

## Assessment of the Biomolecules Profiles and *In-Vitro* Biological Activities of *Cymbopogon citratus* Roots

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Page | 4385

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*Date Received:* 08-04-2022

*Date Accepted:* 23-07-2022

**DOI:** <https://doi.org/10.48198/NJPAS/22.A19>

### ABSTRACT

The medicinal value of plants lies in their bioactive constituents which usually allow them to act as remedy to several ailments. The present study determines the biochemical constituents as well as various *in - vitro* biological activities of the *materia medica* of *Cymbopogon citratus* root. The antioxidant properties of test plant root were estimated using standard analytical procedures, while antibacterial activity was assayed using agar- well diffusion techniques. Proximate analyses of ethanol and aqueous extracts of sample revealed that the sample contains significant amount of moisture, crude protein, ash content, crude fat, carbohydrate and crude fibre. Root extracts of *Cymbopogon citratus* revealed the presence of alkaloids, saponins, tannins, anthraquinones, steroids, phenols and flavonoids at varying concentrations, helping to deactivate and absorb free radicals. Thus, both ethanol and aqueous extracts of the plant have high antioxidant activity and are good radical scavengers. Assay for *in - vitro* antioxidant properties showed that the root of *Cymbopogon citratus* has very potent antioxidant ability and produced concentration dependent increase in antioxidant activity. The ethanol root extract also exhibited antibacterial activity against *Salmonella typhi* but inactive on *Escherichia coli*, *Listeria monocytogenes* and *Staphylococcus aureus* obtained from clinical source. The amounts of phytochemicals, antioxidant and antibacterial activities were observed more in ethanol extract compared to aqueous extract. The study concludes that *Cymbopogon citratus* root is a potential nutraceutical effective as *materia medica* in salmonellosis and hence can boost research in nutrition and herbal medicine.

**Keywords:** Antibacterial activity, Bioactive constituents, *Cymbopogon citratus*, Free radicals, *Materia medica*,

### Introduction

Plants have immense impact on the nutrition and health of human exhibiting curative tendency for ailments. Plants contain a broad range of biochemically active compounds which are the primary sources of nutrition and various

medicines. Wild plants including those that are under-utilized are sources of nutraceuticals providing vitamins, trace elements and minerals, thereby improving health and nutrition (Leonti, 2012). Several traditionally known medicinal plants contain several different pharmacologically

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active compounds that may act individually or synergistically to improve health and function as food for growth and body maintenance (Afolayan and Jimoh, 2009; Ubwa *et al.*, 2014; Verma and Kaushal, 2014). Researchers' attention focuses on investigating each plant with a new approach regarding their probable use for food and medicine. Verma and Kaushal, (2014) reported that carbohydrate, proteins, vitamins, steroids and lipids which are primary metabolites in food provide nutrition while Zheng and Wang, (2001) stated that secondary metabolites, such as phenols, flavonoids, tannins, alkaloids, terpenoids, lignin, quinones, coumarins and amines function optimally as antioxidants. Similarly, many plants (wild or domesticated) provide energy, vitamins and minerals that maintain the physiological equilibrium of the body. Ebert (2014) however, reported that the nutritional potential of uncultivated plant species is superior relative to the cultivated variety. Several ethno-pharmacological researches on wild edibles as nutraceuticals used for the cure of jaundice, diabetes, wounds, cancer e. t. c have also received great attention (Mir, 2014). Foods of plant origin are abundant resources of bioactive compounds which possess a great variety of biological activities including antioxidant potential. Fruits and vegetables as food result in decline possibility of chronic and neurodegenerative diseases, mostly due to the occurrence of antioxidants (phenolic compounds and tocopherols) by interruption or prevention of oxidative reactions (Di Matteo and Esposito, 2003).

The occurrence of infectious diseases is increasing globally and the use of antimicrobials for cure is trending. Plant antimicrobials are naturally occurring secondary metabolites such as tannins, flavonoids, quinones, coumarins, terpenoids, alkaloids and polypeptides which exert innocuous antimicrobial activity compare to man-made or synthetic drugs (Savoia, 2012). From native accounts, the use of natural substances, particularly of plant origin, for preventive and curative

potentialities is common and used for holistic healing. These plants possess phyto-compounds at varying qualitative and quantitative concentrations which account for their use as medicinal plant. Among the many medicinal plants possessing such healing potentials as claimed by the locals is *Cymbopogon citratus*.

*Cymbopogon citratus* also known as Lemon grass is an aromatic coarse perennial herb of 1.5 m high with rhizomes and densely tufted fibrous root (Adekomi *et al.*, 2012). *C. citratus* is an important member of the *Gramineae* family in use since ancient times for their local recipes. *C. citratus* is a fast -growing grass native to South India and Sri Lanka, now widely domesticated in several tropical and subtropical countries of Africa, America and Asia (Chanthal, *et al.*, 2012). The plant has short underground stems with ringed segments, coarse, green slightly leathery leaves in dense clusters (Omotade, 2009). Freshly cut and partially dried leaves are used extensively in Ayurvedic medicine. The grass is a folk remedy for leprosy, malaria, coughs, elephantiasis, flu, gingivitis, headache, fever, hypertension, pneumonia, nervous, gastrointestinal and vascular disorders (Karkala and Bhushan, 2014) possessing various pharmacological activities such as antioxidant (Hanisa *et al.*, 2011; Garg *et al.*, 2012) and antimicrobial (Danlami *et al.*, 2011) properties. There is however, dearth of information in literatures on the root of this plant. The present study therefore seeks to assess the nutritional composition; phytochemicals, antioxidant properties and antibacterial activities of *Cymbopogon citratus* root.



**Plate 1:** *Cymbopogon citratus* (Lemon grass) in domesticated growing in Igboegunrin Community, Ilaje Local Government Area of Ondo State, Nigeria

## Materials and Methods

### *Plant material and authentication*

Fresh roots of *Cymbopogon citratus* (Lemon grass) was collected from Igboegunrin Community in Ilaje Local Government Area of Ondo State, Nigeria. A voucher specimen number OAUSTECH/104 was assigned to the sample after authentication at the Herbarium of Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria and then deposited at the Herbarium Section of Botany Unit of the University.

### *Microorganisms used in bioassay*

Pure culture of clinical isolates of *Esherichia coli*, *Staphylococcus aureus*, *Salmonella typhi* and *Listeria monocytogenes* were obtained from Excel Medical Laboratory, Okitipupa, Nigeria. Purity and identity of isolates were confirmed using standard microbiological procedures (Cowan and Steel, 1991).

### *Preparation of root extracts of Cymbopogon citratus*

Plant root samples were sliced and air-dried to constant weight at room temperature and then ground to powder with mechanical blender (model AA255FS, Agilent Technologies, U.S.A). Twenty gram (20 g) of pulverized sample was soaked in 100 ml of 70% ethanol and water (with occasional

shaking) to obtain the ethanol and aqueous extracts respectively. The ethanol and aqueous extracts were filtered and the filtrates concentrated under reduced pressure using rotary vacuum evaporator (model AA215FS, Agilent Technologies, U.S.A) to obtain pure extracts. Pulverized sample and pure extracts of sample were then transferred into airtight containers and stored in a refrigerator at 4°C until required for use.

### *Organoleptic evaluation*

The organoleptic properties of the root extracts were determined according to the procedure of Gami and Parabia (2010).

### *Determination of biomolecule constituents of Cymbopogon citratus root*

The proximate composition (fiber, moisture, protein, lipid, ash and carbohydrates) of *Cymbopogon citratus* root extracts were determined according to AOAC (2010) while gross energy values (kcal/100 g) were determined by multiplying the protein and carbohydrate contents by 4 and fat content by 9 (AOAC, 2010) i.e., (Crude protein × 4) + (Total carbohydrate × 4) + (Crude fat × 9). The standard analytical method described by AOAC (2010) was used to determine the mineral constituents of *Cymbopogon citratus* root. One (1g) of the pulverized sample was placed in a crucible and ignited in a muffle furnace at 550°C for 6 hours. The resulting ash was then dissolved in 10 ml of 10% HNO<sub>3</sub> and slowly heated for 20 minutes and thereafter filtered. The filtrate was used for the determination of the mineral contents. Atomic absorption spectrophotometer (AAS) (model AA280FS, Agilent Technologies, U.S.A) was used to determine Fe and Mg according to the protocol of the manufacturer.

### *Secondary metabolite screening*

Ethanol and aqueous extracts of *Cymbopogon citratus* root were used to screen for secondary metabolites; saponins, alkaloids, flavonoids, tannins, steroids, phenolics, cardiac glycosides,

anthraquinones, cardenolides and dienolides, chalcones, phlobatannins and terpenes using the procedure of Harborne (1998).

### ***In-vitro Antioxidant evaluation***

The procedure described by Singh *et al.* (2002) was used to evaluate the radical scavenging ability, 1,1-diphenyl 1- ***Preparation of inoculum for antibacterial activity***

Inoculant for antibacterial activity of ethanol and aqueous extracts of *Cymbopogon citratus* root was prepared by separately inoculating one (1) loopful of pure cultures of *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhi* and *Listeria monocytogenes* into sterile nutrient broth (3 ml) in Bijou bottle and incubated at 37°C for 24 hr.

### ***Antibacterial activities of Cymbopogon citratus root extract***

2 picrylhydrazyl (DPPH) and hydrogen peroxide scavenging activity (HPSA) while ferric reducing antioxidant power (FRAP), superoxide scavenging activity (SSA) and nitric oxide scavenging activity (NO) were determined by the method of Zhao *et al.* (2008) and Hazra *et al.*, 2008) was used for the ability to scavenge hydroxyl radical (HRSA) by the reduction in nitro blue tetrazolium (NBT).

The agar-well diffusion method was used to determine the antibacterial activity of ethanol and aqueous extracts of *C. citratus* root against the test organisms. Aliquot (0.1 ml) of 24 hr old broth culture of each test organism was introduced to 9.9 ml distilled water to prepare a 1: 100 dilution of the organism (Ogunmefun *et al.*, 2016). Twenty milliliter (20 ml) of sterile molten MHA prepared in a MacCarthy bottle and cooled to 45°C was inoculated with an aliquot (0.1 ml) from the dilution and then rocked gently to allow proper mixing of inoculum with the medium. The medium (MHA) - culture mixture was poured into a well-labelled sterile Petri dish and allowed to solidify.

The root extracts were filtered using 0.22 µm membrane filter. Varying concentrations (20, 30, 40, 50 and 60 mg/l) of crude extract reconstituted with olive oil was introduced into wells created with sterile 6 mm cork-borer inside the seeded Mueller- Hinton Agar (MHA) but carefully avoided overflow of extract unto the surface the inoculated medium. Sterile olive oil was also introduced to fill separate well to serve as negative control (Ogunmefun *et al.*, 2016) while antibiotic impregnated paper discs (BIOMARK) were the positive controls. Triplicate seeded plates with test extracts and controls were allowed to stay on Laboratory bench for 1 hr to allow diffusion of extracts into the medium and then incubated for 24 hr at 37°C. This procedure was repeated for each test isolates for ethanol and aqueous extracts. The plates were observed for clear zones of inhibition around each well and measured as antibacterial activity expressed as R: Resistant (<14mm), M: Mild (14-16mm) and S: Sensitive (>16mm).

### ***Statistical analysis***

The results obtained in this of study were assessed and analyzed using Statistical Package for Social Sciences (SPSS) computer software (version 20) and Microsoft Excel (2013) software.

### **Results**

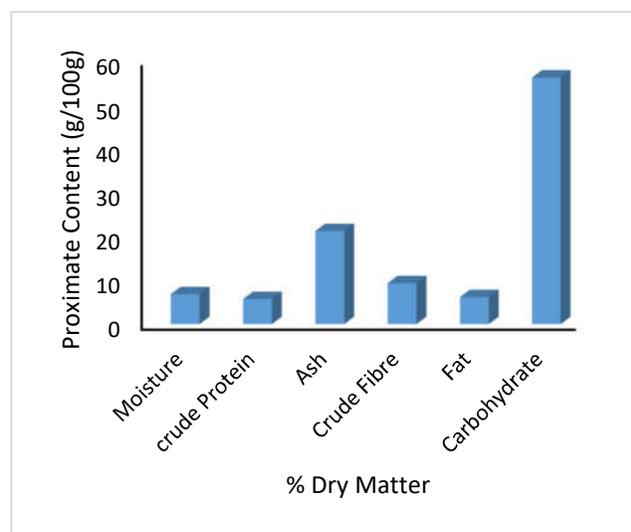
#### ***Organoleptic evaluation***

The organoleptic properties of the ethanol and aqueous extracts of *Cymbopogon citratus* roots, in terms of color, taste, odor and texture were observed and determined. Both extracts exhibited uniqueness in the organoleptic parameters investigated (Table 1).

**Table 1:** Organoleptic properties of extracts of *Cymbopogon citratus* roots.

Parameter	Ethanol extract	Aqueous extract
Colour	Dark brown	Dark brown
Taste	Bitter	Bitter
Odour	Lemon- like	Lemon- like
Texture	Crystalline	Crystalline

The percentage carbohydrates, ash and crude fibre in *Cymbopogon citratus* roots were higher than the fat and crude proteins. The amount of the proximate composition as shown in figure 1 were in order of carbohydrates > ash > crude fibre > moisture > fat > crude proteins.

**Figure 1:** Percentage proximate composition of pulverized *Cymbopogon citratus* roots.

The results of mineral analysis in Table 2 shows that the amount of potassium, calcium manganese, magnesium and sodium were higher than other minerals. The abundance of the minerals assessed were in the order potassium > calcium > manganese > magnesium > sodium > zinc > iron > phosphorus > selenium.

**Table 2:** Mineral composition of *Cymbopogon citratus* root

Minerals	Composition (mg/100 gm)
Sodium	20.2
Potassium	28.8
Calcium	24.2
Iron	14.5
Copper	ND
Zinc	18.1
Lead	ND
Magnesium	22.8
Manganese	24.0
Cobalt (Co)	ND
Phosphorus	12.4
Selenium	5.00
Cadmium (Cd)	ND

**Legend:** ND; Not detected

### Secondary metabolites assay

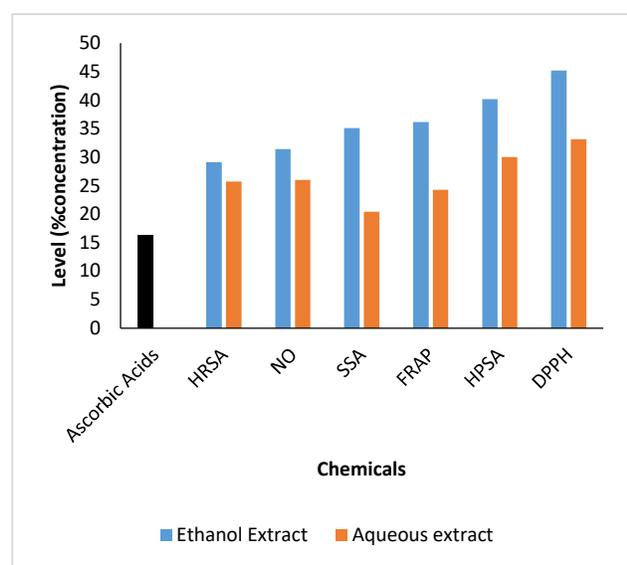
The quantitative phytochemical composition of the test plant root extracts is shown in table 3. Results revealed the presence of a variety of plant secondary metabolites such as alkaloids, anthraquinones, saponins, tannins, steroids, flavonoids, and phenols in varying concentrations. The ethanol extract shows higher concentrations of secondary metabolites relative to the aqueous extract. Phlobatannins and cyanate were not detected from both extracts.

**Table 3:** Phytochemical composition of extracts of *Cymbopogon citratus* roots

Phytochemical	Ethanol extract	Aqueous extract
Alkaloids	2.52	0.43
Saponins	2.64	0.56
Tannins	2.60	0.49
Phlobatannins	ND	ND
Anthraquinones	0.05	0.01
Steroids	1.06	0.07
Flavonoids	2.58	1.05
Phenols	2.40	0.20
Cyanate	ND	ND

Legend: ND; Not detected.

Figure 2 shows the *in vitro* antioxidant activity of *Cymbopogon citratus* roots extracts. The experimental extracts obtained by means of solvents (ethanol and aqueous), and the proportions were capable of inhibiting the DPPH radical, NO scavenging, FRAP, SSA, HRSA and HPSA. The potential for antioxidants varied greatly amongst the functional indices and ranged in order DPPH > HPSA > FRAP > SSA > NO > HRSA. Result shows a good correlation has been observed between the polyphenol and the antioxidant activity of the roots of *Cymbopogon citratus*.



**Figure 2:** *In vitro* antioxidants activities of *Cymbopogon citratus* root extracts

Keys: **HRSA:** Hydroxyl radical scavenging activity, **NO:** Nitric oxide scavenging activity, **SSA:** superoxide scavenging activity, **FRAP:** Ferric reducing antioxidants power, **HPSA:** Hydrogen peroxide scavenging activities, **DPPH:** Radical scavenging activity (1,1-Diphenyl-2-picrylhydrazyl).

**Antibacterial activities plant root extract**

Antibacterial activity of the extracts against *E. coli*, *S. aureus*, *Salmonella typhi* and *L. monocytogenes* was determined by measurement of clear zones of inhibition around the wells. Results show that the ethanol extract inhibited only the growth of *S. typhi* at various dose levels; with the 60 mg/ml of the extract showing pronounced inhibition whereas the growth of *E. coli*, *S. aureus* and *L. monocytogenes*

were not inhibited (Table 4a). The aqueous *Cymbopogon citratus* root extract showed no inhibitory effect on the growth of test isolates (table 4b). The clear zones of inhibition created by conventional antibiotics used as positive control is shown in Table 4c. The isolates showed varying degree of resistance and sensitivity to the conventional antibiotics ranging in the range of 0 - 12 mm (resistant) and 16 - 28 mm (sensitive). Highest inhibitory zone of 28 mm was exhibited against *Staph. aureus* by ciprofloxacin (CIP) followed by 26 mm exhibited on *L. monocytogenes*. *E. coli* and *Salmonella typhi* also showed susceptibility of 24 mm and 21 mm respectively to ciprofloxacin (CIP). The susceptibility of *L. monocytogenes* to the antibiotics was in the order Ampicillin (AMP) > Gentamicin (GEN) > Erythromycin (ERY) > Vancomycin (VAN).

**Table 4a:** Zones of inhibition (mm) of ethanol extract of *Cymbopogon citratus* on test isolates

Clinical Isolates	Extract concentration (mg/ml)				
	20	30	40	50	60
<i>Escherichia coli</i>	0	0	0	0	0
<i>Staph. aureus</i>	0	0	0	0	0
<i>Salmonella typhi</i>	14.0	17.0	25.0	28.0	30.0
<i>Listeria monocytogenes</i>	0	0	0	0	0

**Table 4b:** Zones of inhibition (mm) of aqueous extract of *Cymbopogon citrates* on test isolate

Clinical Isolates	Extract concentration (mg/ml)				
	20	30	40	50	60
<i>Escherichia coli</i>	0	0	0	0	0
<i>Staph. aureus</i>	0	0	0	0	0
<i>Salmonella typhi</i>	0	0	0	0	0
<i>Listeria monocytogenes</i>	0	0	0	0	0

**Table 4c:** Zones of inhibition (mm) of convention antibiotics (BIOMARK) on test clinical isolates

Clinical isolates	Conventional antibiotics (control) on test clinical isolates															
	AMP	MEM	ERY	TET	COT	CRX	GEN	CIP	AUG	VAN	CPZ	CP	CHL	CTR	CTX	AMK
<i>Escherichia coli</i>	0	0	0	0	8	2	5	24	0	0	7	0	0	8	16	22
<i>Staph. aureus</i>	12	0	6	0	0	0	7	28	6	0	5	0	0	0	0	0
<i>Salmonella typhi</i>	0	0	6	6	6	0	4	21	0	0	0	0	6	12	0	18
<i>L.monocytogenes</i>	26	4	18	3	0	0	21	4	4	16	3	0	0	0	3	0

**Legend:** AMP: Ampicillin, MEM: Meropenem, ERY: Erythromycin, TET: Tetracycline, COT: Cotrimoxazole, CRX: Cefuroxime, GEN: Gentamicin, CIP: Ciprofloxacin, AUG: Augmentin, VAN: Vancomycin, CPZ: Ceflazidime, CP: Cephaixin, CHL: Chloramphenicol, CTR: Ceftriaxone, CTX: Cefotaxime, AMK: Amikaein.

## Discussion

The uncontrolled dependence on antibiotics for the treatment of bacterial infections among the human population has resulted in the emergence and wide spread of multidrug resistant strains constituting a global concern to health. Plants used in disease treatment contain bioactive principles with biological activity, some of which cause the characteristic odor, pungency and color of plants, while others are responsible the plants' culinary, medicinal or poisonous virtue (Evans, 2002; Gami and Parabia, 2010).

Plants or organisms that eat plants are the main sources of food for humans. Many plant-derived medicines, fibres, and dyes; metals, brick can be replaced by synthetic chemicals and petroleum derivatives while concrete can replace wood but, there is still no replacement to plants as human food sources. Foods' proximate composition is a major index of nutritious potentials of plants. This study showed higher carbohydrate and ash contents in the roots of *Cymbopogon citratus* than fiber, moisture, fat, and protein while the crude fiber contents showed quantifiable percentage enough to keep the digestive system healthy (Adaji *et al.*, 2020). The data obtained show that *Cymbopogon citratus* roots compares favorably with other fast energy giving food stuffs.

The results of this study showed that potassium, calcium, manganese, magnesium and sodium which are important mineral constituents of food

were in reasonable amount while iron, zinc, phosphorus and selenium were in minimal amount. The values obtained were comparable with values reported by (Adaji *et al.*, 2020) for some other medicinal plants. These results suggest that *Cymbopogon citratus* root contains almost all the minerals required for proper enhancement of body system functions including regulation of muscle and heart contractions, fluid balance and nerves signal relay. These minerals have also been reported to reduce blood pressure and render protection against stroke Adaji *et al.* (2020). This implies that regular intake of *C. citratus* would increase the level of these minerals in the body for enhancement of physiological functions. Calcium present was 24.2 mg/100g and therefore suitable for maintaining strong teeth and bones, as well as enhance blood vessel actions and help the release of hormones and enzymes affecting body physiology and well-being (Adaji *et al.*, 2020). The composition Mg, P and Ca (mg/100 g) in the test plant root were lower than Mg (90.62), P (207.50) and Ca (110.17) for cocoyam reported by Ndabikunze *et al.* (2011). Potassium content was highest among the minerals present in the plant material with the value of 28.8 mg/100g. The preponderance of potassium in this medicinal plant may be due to the absorption and accumulation of this element from the habitat. Minerals in general are required in the diet for metabolic reactions, transmission of nerve impulses, rigid bone formation and regulation of water and salt balance among others. The present study showed that there is abundance of minerals

in the root of *Cymbopogon citratus*. Njoku and Ohia (2007) reported that consumption of nutrient rich foods such as *Cymbopogon citratus* help the utilization of protein, carbohydrates and other nutrients by the body.

Phytochemical screening of the extracts revealed the presence of saponins, tannins, alkaloids, flavonoids, phenols, steroids and anthraquinones which varies quantitatively from low to highly present between the two extracts. The ethanol extract showed higher concentrations compared to the aqueous extract. Quantitative phytochemical analysis of the two extracts of *Cymbopogon citratus* root, showed the presence of polyphenolic compounds which acts as antioxidant agents and scavenge free radicals (Milliauskas *et al.*, 2004). The concentrations of phenols and flavonoids contributed the anti-oxidant activities of the plant extracts. The maximum antioxidant capacity of these root extracts which was more pronounced in the ethanol extract could be ascribed to the presence of phenolic plant secondary metabolites, thereby suggesting that polyphenol compounds remain the primary contributors to the antioxidant ability possessed by *Cymbopogon citratus* root. Schneider and Wolfling (2004) reported that saponins inhibit  $\text{Na}^+$  efflux by blockage of the influx of concentration in the cells, activating a  $\text{Na}^+ - \text{Ca}_2^+$  antiporter in cardiac muscles and further said the increase in  $\text{Ca}_2^+$  influx through this antiporter strengthens the contraction of heart muscles. The valuable pharmaceutical properties of *Cymbopogon citratus* may also be attributed to the presence of alkaloids which (Edeoga and Enata, 2001) reported to possess a stimulating effect, act as topical anesthetic in ophthalmology, efficient pain reliever, antipuretic and other functions. High Flavonoids level with other antioxidant vitamins and enzyme may help provide protection against oxidative stress induced diseases thereby contributing to the total antioxidative defense system of the human body. This assertion is based on the studies of Harborne and Williams (2000) who attributed antioxidant

properties to be due to the presence of flavonoids and may account for the high lipid peroxidation inhibition found in certain species of the studied botanic. The medicinal values of *Cymbopogon citratus* therefore may be attributed to the presence of these phytochemicals.

The antioxidative potential of this medicinal plant was found to be efficacious but depends on the extraction solvent used, and this was found to be more pronounced with ethanol extract. Sahu *et al.* (2013) attributed the increased antioxidant potential with high efficacy of medicinal plants to the positive correlation with high quantity of powerful chain-breaking antioxidants like phenolics and other phytoconstituents. Different mechanisms like scavenging of free radicals, chelation of metal ions, and inhibition of enzymes may be responsible for good therapeutic antioxidant potential of medicinal plants (Soumia *et al.*, 2014).

Food and water - borne diseases are common in developing continents, causing deaths particularly among rural dwellers. This usually is caused by lack of access to potable water, the consumption of under- processed food, contaminated fruits and vegetables and inefficient or inadequate healthcare delivery. The emergence and spread of multidrug resistant pathogens present substantial challenge the healthcare sector and threatens the current antibacterial therapy in a large part of the world especially the developing countries. This therefore necessitated a search for new sources of antimicrobial substances of plant origin since plants produce diverse bioactive compounds of known therapeutic potentials. This study was conducted to assess the antibacterial activity of *Cymbopogon citratus* root extracts against food and water-borne human pathogens.

Although some plant extracts exhibit a good antibacterial activity against different pathogens, the extracts of *Cymbopogon citratus* root showed no antibacterial activity against the test pathogens except *Salmonella typhi*. This result agrees with

the report of Romero *et al.* (2005) which stated that many crude plant extracts exert a limited antibacterial activity against the test bacterial isolates. The ethanol extract of *C. citratus* root showed maximum activity against *S. typhi* compared to the aqueous extract. The susceptibility of *S. typhi* to ethanol extract at 30 - 60 mg/ml compares favorably with Amikacin (18 mm) and Ciprofloxacin (21 mm). This result was similar to those of other studies that reported on the antibacterial activity of methanol extract of *Oxalis corniculata* (Raghavendra *et al.*, 2006).

However, contrary to our findings, antibacterial activity against *S. aureus* was also reported. The difference in results could be attributed to the use of plant extracts in less concentrations of graded doses (20, 30, 40, 50, and 60 mg/ml) compared to that of Raghavendra *et al.* (2006) who used (250mg/ml). The antibacterial activity of *Oxalis corniculata* against *S. aureus* was also reported (Mohan and Pandey, 2016).

The lack of inhibition by the aqueous extract suggests that the active constituents that gave antibacterial activity could not be extracted maximally by distilled water. This assertion is in agreement with Aiyegoro (2008) which stated that non-exhibition of antibacterial activity of aqueous extract on the test organisms as observed in this study, may be attributed to the insolubility of the various organic compounds in water which were responsible for antimicrobial potentials. The effectiveness of action of the ethanol extract seems to be dose-dependent similar to reported by Oboh (2001). Therefore, it can be concluded that the antibacterial activity of the extract is not only dose- dependent, but also on the type and nature of extractant used or differences in solvent system.

From the present study, *S. typhi* is sensitive to ethanol extract of *Cymbopogon citratus* root. Hassan *et al.* (2016) also detected different degrees of antimicrobial activity of *C. tamala* against all tested gram positive and gram- negative bacteria contrary to our result where only *S. typhi*

was found sensitive. The emergence of multidrug resistant variants of *S. typhi* is posing the enormous concern to mankind. The significant activity shown by the extract of *C. citratus* root against *S. typhi* suggests it's potential alternative to fight salmonellosis. The findings from this research revealed that the potency of ethanol extract vary among the organisms whereas all the organisms were resistant to the aqueous extract. This agrees with the report of (Cowan, 1999) that the medicinal value of plants lies in the bioactive phytocomponents present in the plants that dissolve in different solvent systems.

### Conclusion

This study concludes that *Cymbopogon citratus* root contains appreciable amounts of carbohydrate, protein, sodium, potassium, crude fiber and crude fats, diverse biomolecules with antioxidant properties and antibacterial potentials against food and water-borne pathogens in a dose and solvent dependent manner. The root of *Cymbopogon citratus* with the high caloric index suggests its potential as food supplement. Therefore, this plant can be harnessed as a resourceful bioceutical and neutraceutical material and as a potent antibacterial alternative towards improvement of available antibiotics for the treatment of salmonellosis and other food and water-borne diseases. Therefore, the domestication of *Cymbopogon citratus*, will guarantee all- season availability in order to meet the demand for its neutraceutical values. Further study is however, warranted in order to explore their effectiveness against parasites, viruses, and fungi

### Acknowledgement

The authors thank the Technologists of the Biological Science Laboratory of Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria for providing facilities for this research.

## Competing Interest

There is no conflict of interest

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