Phytochemical and Antimicrobial Assessments of Leaf, Stem and Root of *Ipomoea involucrata* (P. Beauv)

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Abstract
Ipomoea involucrata (P. Beauv) is an annual or perennial vigorous twining herb. Phytochemical determination and in vitro antimicrobial activity of the plant leaf, stem and root extracts were investigated against some human pathogens using standard techniques. Duncan's Multiple Range Test (DMRT) was used to measure the significance of any differences. Highest concentrations of flavonoids, saponins, tannins and terpenoids (2.78±0.03, 1.78±0.00, 1.35±0.01 and 2.31±0.01 mg/100g respectively) were found in the leaf, while the highest alkaloid content was detected in the root (2.32±0.028 mg/100g). The inhibitory activities of the leaf, stem and root extracts increased with increasing concentration. The leaf extract showed the highest inhibitory activity against Aspergillus niger, Penicillum chrysogenum and the entire test bacteria except Klebsiella pneumoniae while the root extract showed the highest inhibition of K. pneumoniae, Rhizopus stolonifer and Fusarium oxysporum. Phytochemicals present in different parts of I. involucrata showed both antibacterial and antifungal activities, hence, suggesting its pharmaceutical potential.

Keywords: Alkaloids, Flavonoids, Terpenoids, *Klebsiella pneumonia*, *Penicillum chrysogenum*, Zone of inhibition.

Introduction

Ipomoea involucrata (P. Beauv) belongs to the family *Convolvulaceae*. Akobundu and Agyakwa[1] documented the description of this plant. It is an annual or perennial twiner with hairy stems rooting at nodes. It is reproduced from both seeds and stock. The stem is slender, rather tough, with short soft or long hairs and it either trials or climbs on other plants. The leaves are alternate, ovate, 7 cm long and 5 cm wide, heart-shaped at the base, blunt to acuminate-mucronate at the apex, hairy and with entire margins. The petiole is 2-5 cm long. The inflorescence is an axillary cyme on a long peduncle, 10-12 cm long. The buds are packed in the involucre and the flowers open one after the other. The flowers are purplish, trumpet-shaped and are subtended by a large, boat-shaped, long and hairy involucre.

The genus *Ipomoea* occurs in the tropics of the world although some species also reach temperate zones.[2] *Ipomoea involucrata* is very common throughout tropical Africa.[3] In Nigeria, it is commonly found in both Northern and Southern regions. It is also widely distributed throughout Ghana, tropical West Africa, Tanzania, East tropical Africa, Zimbabwe, South Tropical Africa and northern South Africa.[4]

Ipomoea involucrata has a wide variety of ethnobotanical uses in West Africa. Burkill[5] stated some of its traditional uses. In Gabon, it is considered as a good talisman for fecundity so that pregnant women sometimes wear a liane around the waist. In Congo, a length of stem is sometimes tied around baby loins to promote walking. In Guinea, the Lele cook and eat the leaves as spinach with rice or with fonio (*Digitaria exilis*). In Sierra Leone, a decoction of the fresh sap is taken as a remedy for gonorrhoea. The leaves are used in Nigeria for asthma. In Congo, leaf-sap is applied and rubbed into areas of localized oedema and is instilled into the eyes for filarial infection; an aqueous decoction is taken by women at childbirth to hasten expulsion of the after-birth. In Ivory Coast, its preparation is added to baths or made into a lotion for treating jaundice. Moreover, Okafor[6] reported that the whole plant parts are used in treatment of convulsion in Nigeria. In Ghana, the stems and leaves are used for treating anaemia cases by local herbalists.[7]

Quality of medicinal plants as an antimicrobial agent is based on the ability and degree with which their phytochemical constituents restrain the growth of pathogens. Microorganisms including bacteria, fungi, protozoa and viruses are considered pathogenic when they reach a population size that is large enough to cause disease. Moreover, most synthetic drugs that are supposed to fight germs have lost their potency because human pathogens have developed immunity against them.

On the other hand, traditional medicine that had an age long existence had started gaining credence over the last decade. This is because plant-based drugs are considered to be effective, relatively inexpensive and easily available. In addition, they have negligible or no side effects. The efficacy of the phytochemicals is either individually or synergistically. Hence, current research efforts are focused on finding alternative drugs from plant sources.

The objectives of this study, therefore, were to screen and compare the phytochemical composition of *I. involucrata* leaf, stem and root extracts, as well as to investigate the antibacterial and antifungal activities of the plant parts extracts against some human pathogens.

Material and Methods

Collection and preparation of plant sample: Mature *I. involucrata* was collected from an abandoned farmland near

Department of Botany laboratory at Nnamdi Azikiwe University, Awka in the month of May. The plant was identified and authenticated by Dr C.A. Ezeabara, a plant taxonomist in Department of Botany Nnamdi Azikiwe University, Awka, Nigeria.

The leaf, stem and root were cut into pieces with a knife and then oven-dried (Model DX1032CXs, USA) at a temperature of 65 ^{o}C for 12 hours. The samples were ground in a mortar with a pestle and then in a blender (Panasonic, Model Mx-Gx1521w, China) into powdered form and stored in an airtight container prior to analyses.

Extraction of plant material: The methanol extracts of the plant were prepared by soaking the respective powdered samples of the leaf, stem and root in 100ml of methanol. The concentrations of the extracts were determined by adding 50g, 75g, 100g and 150g in 100ml of methanol. The whole set up was left for 24 hours at room temperature and thereafter filtered using Whatmann filter paper. The extract was then concentrated to 50ml of the extract and stored in an airtight container in a refrigerator at 40 ^{o}C prior to analyses.

Qualitative phytochemical analysis: Qualitative tests were conducted to determine the presence of alkaloids, anthraquinones, flavonoids, phenols, sterols, saponins, tannins and terpenoids with the methods outlined by Ezeabara and Okonkwo.[8]

Quantitative phytochemical analysis: Alkaloids, flavonoids and saponins were determined using the alkaline precipitation gravimetric method, gravimetric method and double extraction gravimetric method respectively.[9] Phenols were determined using the Folin-Ciocaltean colorimetric method.[10] Tannin content of the samples was determined using the Folin-Dennis colorimetric method described by Kirk and Sawyer.[11] Anthraquinones were determined by spectrophotometric method as described by Ezeabara and Egwuoba[12]. Total terpenoid level was determined by the method outlined by Ferguson.[13] Determination of sterol content was done by the method described by Harborne.[9]

Determination of antimicrobial activity

Test organisms: The bacterial strains used were the gram-positive: *Staphylococcuss aureus and Streptococcus pneumoniae* and the gram-negative: *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhi* and *Shigella sonnei*. The test fungi were *Aspergillus niger*, *Fusarium oxysporum*, *Penicillium chrysogenum* and *Rhizopus stolonifer*.

Sources of test organism: The pure cultures of the microorganisms were collected from the Department of Pathology, National Root Crop Research Institute, Umudike, Abia State, Nigeria.

Antimicrobial susceptibility testing: The sensitivity test of the plant extract was assessed using agar well diffusion method as described by the International Commission on Microbiological Specifications for Foods.[14] Both bacteria and fungi pathogens were first grown in nutritional bath before use and later sub-cultured in Mueller-Hinton Agar (Oxoid Ltd).

Thirty-eight grams (38 g) of the medium was suspended in 1litre of distilled water. The medium was entirely dissolved by heating with constant stirring and later boiled for 1 minute. The mixture was autoclaved at 121 ^{o}C for 15 minutes and cooled at room temperature. The cooled Mueller-Hinton agar was then poured into sterile Petri dishes on a level laboratory bench and a uniform depth of 4 mm was obtained. The Petri dishes were left to solidify at room temperature. The final pH of the prepared Mueller-Hinton agar was checked to ensure it was 7.3 ± 1 at 25 ^{o}C.

A sterile 6 mm cork borer was then used to bore wells in the agar medium. The wells were filled up with the solution of the extract and care was taken not to spill the solution on surface of the medium. The plates were allowed to stand on the laboratory bench for 2 hours to allow proper influx of the solution into the medium. Afterwards, they were incubated at 37 ^{o}C for 24 hours. The plates were later observed for the zones of inhibition. The effects of the extract on bacteria and fungi pathogens were compared with those of the standard antibiotic used at a concentration of 100 mg/ml. Ampicillin was used for bacteria while fungabacter was used for fungi.

Statistical analysis: The experimental design adopted for the study was completely randomized design. Analysis of Variance (ANOVA) using SPSS version 21 was used to analyse the data. Test of significance was measured using Duncan's Multiple Range Test (DMRT). The data were then expressed as mean ± standard deviation of triplicate evaluations.

Results

Alkaloids, anthraquinones, flavonoids, phenols, saponins, sterols, tannins and terpenoids were detected in parts of *I. involucrata* (Table 1). The levels of flavonoids ranged from 1.45±0.04 mg/100g in the stem to 2.78±0.03 mg/100g in the leaf. Saponin content varied from 1.08±0.02 mg/100g present in the root to 1.78±0.00 mg/100g in the leaf. Highest quantity of alkaloids was found in the root (2.32±0.03 mg/100g) while the least was detected in the stem (0.53±0.01 mg/100g). Phenol contents ranged from 0.25±0.00 mg/100g in the stem to 0.46±0.00 mg/100g in the root. Concentration of sterols ranged from 0.18±0.00 mg/100g in the root to 0.42±0.00 mg/100g in the leaf. Highest level of anthraquinones was present in the root (1.23±0.00 mg/100g) while the least was detected in the leaf (0.65±0.28 mg/100g). Terpenoid content ranged from 1.06±0.00 mg/100g in the root to 2.31±0.01 mg/100g in the leaf. There was no significant difference between the tannin contents of the leaf and root that were the highest levels while the least was found in the stem (1.05±0.00 mg/100g).

At 100% concentration, the leaf extract showed the highest inhibition of *Staphylococcus aureus* (5.71±0.01 mm), *Salmonella typhi* (4.80±0.00 mm), *Escherichia coli* (3.80±0.00 mm), *Pseudomonas aeruginosa* (5.25±0.35 mm), *Shigella sonnei* (5.03±0.04 mm) and *Streptococcus pneumoniae* (6.09±0.13 mm), while the root extract showed the highest inhibitory activity against *Klebsiella pneumoniae* (6.80±0.00 mm) (Table 2). In addition, the leaf extract showed the highest inhibition of *Aspergillus niger* (6.50±0.00 mm), *Rhizopus stolonifer* (6.76±0.34 mm) and *Fusarium oxysporum* (6.40±0.14 mm), while the stem extract showed the highest inhibitory activity against *Penicillum chrysogenum* (8.30±0.00 mm) (Table 3).

At 150% concentration, the leaf extract showed the highest inhibitory activity against all the test bacteria (Table 2).The leaf extracts showed the highest inhibition of *A. niger* (8.45±0.00 mm), *P. chrysogenum* (9.80±0.00 mm) and *R. stolonifer* (9.45±0.00 mm) while the root extract showed the highest inhibition of *F. oxysporum* (8.20±0.00 mm) (Table 3). In addition, at 200% concentration, the leaf extract showed the highest inhibitory activity against all the test bacteria (Table 2) while for antifungal test, the leaf showed the highest inhibitory activity against *A. niger* (10.71±0.01 mm), *P. chrysogenum* (13.00±0.00 mm) and *R. stolonifer* (12.50±0.00 mm) (Table 3). Furthermore, at 250% concentration, the leaf extract showed the highest inhibition of *S. aureus* (13.50±0.00 mm), *Salmonella typhi* (12.54±0.09 mm), *E. coli* (11.75±0.07 mm), *P. aeruginosa* (12.78±0.04 mm), *Shigella sonnei* (12.30±0.00 mm) and *Streptococcus pneumoniae* (14.30±0.42 mm), while the root extract showed the highest inhibitory activity against *K. pneumoniae* (14.30±0.71 mm) (Table 2). Moreover, the leaf extract showed the highest inhibition of *A. niger* (13.60±0.14 mm) and *P. chrysogenum* (15.78±0.03 mm) while the root extract showed the highest inhibition of *R. stolonifer* (14.40±0.28 mm) and *F. oxysporum* (14.55±0.07 mm) (Table 3).

The leaf extract showed the highest inhibition of *K. pneumoniae* at 100–200% concentrations and *S. pneumoniae* at 250% concentration (Figure 1). The stem extract showed the highest inhibitory activity against *S. pneumoniae* at 100% and 150% concentrations and *K. pneumoniae* at 200% and 250% concentrations (Figure 2). The root extract showed the highest inhibitory activity against *K. pneumoniae* at all concentrations (Figure 3). The leaf and stem extracts showed the highest inhibition of *P. chrysogenum* followed by *R. stolonifer* at all concentrations (Figures 4 and 5). The root extract showed the highest inhibitory activity against *F. oxysporum* at 150–250% concentrations (Figure 6).

Discussion

Generally, it was observed that there was variation in the concentrations of the phytochemicals present in different parts of *I. involucrata*. The leaf contained the highest level of flavonoids, saponins, terpenoids and tannins. The stem contained the highest concentration of anthraquinones while the root contained the highest concentration of alkaloids and phenols. These secondary metabolites exert different biological actions on humans and animals. In Nigeria, the whole *I. involucrata* parts are used in treatment of generalized pain.[7]

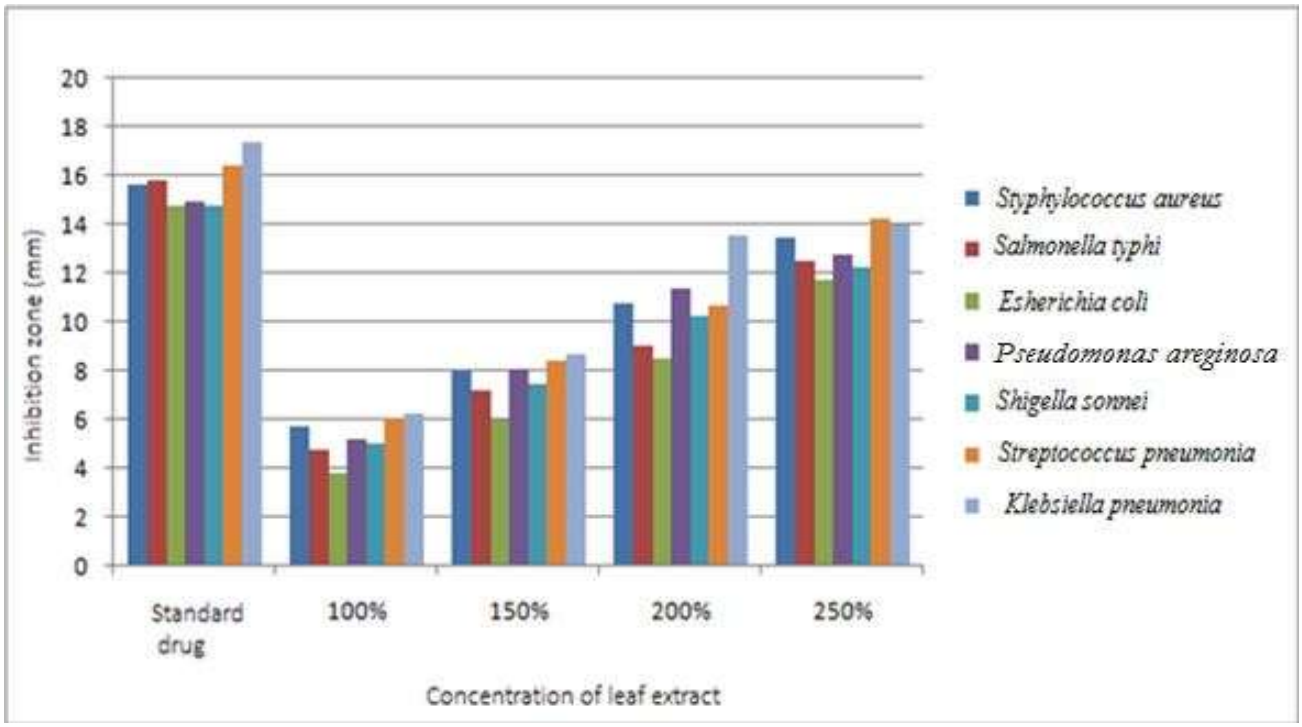

Figure 1: Zone of Inhibition (mm) of bacterial pathogens by leaf extract of *Ipomoea involuncrata*

Table 1
Mean phytochemical composition of the leaf, stem and root of *Ipomoea involucrata*

Phytochemical Composition (mg/100g)								
Plant part	**Flavonoids**	**Saponins**	**Alkaloids**	**Phenols**	**Sterols**	**Anthraquinones**	**Terpenoids**	**Tannins**
Leaf	2.78±0.03^{c}	1.78±0.00^{c}	1.64±0.02^{b}	0.38±0.00^{b}	0.42±0.00^{c}	0.65±0.28^{a}	2.31±0.01^{c}	1.35±0.01^{b}
Stem	1.45±0.04^{a}	1.24±0.01^{b}	0.53±0.01^{a}	0.25±0.00^{a}	0.23±0.00^{b}	0.72±0.00^{c}	1.82±0.03^{b}	1.05±0.00^{a}
Root	1.85±0.00^{b}	1.08±0.02^{a}	2.32±0.03^{c}	0.46±0.00^{c}	0.18±0.00^{a}	1.23±0.00^{b}	1.06±0.00^{a}	1.32±0.04^{b}

Values are in Mean ± Std of three replicates. Different letters in a column depict that the respective means were significantly different (p>0.05).

Table 2
Effects of leaf, stem and root methanol extracts of *Ipomoea involucrata* on bacterial pathogens

Concentration (%)	**Bacterial Strains**	**Mean Zone of Inhibition (mm) ± SD**			
		Control	**Leaf**	**Stem**	**Root**
100	*Staphylococcus aureus*	15.65±0.50^{d}	5.71±0.01^{c}	4.20±0.00^{a}	5.00±0.00^{b}
	Salmonella typhi	15.84±0.00^{d}	4.80±0.00^{c}	3.50±0.00^{a}	4.23±0.04b
	Escherichia coli	14.81±0.01^{d}	3.80±0.00^{c}	2.43±0.04^{a}	3.61±0.01^{b}
	Pseudomonas aeruginosa	15.00±0.00^{b}	5.25±0.35^{a}	4.83±0.04^{a}	5.20±0.00^{a}
	Shigella sonnei	14.75±0.00^{d}	5.03±0.04^{c}	3.83±0.04^{a}	4.80±0.00^{b}
	Streptococcus pneumoniae	16.40±0.00^{c}	6.09±0.13^{b}	5.20±0.00^{a}	5.46±0.34^{a}
	Klebsiella pneumoniae	17.43±0.04^{d}	6.24±0.01^{b}	5.00±0.00^{a}	6.80±0.00^{c}
150	*Staphylococcus aureus*	15.65±0.50^{c}	8.01±0.01^{b}	6.00±0.00^{a}	7.60±0.00^{b}
	Salmonella typhi	15.84±0.00^{d}	7.25±0.00^{c}	4.93±0.01^{a}	6.50±0.00^{b}
	Escherichia coli	14.81±0.01^{d}	6.00±0.00^{c}	3.83±0.04^{a}	5.40±0.00^{b}
	Pseudomonas aeruginosa	15.00±0.00^{d}	8.08±0.11^{c}	6.50±0.00^{a}	7.80±0.00^{b}
	Shigella sonnei	14.75±0.00^{d}	7.51±0.01^{c}	5.20±0.00^{a}	7.20±0.00^{b}
	Streptococcus pneumoniae	16.40±0.00^{c}	8.46±0.37^{b}	7.50±0.00^{a}	8.25±0.00^{b}
	Klebsiella pneumoniae	17.43±0.04^{d}	8.70±0.00^{c}	6.40±0.00^{a}	8.50±0.00^{b}
200	*Staphylococcus aureus*	15.65±0.50^{c}	10.80±0.71^{b}	8.28±0.04^{a}	9.25±0.00^{a}
	Salmonella typhi	15.84±0.00^{d}	9.00±0.00^{c}	6.00±0.00^{a}	8.16±0.00^{b}
	Escherichia coli	14.81±0.01^{d}	8.50±0.00^{c}	5.00±0.00^{a}	7.20±0.00^{b}
	Pseudomonas aeruginosa	15.00±0.00^{d}	11.41±0.01^{c}	9.10±0.14^{a}	10.21±0.06^{b}
	Shigella sonnei	14.75±0.00^{d}	10.26±0.09^{c}	7.08±0.11^{a}	9.53±0.11^{b}
	Streptococcus pneumoniae	16.40±0.00^{d}	10.72±0.00^{c}	9.23±0.04^{a}	10.24±0.06^{b}
	Klebsiella pneumoniae	17.43±0.04^{d}	13.55±0.07^{c}	11.45±0.21^{b}	10.85±0.21^{a}
250	*Staphylococcus aureus*	15.65±0.50^{c}	13.50±0.00^{b}	11.61±0.01^{a}	12.00±0.00^{a}
	Salmonella typhi	15.84±0.00^{d}	12.54±0.09^{c}	10.71±0.01^{a}	11.40±0.00^{b}
	Escherichia coli	14.81±0.01^{d}	11.75±0.07^{c}	9.52±0.03^{a}	10.50±0.00^{b}
	Pseudomonas aeruginosa	15.00±0.00^{d}	12.78±0.04^{c}	12.60±0.00^{b}	12.00±0.00^{a}
	Shigella sonnei	14.75±0.00^{d}	12.30±0.00^{c}	11.20±0.00^{b}	11.00±0.00^{a}
	Streptococcus pneumoniae	16.40±0.00^{c}	14.30±0.42^{b}	13.00±0.00^{a}	13.50±0.00^{a}
	Klebsiella pneumoniae	17.43±0.04^{b}	14.00±0.00^{a}	13.55±0.07^{a}	14.30±0.71^{a}

Values are in Mean ± Std of triplicate determinations. Different letters in a row are significantly different (p>0.05).

Table 3
Effects of methanol extracts of *Ipomoea involucrata* leaf, stem and root on fungal pathogens

Concentration (%)	Fungal strains	Mean Zone of Inhibition (mm) ± SD			
		Control	Leaf	Stem	Root
100	*Aspergillus niger*	16.83±0.04^{d}	6.50±0.00^{c}	5.42±0.00^{a}	5.80±0.00^{b}
	Penicillum chrysogenum	17.00±0.00^{d}	7.41±0.01^{b}	8.30±0.00^{c}	6.50±0.00^{a}
	Rhizopus stolonifer	19.50±0.00^{c}	6.76±0.34^{b}	6.75±0.00^{b}	6.00±0.00^{a}
	Fusarium oxysporum	16.82±0.11^{d}	6.40±0.14^{c}	4.31±0.01^{a}	5.20±0.00^{b}
150	*Aspergillus niger*	16.83±0.04^{d}	8.45±0.00^{c}	6.50±0.00^{a}	8.00±0.00^{b}
	Penicillum chrysogenum	17.00±0.00^{d}	9.80±0.00^{c}	9.20±0.00^{b}	7.71±0.13^{a}
	Rhizopus stolonifer	19.50±0.00^{d}	9.45±0.00^{c}	7.00±0.00^{a}	8.15±0.00^{b}
	Fusarium oxysporum	16.82±0.11^{d}	8.20±0.00^{b}	5.71±0.01^{a}	9.87±0.04^{c}
200	*Aspergillus niger*	16.83±0.04^{d}	10.71±0.01^{c}	9.23±0.04^{a}	10.33±0.04^{b}
	Penicillum chrysogenum	17.00±0.00^{d}	13.00±0.00^{c}	12.88±0.04^{b}	9.46±0.06^{a}
	Rhizopus stolonifer	19.50±0.00^{c}	12.50±0.00^{b}	11.41±0.01^{a}	11.40±0.00^{a}
	Fusarium oxysporum	16.82±0.11^{d}	11.00±0.00^{b}	9.45±0.00^{a}	12.64±0.06^{c}
250	*Aspergillus niger*	16.83±0.04^{d}	13.60±0.14^{c}	12.43±0.04^{a}	12.77±0.04^{b}
	Penicillum chrysogenum	17.00±0.00^{d}	15.78±0.03^{c}	14.60±0.00^{b}	13.60±0.28^{a}
	Rhizopus stolonifer	19.50±0.00^{c}	14.00±0.00^{a}	13.62±0.31a	14.40±0.28^{b}
	Fusarium oxysporum	16.82±0.11^{d}	13.25±0.35^{b}	12.60±0.00^{a}	14.55±0.07^{c}

Results are in Mean± Std of triplicate determinations. Means with the different letter in a row are significantly different (p>0.05).

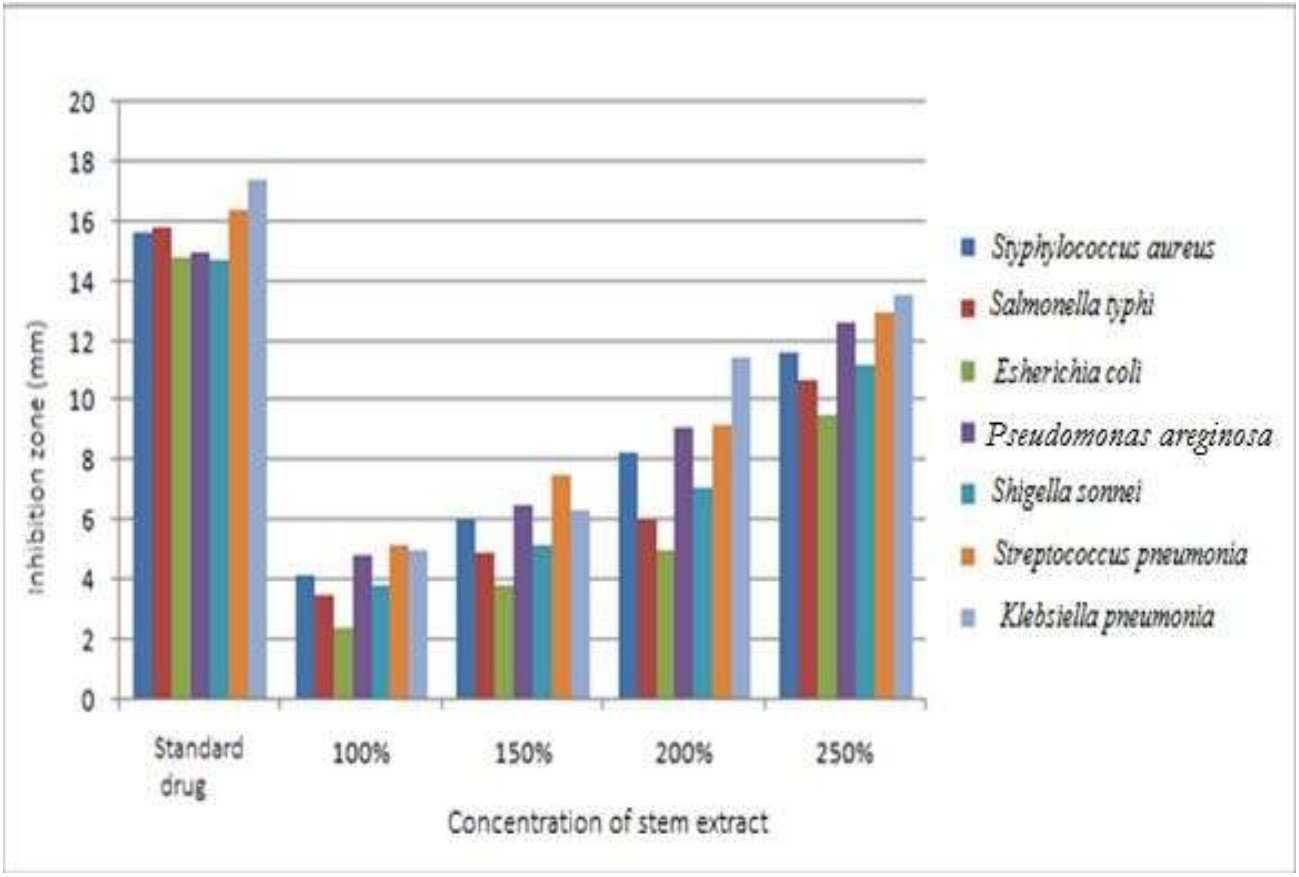

Figure 2: Zone of Inhibition (mm) of bacterial pathogens by stem extract of *Ipomoea involuncrata*

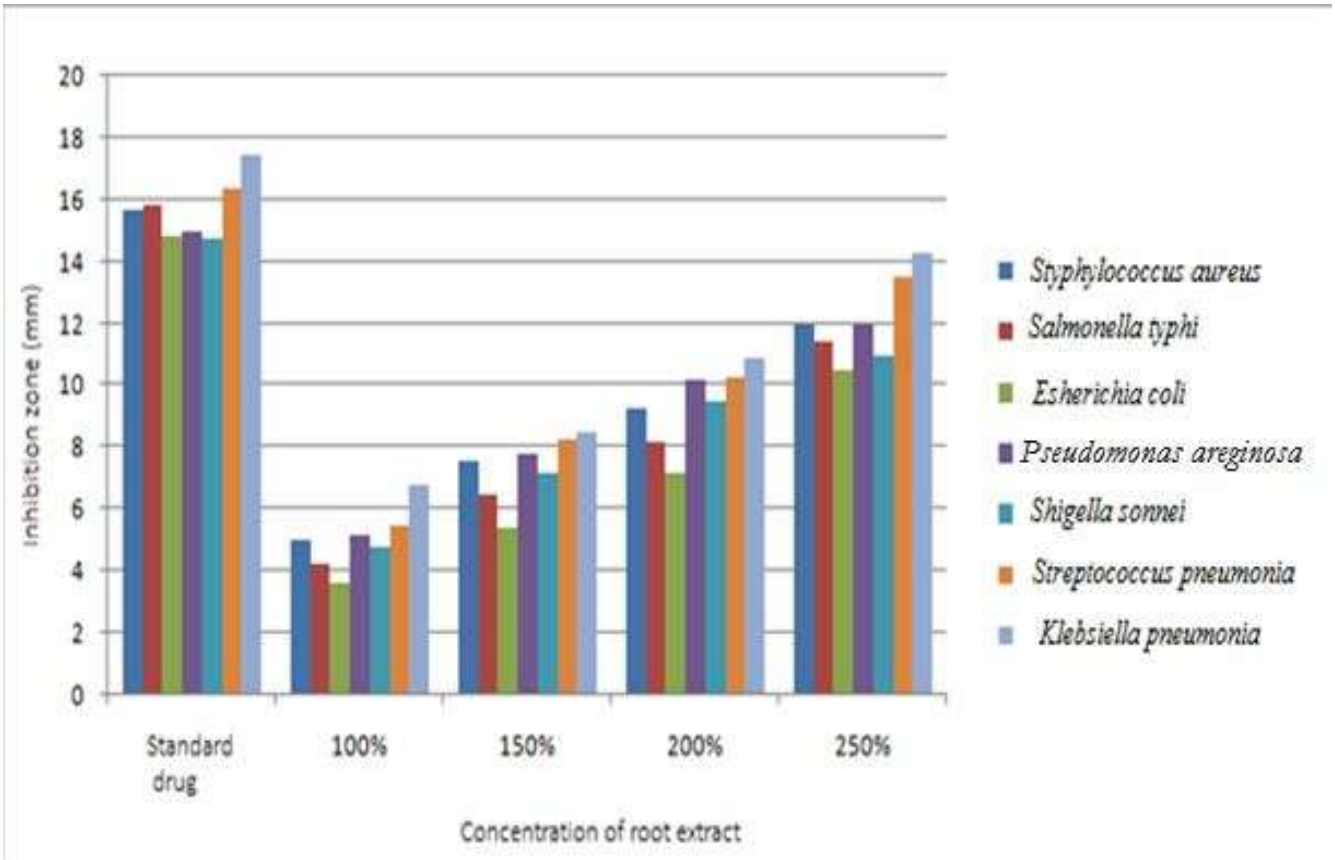

Figure 3: Zone of Inhibition (mm) of bacterial pathogens by root extract of *Ipomoea involuncrata*

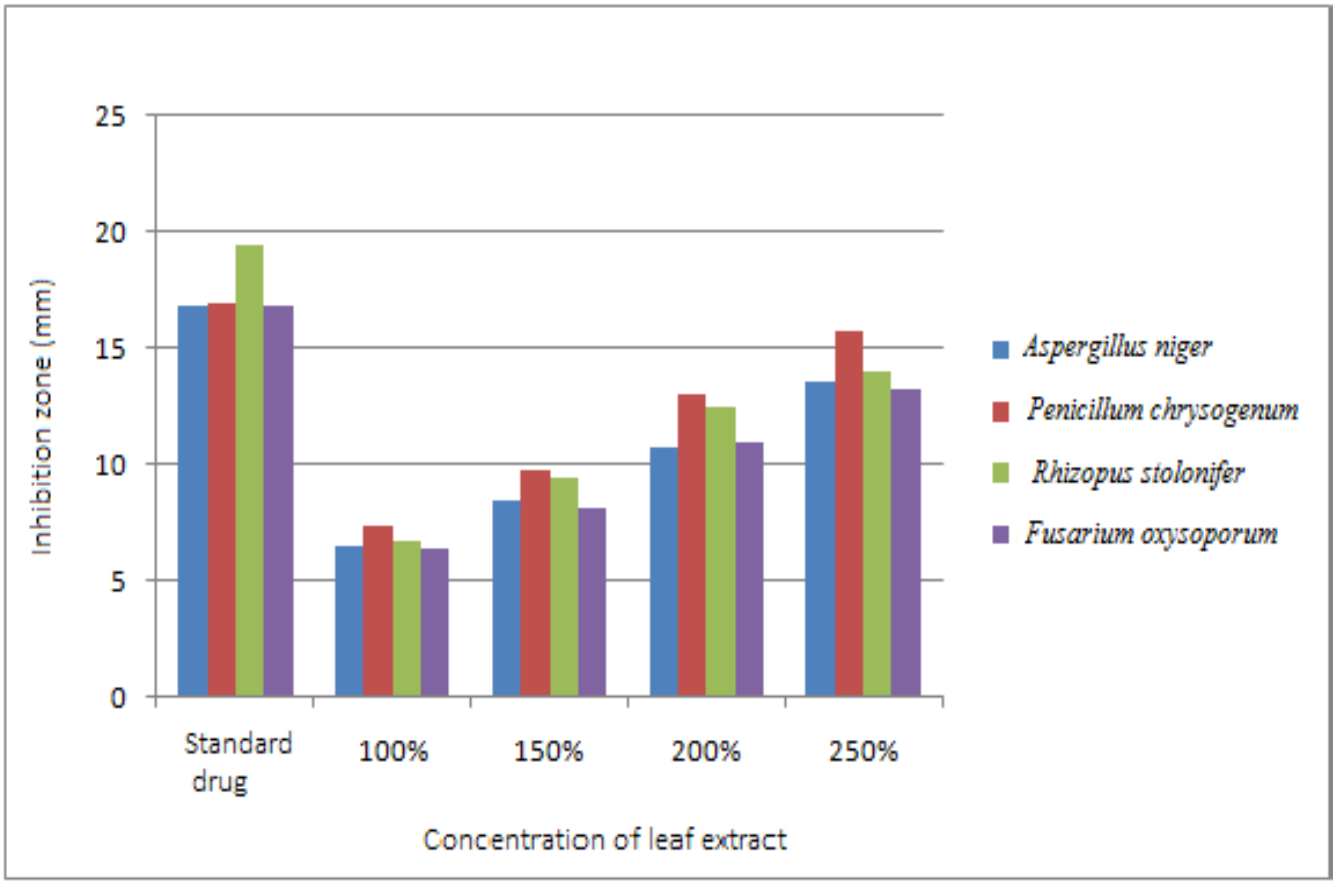

Figure 4: Zone of Inhibition (mm) of fungal pathogens by leaf extract of *Ipomoea involuncrata*

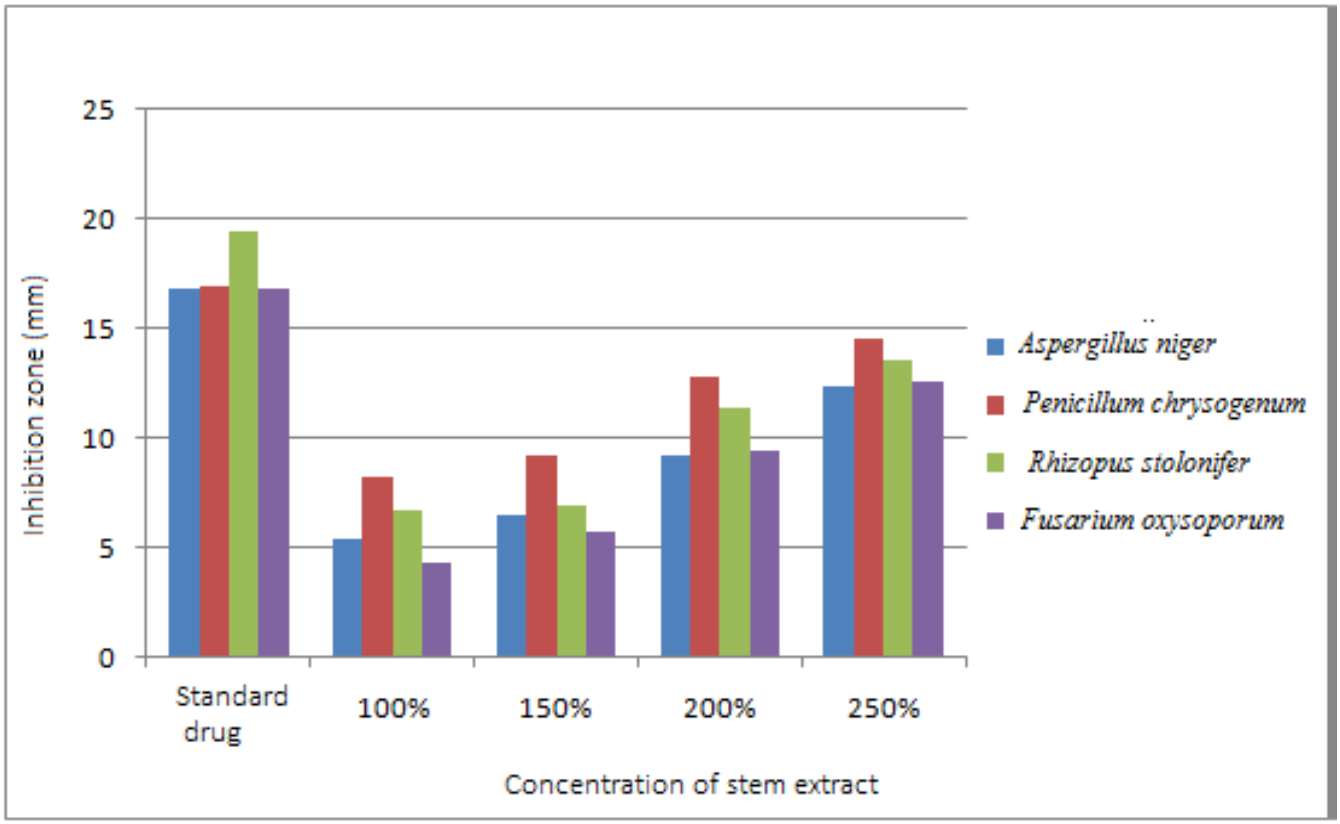

Figure 5: Zone of Inhibition (mm) of fungal pathogens by stem extract of *Ipomoea involuncrata*

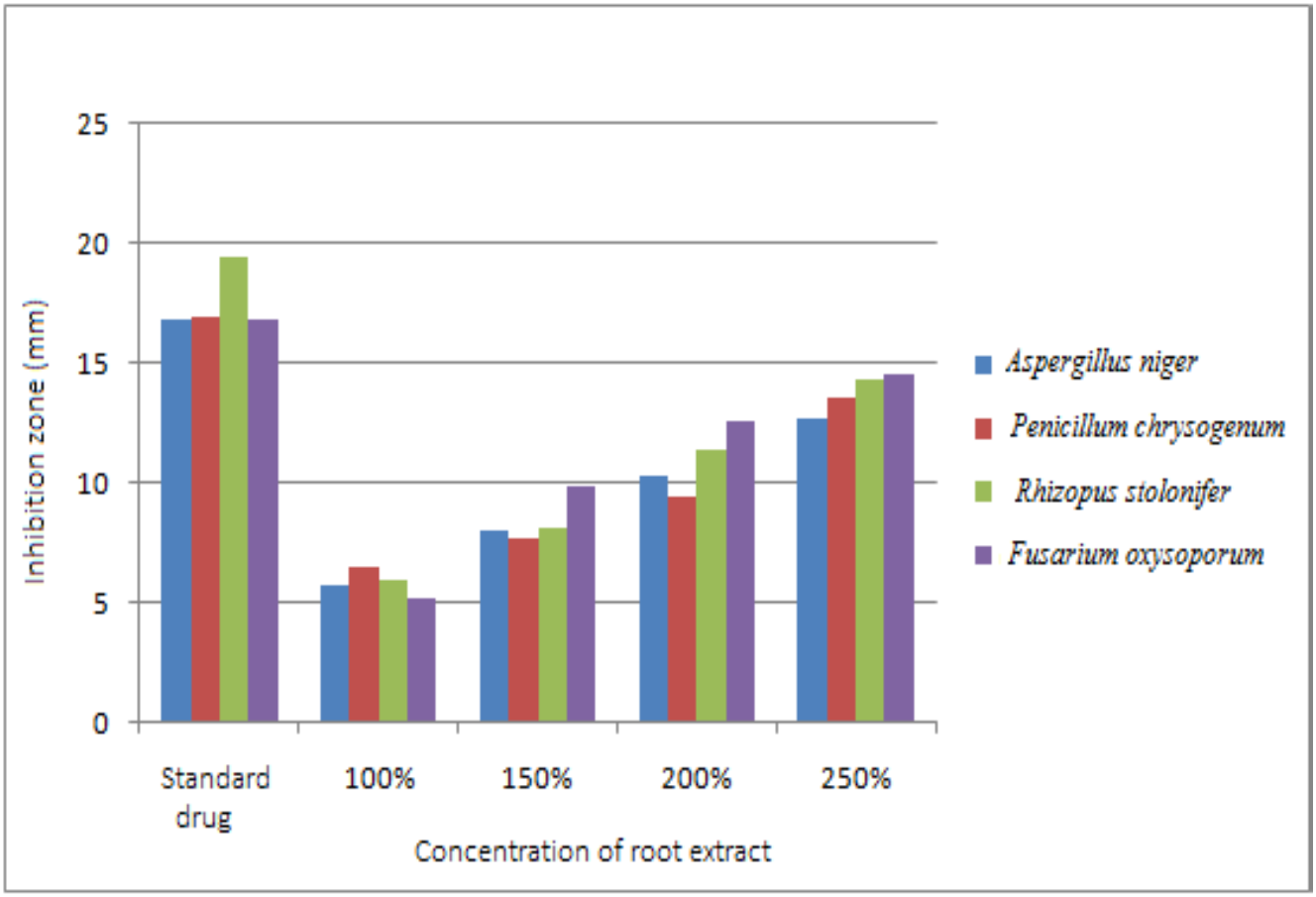

Figure 6: Zone of Inhibition (mm) of fungal pathogens by root extract of *Ipomoea involuncrata*

In addition, in Lagos, Nigeria, it is made into an infusion, drunk as a stimulant or preventive of fever whilst a compress of pounded up stems is used for headache in Congo.[6] Moreover, an aqueous decoction is taken by women for dysmenorrhoeal in Congo. These ethnomedicinal applications of *I. involucrata* could be as a result of the stimulating and painkilling qualities of alkaloids in living beings, coupled with the synergistic effects of anthraquinones, flavonoids, phenols, saponins, sterols, tannins and terpenoids that were present in the plant parts.

In the antimicrobial study, the leaf, stem and root extracts of *I. involucrata* exhibited antibacterial and antifungal activities against all the human pathogens tested. The effects of the extracts varied and were dose-dependent. This indicates that the quantity of active ingredients increased with increasing concentration of the plant extracts, hence exerts higher actions. The antibacterial and antifungal potentials of *I. involucrata* could be associated with the bitter or astringent taste of tannins[15,16] as well as foaming property of saponins[17] in addition to the interactive actions of alkaloids, anthraquinones, flavonoids, phenols, sterols and terpenoids.

The leaf, stem and root extracts showed the highest inhibition of *K. pneumoniae* at 200% concentration, while at 250%, the highest inhibitory activity was shown by the stem and root. This indicates that the whole plant parts could be applied for treatment of *pneumonia* at high level of the extract. Puspanadan *et al*[18] reported that *K. pneumoniae* is one of the most important members of *Klebsiella* genus in Enterobacteriaceae family, which is responsible for *pneumonia.* At 100% and 150% concentrations, the stem extract showed the highest inhibition against *S. pneumoniae* whereas the leaf extract had the highest inhibition at 250% concentration. This finding showed that at low concentration, the stem extract of *I. involucrata* will exhibit inhibitory activity against *S. pneumoniae* while at high concentration the leaf extract will show high inhibitory activity. Furthermore, *Streptococcus pneumoniae* is one of the most common causes of bacterial meningitis in adults and young adults along with *Neisseria meningitidis* and is the leading cause of bacterial meningitis in adults in the USA.[19] Moreover, the respiratory tract, sinuses and nasal cavity are the parts of host body that are usually infected.

In the antifungal investigation, the leaf and stem extracts showed the highest inhibitory activity against *A. niger*. Aspergillosis caused by the fungus *Aspergillus* usually occurs in people with lung diseases or weakened immune systems. The actions of the leaf and stem extracts of *I. involucrata* showed that they could be used in treatment of aspergillosis. The leaf and stem extracts showed the highest inhibitory activity against *P. chrysogenum* at all concentrations while the root extract showed the highest inhibition of *P. chrysogenum* at 100% concentration. Hence, the leaf and stem extracts of *I. involucrata* are to be considered for treatment of ailments caused by *P. chrysogenum*. Shokouhi *et al*[20] reported that *P. chrysogenum* might be recognized as a cause of systemic mycosis. The root extract exhibited the highest inhibitory activity against *F. oxysporum* followed by *R. stolonifer* at 150–250% concentrations. *Fusarium oxysporum* generally affects immunocompromised individuals.[21] Root methanol extract of *Sida acuta* Burm. f. also showed high inhibitory activity against *Rhizopus* sp (12.87±0.57 mm) at high concentration.[22] The root extract of *I. involucrata* therefore, can be used in treatment of diseases caused by *F. oxysporum* and *R. stolonifer*.

Conclusion

This study showed that high concentrations of flavonoids, saponins, sterols, terpenoids and tannins are present in *I. involucrata* leaf extract; high level of anthraquinones can be found in the stem, while the root extract should be regarded as a good source of alkaloids and phenols. Moreover, the leaf, stem and root extracts of *I. involucrata* exhibited antibacterial and antifungal activities.

Hence, extracts of these parts of *I. involucrata* are suggested for development of new drugs targeted at the treatment of infectious diseases caused by *K.pneumoniae, S. pneumoniae, A. niger, F. oxysporum, P. chrysogenum* and *R. stolonifer* in human beings.

References

1. Akobundu I.O. and Agyakwa C.W., A Handbook of West African Weeds, 2nd edition, International Institute of Tropical Agriculture, Ibadan, 564 **(1998)**

2. Cao S., Guzza R.C., Wisse J.H., Miller J.S., Evans R., Kingston D.G. and Ipomoeassins A.E., cytotoxic macrocyclic glicoresins from the leaves of *Ipomoea squamosa* from the Suriname rainforest, *J. Nat. Prod.*,**68**, 487–492 **(2005)**

3. Hutchinson J. and Dalziel J., Flora of West Tropical Africa, 2nd edition, Crown Agents, London, 544 **(1963)**

4. Essiett U.A. and Akpabio K.E., The comparatives anatomy of *Talinum triangulare* and *Talinum portulacifolium* in Nigeria, *Int. J. Biotech. Allied Sci.*, **4(1),** 424–432 **(2009)**

5. Burkill H.M., The Useful Plants of West Tropical Africa, 2nd edition, Royal Botanic Garden, Kew, 960 **(1985)**

6. Okafor J.C., Tropical Plants in Health Care Delivery in Nigeria, Bookbuilders, Ibadan, 188 **(2013)**

7. Okudaira R., Kyanba H., Ichiba T. and Toyokawa T., *Ipomoea* extracts with disaccharidase-inhibiting activities, *Japanese J. Sanit.*, **200,** 521–3221 **(2005)**

8. Ezeabara C.A. and Okonkwo E.E., Comparison of phytochemical and proximate components of leaf, stem and root of C*roton hirtus* L'Herit and *Croton lobatus* Linn., *J. Pharma Sci.*,**1(3),** 47–56 **(2016)**

9. Harborne J.B., Phytochemical Methods, Chapman and Hall, London, 273 **(1973)**

10. Association of Official Analytical Chemists, Official Methods of Analysis, 15th edition, International Association of Official Analytical Chemists, Washington D.C., 122 **(1990)**

11. Kirk H. and Sawyer R., Frait Pearson Chemical Analysis of Food, 8th edition, Longman Scientific and Technical, Edinburgh, 211–212 **(1998)**

12. Ezeabara C.A. and Egwuoba G.C., Comparative screening of phytochemical and proximate constituents of leaf, stem and root of *Oldenlandia corymbosa* L. and *Oldenlandia herbacea* (L.) Roxb., *Am. J. Life Sci. Res*,**4(3),** 113–118 **(2009)**

13. Ferguson N.M., A textbook of Pharmacognosy, Macmillan Company, New Delhi, 191**(1956)**

14. International Commission on Microbiological Specifications for Food, Principles for the establishment of microbiological food safety objectives and related control measures, *Food Control*, **9(6),** 379–384 **(1998)**

15. McGee H., On Food and Cooking: The Science and Lore of the Kitchen, Scribner, New York, 714 **(2004)**

16. Noypitak S., Terdwongworakul A., Krisanapook K. and Kasemsumran S., Evaluation of astringency and tannin content in 'Xichu' Persimmons using near infrared spectroscopy, *Int. J. Food Prop.*,**18(5)**, 1014–1028 **(2015)**

17. Chem Y., Yang C., Chang M., Ciou Y. and Huang Y., Foam properties and detergent abilities of the saponin from *Camellia oleifera*,*Int. J. Mol. Sci.*,**11(11),** 4417– 4425 **(2010)**.

18. Puspanadan S., Afsah-Hejri L., Loo Y.Y., Nillian E., Kuan C.H., Goh S.G., Chang W.S., Lye Y.L., John Y.H., Rukayadi Y., Yoshitsugu N., Nishibuchi M. and Son R., Detection of *Klebsiella pneumoniae* in raw vegetables using Most Probable Number-Polymerase Chain Reaction (MPN-PCR), *Int. Food Res. J.*, **19(4),** 1757–1762 **(2012)**

19. Dagan R., Gradstein S., Belmaker I., Porat N., Siton Y., Weber G., Janco J. and Yagupsky P., An outbreak of *Streptococcus pneumoniae* serotype 1 in a closed community in southern Isreal, *Clin. Infect. Dis.*, **30(2),** 319–321**(2000)**

20. Shokouhi S., Tehrani S. and Hemmatian M., Mixed pulmonary infection with *Penicillium notatum* and *Pneumocytis jiroveci* in a patient with acute myeloid leukemia, *Tanaffos*, **15(1),** 53–58 **(2016)**.

21. Gupta A.K., Baran R. and Summerbell R.C., *Fusarium* infections of the skin, *Curr. Infect. Dis.*,**13 (2),** 121– 128 **(2000)**

22. Ezeabara C.A. and Egenti M.O., Phytochemical and antimicrobial investigations on various parts of *Sida acuta* Burm. f., *J. Ayurv Herbal Med.*, **4(2),** 71–75 **(2018)**.

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