasted and boiled in water to produce tea as folk medicine (Perry, 1980). These plants have also been reported to treat constipation, common cold, fevers, intestinal disorders and in healing of wounds (Burkill, 1995).

The importance of medicinal plants has been elucidated by Edeoga *et al*. (2003, 2005) and their importance in the pharmaceutical industry. These medicinal plants have been underutilized in orthodox medicine but have confirmed to be used worldwide in the pharmaceutical, food, cosmetics and perfume industries (Robber and Speedie, 1996).

Alkaloids are very important in medicine and constitute most of the valuable drugs. They have marked physiological effect on animals (Edeoga and Eriata, 2001) and show considerable pharmaceutical activity (Davis and Heywood, 1963). Alkaloids are stimulants acts and by prolonging actions of several hormones which require phosphodiestrerase (Chukwu, 2000) though are poisonous to cattle (Holm *et al*., 1997).

Tannins are useful in medicine because of their astringent properties. Tannins and Alkaloids are known to have anti-herbivore defense functions in plants (Harborne, 1988). Thus, the presence of tannins and alkaloids in medicinal plants could be serving as a deterrent to grazers (Edeoga and Eriata, 2001). Herbs that contain tannins are recommended for a wide range of treatments including inflammation, liver injury, kidney problems, arteriosclerosis, hypertension, stomach problems and inhibition of active oxygen and are commonly recommended as diuretics, anti-diarrheas and haemostatic (Zhu *et al*., 1997)

Saponins are glycosides widely occurring in a variety of plants and are characterized by their bitter taste and foaming in aqueous solution. They prevent disease invasion of plants by parasitic fungi (Igile *et al*., 1994). Steroidal saponins from various studies indicate their importance and the interest in pharmacy due to their relationship with such compounds such as sex hormones especially in development of the female contraceptive pills (Okwu, 2003). In medicine, it is used to some extent as an expectorant and emulsifying agent (Edeoga and Ikem, 2001).

Flavonoids are the commonest phenolic constituents having 15-compounds generally distributed throughout the plants kingdom (Harborne, 1988). Some flavonoids have antibacterial function with gram-positive species more sensitive to isoflavanones, than their negative counterpart. Flavours are related to flavonoids and they promote particular tastes to prepared foods. The presence of flavonoids in plants have shown some effects like antibacterial, antiviral, antitoxin, antioxidant, anti-inflammatory anti-carcinogenic activities (Huang and Ferraro, 1992). Isoflavanones, isoflavans, isoflavonones are extremely fungal pathogens (Dakoro, 1995). They act as allelochemicals widely used in insecticides and in treatment certain physiological disorders and disease control.

Phenols are synthesized via the shikimic acids pathway. Phenolic compounds are known to have anti-fungal and anti-microbial effects. Phenolic compounds believe to be active ingredients in the herbicide found up as well as some other commercial herbicide formulation (Heyde, 1990).

The acceptance of traditional medicine as an alternative form of health care hassled researchers to further investigate the antimicrobial and other health benefits of these medicinal plants. Medicinal plants are the richest bio-resources of drugs of traditional systems of medicine, modern medicine, nutraceuticals, food supplements, folk medicines, pharmaceutical intermediates and chemical entities for synthetic drugs. Extracting the relatively complex mixtures of metabolites is achieved by using selective solvents. During extraction, solvents diffuse into the solid plant material and solubilize compounds with similar polarity (Afolayan *et al*., 2008).

2. Materials and Methods

2.1. Collection of Plant Materials

Mature plants of the three species, *C. alata*, *C. occidentalis* and *C. sieberiana* were collected from different locations of South Eastern Nigeria by various investigators as in Table 1. Only healthy, fresh and succulent parts of the plants were collected. The three specimens were identified and authenticated at the Herbarium of the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike. Herbarium specimens were also studied at the various institutions as well making reference to the Flora of West Tropical Africa by Hutchinson and Dalziel (1963).

Table 1. *Collection sites of the three Cassia species studied.*

Species	Sites of collection
Cassia alata	The Botanical Garden, Abia State Polytechnic, Aba, Abia State.
Cassia occidentalis	Forestry Research Department, M.O.U.A,Umudike, Umuahia, Abia State.
Cassia sieberiana	Science Village, Nnamdi Azikiwe University, Awka, Anambra State.

Table 2. *Ethnobotanical uses of the studied Cassia species around the world.*

Species	Location	Ailment & Treatment/ Properties and Action
Cassia alata	Asia	Laxative properties, Constipation, Intestinal worm expeller, Eczema, Ringworm.
	Congo Brazzaville	Child delivery, Cough, Mouthwash, Stomatitis, Bronchitis, Expectorant, Astringent properties, Fungicide properties.
	India	Expectorant in bronchitis and dyspnoea.
	China	Diuresis, Sudorific.
	South America	Tympanites for poisonous bites, Stomach pain, Dysentery, Hemorrhoids, Schistomiasis, Gonorrhea, Convulsion, Heart failure, Oedema, Jaundice, Headache, Hernia, Paralysis.
	Cote d'Ivoire	Liver problems, Urticaria rhinitis, Loss of appetite.
Sources: Ajose, 2005; Arbonnier, 2004; Elujoba *et al*., 1989; Gill, 1992; Idu *et al*., 2006; Palanichamy and Nagaraj, 1990; Ross, 2003.		
Species	**Location**	**Ailment & Treatment/ Properties and Action**
Cassia occidentalis	Panama	Stomach-ache, Dyspepsia, Flatulence, Constipation.
	India	Dyspepsia, Flatulence, Constipation, Hic-cough, Hepatitis, Liver cirrhosis, Whooping cough, Diuresis.
	Peru and Brazil	Fortify liver,Diuresis.
	Benin Republic	Hepatitis, Jaundice, Fever, Cough, Asthma.
	Suriname	Sore-throat, Cold, Flu, Asthma, Diuresis, Hypertension.
	Garbon& Guinea	Diuresis
	Congo	Ease of child delivery.
	Senegal	Female fertility.
Sources: Neuwinger, 1996; Panda, 2004; Warrier, 1994.		
Species	**Location**	**Ailment & Treatment/ Properties and Action**
Cassia sieberiana	Senegal	Purgative, Diuresis, Malaria, Stomach ache, Ulcer, Diarrhea, Gonorrhea.
	Uganda	Toothache, Skin diseases, Diarrhoea, Dysentery, Vomiting.
	Cote d'Ivoire	Intestinal worm expeller, Venereal diseases, Sterility, Dysmenorrhea, Aphrodisia, Fish poison.
	Burkina Faso	Malaria, Laxative.
	Benin Republic	Sleeping sickness, Hemorrhoids, Bilharzia, Leprosy, Dropsy, Blood dysentery.
Sources: Arbonnier, 2004; Brenan, 1967; Burkill, 1995; Neuwinger, 2000.		

2.2. Preparation and Analysis

The plant materials were air-dried and milled into uniform powder using Thomas-Willey milling machine. The aqueous extract of each sample was determined by soaking 50g of dried powdered sample in 10ml of distilled water for 12hours. The mixtures were filtered using Whatman filter paper and excess water removed by concentration by boiling the extract to 100^0C for 10 minutes.

2.3. Phytochemical Determination

2.3.1. QualitativeDetermination of the Chemical Constituents

Freshly prepared ground samples are chemically tested for the presence of chemical constituents using standard procedures (Trease and Evans, 1989). Water or ethanol extracts are commonly used.

(i). Test for Alkaloids

One mL of extract of the sample was shaken with 5.0ml of 2% HCl on a steam bath and filtered. To 1.0mL of the filtrate was treated with Wagner's Reagent (Iodine in Potassium-Iodine solution) and observed for reddish brown precipitate.

(ii). Test for Tannins

To 1.0mL of extract was added an equal volume of bromine water. The formation of a greenish to red precipitate was taken as evidence for presence of condensed tannins.

(iii). Test for Flavonoids

To 1.0mL of extract 1.0ml of 10% lead acetate was added. The formation of yellow precipitate is taken precipitate for flavonoids.

(iv). Test for Saponins

One mL of extract was boiled with 5.0ml of distilled water for 5 minutes and decanted while still hot. The filtrate is used for the test. 1.0ml of the filtrate was diluted with 4.0ml of distilled water, shaken vigorously and observed on standing for stable froth.

(v). Test for Phenols

To 1.0mL of extract was added 1.0ml of 10% ferric chloride. The formation of a greenish-brown or black precipitate or colour is taken as positive for phenolic nucleus.

2.3.2. Quantitative Determination of the Chemical Constituents

(i). Alkaloid Determination

5g of the sample were weighed into a 250mL beaker and 200mL of 20% acetic acid in ethanol was added and covered to stand for 4 hours. This was filtered and the extract was concentrated using a water-bath to one quarter of the original volume. Concentrated ammonium hydroxide was added drop wise to the extract until the preparation was complete. The whole solution was allowed to settle and the precipitate was collected by filtration and weighed (Harborne, 1973; Obadoni and Ochuko, 2001).

(ii). Tannin Determination

500 mg of the sample was weighed into 100 mL plastic bottle. 50 mL of distilled water was shaken for one hour in a mechanical shaker. This was filtered into a 50 mL volumetric flask and made up to the mark. Then 5 mL of the filtrate was pipette out into a tube and mixed with 3 mL of 0.1M $FeCl_3$ in 0.1N HCl and 0.008M potassium ferrocyanide. The absorbance was measured in a spectrophotometer at 120nm wavelengths, within 10 minutes. A blank sample was prepared and the colour also developed and read at the same wavelength. A standard was prepared using tannin acid to get 100 ppm and measured (Van-Burden and Robinson, 1981).

(iii). Flavonoid Determination

100g of the plant sample were extracted repeatedly with 100 mL of 80% aqueous methanol at room temperature. The whole solution was filtered through Whatman filter paper No. 42 (125mm). The filtrate was later transferred into a crucible and evaporated to dryness over a water bath and weighed (Boham and Kocipai, 1994).

(iv). Saponin Determination

The samples were ground. 20g of each plant samples were dispersed in 200 mL of 20% ethanol. The suspension was heated over a hot water bath for 4 hours with continuous stirring at about 55^0C. The mixture was filtered and the residue re-extracted with another 200 mL of 20% ethanol. The combined extracts were reduced to 40 mL over water bath at about 90^0C. The concentrate was transferred into a 250 mL separator funnel and 20 mL of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. 60 mL of n-butanol was added. The combined n-butanol extracts were washed twice with 10 mL of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation, the samples were dried in the oven to a constant weight. The saponin content was calculated in percentage (Harborne, 1973).

(v). Phenol Determination

For the extraction of the phenolic component, the fat free sample was boiled with 50 mL of ether for 15 minutes. 5 mL of the extract was pipette into a 50 mL flask, and then 10 mL of distilled water was added, 2 mL of ammonium hydroxide solution and 5 mL of the extract was pipette into a 50 mL flask, and then 10 mL of distilled water was added, 2 mL of ammonium hydroxide solution and 5 mL of concentration amyl alcohol were also added. The samples were left to react for 30 minutes for colour development. The absorbance of the solution was read using a spectrophotometer at 505 nm wavelengths (Harborne, 1973; Obadoni and Ochuko, 2001).

3. Result

The qualitative analysis of the crude chemical constituents in the *Cassia* species studied is summarized in Table 3. Alkaloids were very highly present in the leaves of *C. alata*, *C. occidentalis* and *C. sieberiana*. They were also found to be highly present in the stems, roots and pods of all the investigated species, expect for the pods of *C. alata* , which was very highly present as compared to the leaves.

The leaves, stems, roots and pods of all the investigated species concurrently have tannins highly present in them and saponins very highly present as well. This will go a long way to prove that investigated species are a rich source of saponins, being the most abundant in all the phytochemicals evaluated.

However, flavonoids were very highly present in the stems and roots of *C. alata* and pods of *C. occidentalis* but highly present in the remaining parts of the investigated species as well as in the leaves, stems, roots and pods of *C. sieberiana*.

Results of the phenols show clearly that phenols were concurrently fairly present in the leaves, stems, roots and pods of the studied *Cassia* species. This reveals that phenols are the least abundant among the phytochemicals investigated.

Table 3. *Qualitative analysis of the crude chemical constituents in the studied Cassia species.*

Taxa		Alkaloids	Tannins	Flavonoids	Saponins	Phenols
	Leaf	+ + +	+ +	+ +	+ + +	+
C. alata	Stem	+ +	+ +	+ + +	+ + +	+
	Root	+ +	+ +	+ +	+ + +	+
	Pod	+ + +	+ +	+ + +	+ + +	+
	Leaf	+ + +	+ +	+ +	+ + +	+
C. occidentalis	Stem	+ +	+ +	+ +	+ + +	+
	Root	+ +	+ +	+ +	+ + +	+
	Pod	+ +		+ + +	+ + +	+
	Leaf	+ + +	+ +	+ +	+ + +	+
C. sieberiana	Stem	+ +	+ +	+ +	+ + +	+
	Root	+ +	+ +	+ +	+ + +	+
	Pod	+ +	+ +	+ +	+ + +	+

(2.00% - ~ = Very highly present; 1.00 – 1.99% = Highly present; 0.01 – 0.99% = Fairly present)

KEY

+ + + = Very highly present

+ + = Highly present

+ = Fairly present

The quantitative estimation of the percentage crude chemical constituents in *Cassia* species studied is summarized in Table 4 and Chart 1-5. From the present investigation, all the vegetative and reproductive parts of the studied species were very rich in alkaloids, tannins, flavonoids and saponins in general except for phenols that were fairly abundant. The leaves of *C. alata* ranked the highest percentage of crude alkaloids (4.06±0.51%), tannins (1.54±0.01%), flavonoids (1.48±0.14%), saponins (4.28±0.01%) and phenols (0.36±0.00%) when compared to the leaves of *C. occidentalis* and *C. sieberiana*.

The stems of the *Cassia* species contained appreciable amount of the crude chemical constituents, which indicatedthat the stem parts of these investigated species are also anabundant source of phytochemicals. Form this result in general; the stems of *C. alata* also recorded the highest percentage of crude alkaloids (1.46±0.00%), tannins (1.23±00%), flavonoids (2.49±0.00%), saponins (2.36±0.03%) and phenols (0.19±0.00) when compared to other investigated species respectively.

The roots of the studied *Cassia* species also recorded notable amounts of the crude chemicals. Comparing the roots of the studied species, *C. alata* once again contained the highest percentage of crude alkaloids (1.62±0.03%), tannins (1.22±0.0%), flavonoids (1.90±0.03%), saponins (2.73±0.01%) and phenols (0.25±0.0%). From the investigation, it revealed that the leaves, stems and roots of *C. alata* are very abundant in all phytochemicals investigated.

The pods of these investigated species recorded relatively higher amounts of phytochemicals when compared to the stems and roots of the plants. This indicates that the reproductive structures of these species are also a rich source of crude chemical constituents. From the overall result, the pods of *C. alata* lead in ranking the highest crude alkaloids (2.70±0.03%), flavonoids (2.68±0.00%), saponins (3.94±0.04%) and phenols (0.28±0.00%) while the pods of *C. occidentalis* contained the highest amount of tannin (1.35±0.00%) respectively.

In general, the plants produced high yield alkaloids ranging from (1.24 ± 0.06% - 4.06 ± 0.51%), tannins (1.12 ± 0.01% - 1.54 ± 0%), flavonoids (1.18 ± 0.0% - 2.68 ± 0%) and saponins (2.20 ± 0.03% - 4.28 ± 0.01%). This could explain why they are recommended for a wide range of treatments.

Table 4. *Percentage of the investigated crude phytochemical constituents in the studied Cassia species on dry weight basis.*

Taxa		Alkaloids (%)	Tannins (%)	Flavonoids (%)	Saponins(%)	Phenols (%)
C. alata	Leaf	4.06±0.51	1.54±0.01	1.48±0.14	4.28±0.01	0.36±0.00
	Stem	1.46±0.00	1.23±0.00	2.49±0.10	2.36±0.03	0.19±0.00
	Root	1.62±0.03	1.45±0.01	1.90±0.03	2.73±0.01	0.25±0.00
	Pod	2.70±0.03	1.36±0.00	2.68±0.00	3.94±0.04	0.28±0.00
C. occidentalis	Leaf	3.50±0.03	1.38±0.00	1.24±0.03	4.17±0.01	0.30±0.00
	Stem	1.38±0.03	1.17±0.00	1.83±0.01	2.32±0.03	0.13±0.00
	Root	1.45±0.04	1.29±0.00	1.30±0.03	2.48±0.00	0.19±0.00
	Pod	1.31±0.05	1.48±0.00	2.51±0.01	3.79±0.01	0.25±0.00
C.sieberiana	Leaf	3.01±0.04	1.28±0.00	1.18±0.00	3.39±0.01	0.29±0.01
	Stem	1.44±0.00	1.12±0.01	1.74±0.00	2.20±0.03	0.15±0.00
	Root	1.24±0.06	1.35±0.00	1.24±0.06	2.62±0.03	0.19±0.00
	Pod	1.85±0.01	1.34±0.00	1.85±0.10	3.66±0.00	0.25±0.00

Results are mean of five determination dry weight basis ± standard deviation

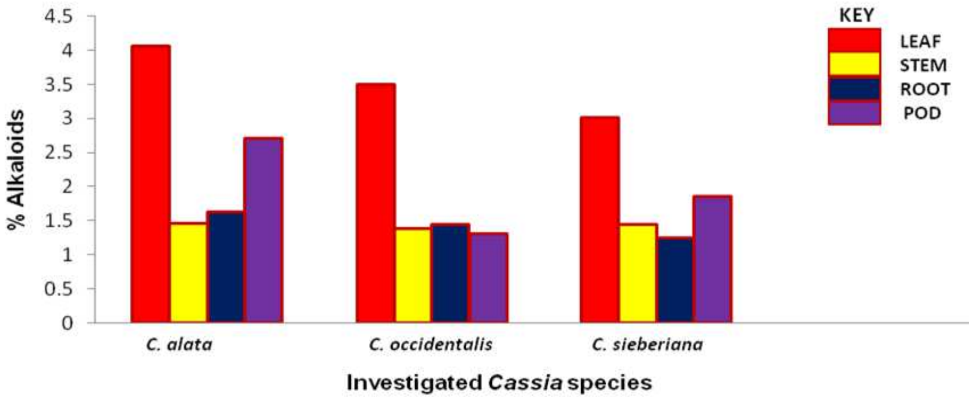

Chart 1. *Percentage alkaloids of the screened Cassia species.*

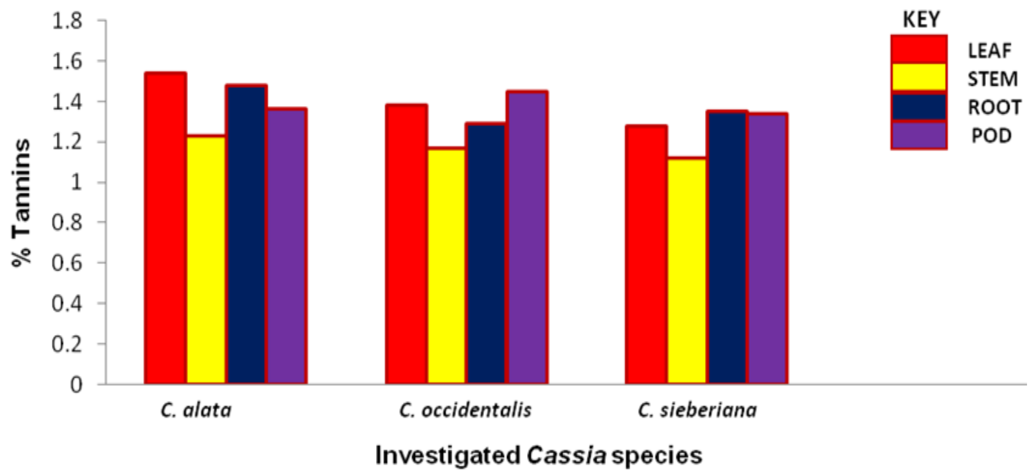

Chart 2. *Percentage tannins of the screened Cassia species.*

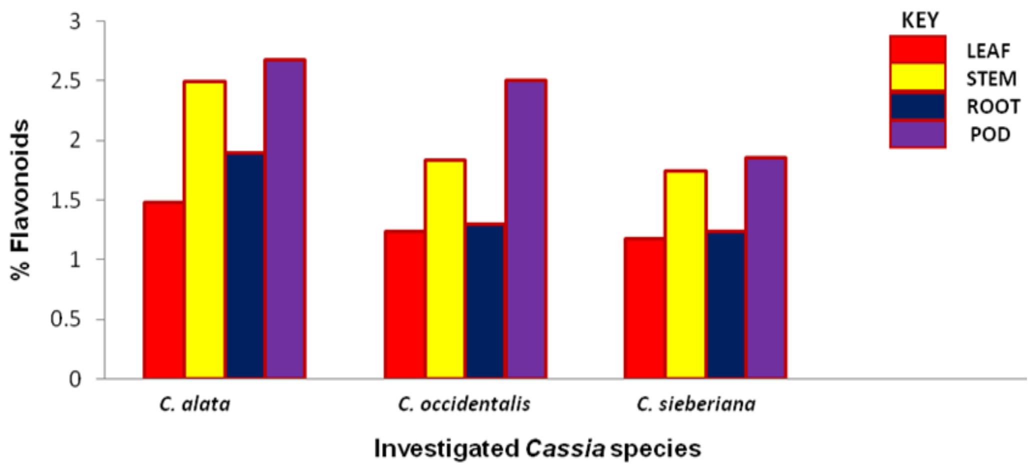

Chart 3. *Percentage flavonoids of the screened Cassia species.*

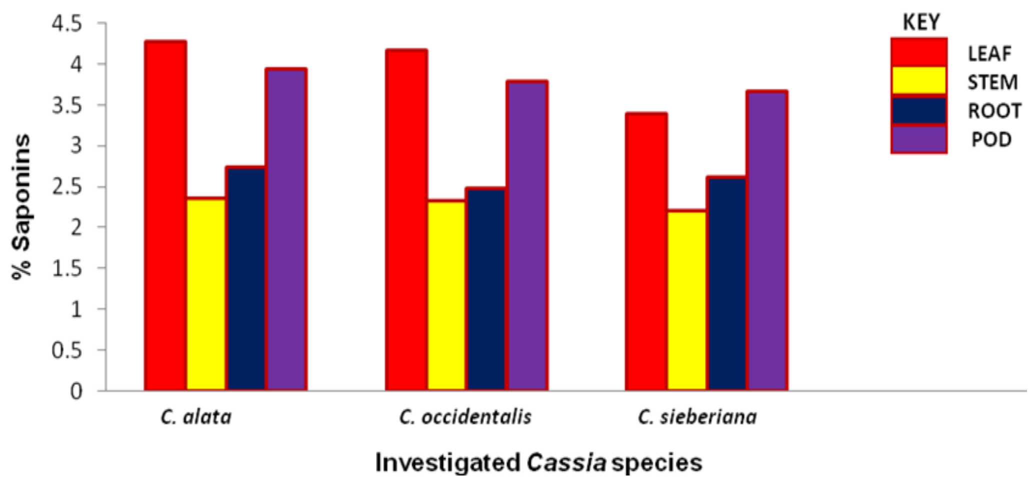

Chart 4. *Percentage saponins of the screened Cassia species.*

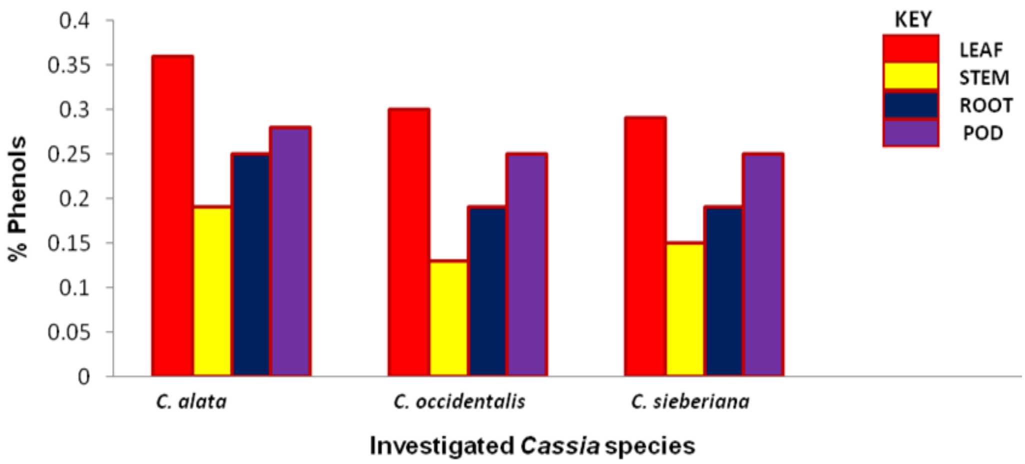

Chart 5. *Percentage phenols of the screened Cassia species.*

4. Discussion

The presence or occurrence of bioactive ingredients and the quantitative estimation of the chemical constituents of the *Cassia* species studied therefore showed that the vegetative and reproductive parts were rich in alkaloids, flavonoids, saponins and tannins, but little amount of phenols were screened from them, especially in their stem and roots. These biologically active chemical substances known as secondary metabolites in medicinal plants form the foundations of modern prescription drugs (Sofowora, 1993). *Cassia* species of medicinal importance have been used effectively and extensively in folk medicine for their good therapeutic value (Abo *et al*., 1999; Elujoba *et al*., 1989). The presence of these chemical substances in the vegetative and reproductive parts of the three *Cassia* species studied provides scientific explanations of the long use, recommendations and activities as antimicrobial, antioxidant, antiplasmodic, anti-hormonal, anti-protozoan etc (Sofowora, 1993).

The leaves of *C. alata* had the highest percentage of alkaloids (4.06%) seconded by the leaves of *C. occidentalis* (3.30%) and then followed by the leaves of *C. siebariana* (3.01%). Alkaloids have been known to have a powerful effect on properties and animal physiology and are used in medicine especially the steroidal alkaloids and also show considerable pharmacological activity (Edeoga and Eriata, 2001). This explains the reason why boiled roots of *C. sieberiana* are used to treat dropsy and hemorrhoids in Benin Republic (Burkill, 1995). Most of the known functions of alkaloids are related to protection and anti-herbivore defense. In addition, presence of alkaloids in the plants prevents insects and chordates from eating it (Holm *et al*., 1997). Pure isolated plant alkaloids and their synthetic derivatives are known for their anti-arrhylthmic, anti-cholinergic, anti-tumor, stimulant and sympathomimetric effects (Okwu, 2005).This may be the reason why the leaf decoction of *C. alata* are used in herbal medicine as expectorant in bronchitis and dyspnoea in India, sudorific in China, treatment of hernia, paralysis, headache and convulsion in South America and as an expectorant for cough in Congo Brazzaville, (Idu *et al*., 2006; Ross, 2003). It may also explain why the infusions of the leaves of *C. occidentalis* are extensively used in the treatment ofsore throat, cold and flu in Suriname, whooping cough, asthma and hypertension in India, Benin Republic and Suriname respectively (Panda, 2004; Neuwinger, 1996). Furthermore, the aphrodisiac, analgesic and antiprotozoal effects of alkaloids may be the reason why the twigs of *C. siberiana* are used as aphrodisia in Cote d'Ivoire and in the treatment of toothache, sleeping sickness and malaria in Uganda, Benin Republic and Senegal respectively (Arbonnier, 2004).

The leaves of *C. alata* recorded the highest percentage of tannins (1.54%) followed by the pods of *C. occidentalis* (1.48%). Tannins are known to be organic substances of diverse composition with astringent properties that promote the healing of wounds and inflamed mucous membranes (Frantisek, 1998; Okwu, 2004). The presence of tannin in the leaves of *C. alata* may be the reason why tea made from them are taken as laxatives and also used in the treatment of constipation and intestinal worms in China (Elujoba *et al*., 1989). Moreover the astringent properties of the leaves and flowers of *C. alata* can be attributed to the presence of tannins and also the reason they are used as tympanites for poisonous bites and stomach pain in South America (Palanichany and Nagaraj, 1990). Tannins and alkaloids have been documented to show anti-herbivore defense function in plant (Stevens *et al*., 1995) and this could explain why the leaves of the studied *Cassia* species are hardly grazed by herbivores. The presence of hydrolysable tannins (Vijayalakshmi *et al*., 2013) in *C. occidentalis* and explains why tea madefrom its fresh leaves are recommended for the treatment of gastrointestinal complaints like stomachache, dyspepsia, flatulence and constipation in Panama and India (Warrier, 1994). Similarly, this may also be the reason why the entire parts of *C. siberiana* are used as purgatives in Burkina Faso and in the treatment of stomachache and ulcer in Senegal (Arbonnier, 2004). High levels of tannins in diet have been reported to cause growth suppression. Tannins also have the potential to complex divalent ions such as zinc, iron and copper etc resulting in their unavailability (Okwu, 2004) and have been also reported to form complexes with digestive enzymes thus reducing the digestibility of proteins in foods (Amelio, 1999).

The pods of *C. alata* recorded the highest percentage of flavonoids (2.68%) followed by the pods of *C. occidentalis* (2.51%).Although flavonoids are present in reasonable amount in all theinvestigated parts of these *Cassia* species, the pods and stems are very popular because they have high flavonoid contents. Also, the abundance of flavonoids in the pods over other parts may as well prove the fact that the reproductive parts of plants are a richer source of flavonoids than the vegetative parts because flavonoidsare the pigments found in virtually all plants and are responsible for many of the plant colors that dazzle us with their brilliant shades of yellow, orange, and red in flowers, fruits and seeds (Harborne, 1988). Flavors are related to flavonoids and they promote particular taste to prepared food. This could explain the reason why *C. alata* is used to avert loss of appetite caused by gastro-intestinal problems (Arbonnier, 2004). Flavonoids are known to perform various functions such as anti-oxidant, anti-allergic, anti-viral, anti-carcinogenic, anti-microbial, cardiovascular and hepatoprotective abilities (O'Neil *et al*., 2000). The appreciable flavonoid contents of *C. alata* is significant enough and therefore supports the pharmacological implications shown by the plant especially in the treatment eczema, ringworm, urticara and rhinitis in Asia and Cote d'Ivoire, and also in the treatment of dysentery, schistomiasis, gonorrhea, heart failure and jaundice in South America (Arbonnier, 2004; Palanichamy and Nagaraj, 1990). Also, the influence of flavonoids can explain the reason why *C. occidentalis* is considered hepatoprotective and used to treat various stages of hepatitis, liver cirrhosis and various stages of liver failure in India and the roots also used to treat and fortify the liver in Peru and Brazil (Neuwinger, 1996; Warrier, 1994). Furthermore, the presence of flavonoids in *C. siberiana* plays a role in its leaves, roots and pods being used in traditional medicine. In Uganda, this may be the reason why the powder of different parts of the plant is mixed with butter to treat skin diseases and an infusion of the root employed against venereal diseases, diarrhea, dysentery and vomiting (Brenan, 1967). This may also account for its effective usage in Benin Republic where the roots are also boiled in water and used to treat bilharzia, leprosy, blood dysentery and gonorrhea (Burkill, 1995). Flavonoids may act as metal chelators in the cells and selectively reduce or kill cancer cells with high influx of ion (May, 1982). Likewise, *Cassia* teas containing flavonoids may have health promoting properties.

In all three *Cassia* species screened, all the plant parts exhibited a high percentage of saponins. The leaves of *C. alata* recorded the highest percentage of saponins (4.28%) followed by the leaves of *C. occidentalis* (4.17%). Saponins are often referred to as "natural detergent" because of their foamy nature and they have anti-carcinogenic properties, immune modulation activities and regulation of cell proliferation as well as health benefits such as inhibition of the growth of cancer cell and cholesterol lowering activity (Jimoh and Oladji, 2005).This can explain the reason why the leaf and flower decoction of *C. alata* is used as mouthwash in stomatitis in Congo Brazzaville (Idu *et al*., 2006). Saponins serve as natural antibiotics, which helps the body fight infections and microbial invasion (Okwu, 2005). Saponins have been recorded to prevent disease invasion of plants by parasitic fungi and has shown to affect urine, plasma, fecal output and liver cholesterol concentration (Haedi, 1964).This may be attributed to the fact why the entire parts of *C. alata*, *C. occidentalis* and *C. siberiana* are commonly used extensively as diuretics in China, India, Peru, Brazil, Suriname, Garbon, Guinea, Senegal and almost all parts of the world these *Cassia* species are found because of their high contents of saponins (Arbonnier, 2004; Neuwinger, 1996; Panda, 2004; Ross, 2003; Warrier, 1994).The high percentage of saponins in the leaves of the *C. sieberiana* can be attributed why it is an ingredient of a medicine for intestinal worms in Cote d'Ivoire due to the bitter tasting principles associated with saponins (Arbonnier, 2004). Most saponins which readily dissolve in water are poisonous to fish (Titjari, 1989). Also, the presence of saponins may be the reason why the roots and seeds of *C. sieberiana* are used as a fish poison in Cote d'Ivoire (Neuwinger, 2000). The roots and stems are pulverized and mixed in water to create foam which is then poured to the stream to kill or incapacitate the fishes (Neuwinger, 2000). Occurrence of steroidal saponins from various studies indicates their importance and the interest in pharmacy due to their relationship with such compounds such as sex hormones especially in development of the female contraceptive pills (Okwu, 2003). This may be the reason be why boiled leaves of *C. alata* and *C. occidentalis* are taken in Congo Brazzaville to hasten and ease child delivery (Gill, 1992; Neuwinger, 1996). Also, the presence of saponins may be the reason why the decoction of the roots *C. occidentalis* and *C. siberiana* are widely used in Africa in the treatment of women's problems including improving female fertility in Senegal (Neuwinger, 1996) and treating sterility and dysmenorrhea (Neuwinger, 2000) since steroidal structures could serve as potent starting material in the synthesis of these hormones. Saponins are known to make bronchial secretion more liquid, reduce the congestion of the bronchi and acute the congestion of the bronchi and acute coughing (Okwu, 2005). This may be attributed to the fact why the decoction of the leaves of *C. alata* is used for cough and as expectorant in bronchitis and asthma (Esimone, 2008). Other characteristics of saponins include haemolytic activity, cholesterol binding properties and bitterness (Houghton *et al*., 1996).

Cassia species in general have low phenolic contents when compared to other phytochemicals. The leaves of *C. alata* not only contained the highest alkaloids, tannins and saponins it also contained the highest percentage of phenols compared to other plants, having 0.36% followed by the leaves of *C. occidentalis* (0.30%) respectively. The presence of phenolic compound in the plant proves that they have anti microbial and anti fungal effect (Huang and Ferraro, 1992). According to Ajose (2005) the fungicide properties of *C. alata* may be associated with presence of phenols. The leaves contain a fungicide, chrysophanic acid which is a common ingredient in soap and shampoos and lotions. Chrysaphanol is a form of phenolics (Ajose, 2005). Also, plants that contain phenols could be used as anti inflammatory, immune enhancers and hormone modulators (Okwu and Omodamiro, 2005). Phenols are also known to have the ability to block specific enzymes that cause inflammation and to prevent disease (Okwu, 2004). Phenolic compounds are well known potential phytotoxins and exist as free forms, esters or as glycoside when combined with sugars. Such compounds contribute to the bitter taste, flavours and colour of foods (Manar *et al*., 2006).

5. Conclusion

Current research on herbals has shown that medicinal plants have a potential in today's synthetic era, as numbers of medicines are becoming resistant. The present research on the phytochemicals present in *Cassia* species studied has not only revealed the medicinal potential of these plants as employed by indigenous people but also their attempt to phytochemically characterize some medicinal plants commonly used in traditional medicine among Nigerians and other parts of globe. However, further studies should be carried out to elucidate the anti- microbial activities of these *Cassia* species to affirm the claims by traditional healers of the effectiveness of these plants in treating diseases. The various *Cassia* species studied have been revealed as rich source of phytochemical bases found to be therapeutically active and physiologically important. With this, researchers in medicinal plants will find these plants as potential sources of useful drugs.

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