**Assessment of the Biomolecules Profiles and *In*-*vitro* Biological Activities of *Cymbopogon citratus***

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**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 material medica. The antioxidant properties of *Cymbopogon citratus* roots were estimated using standard analytical procedures, while antibacterial activity was assayed using agar diffusion techniques. Proximate analysis revealed that the sample contains appreciable amount of moisture, crude protein, ash content, crude fat, carbohydrate and crude fibre. The phytochemical analyses of the extracts indicates the presence of alkaloids, saponins, tannins, anthraquineones, steroids, phenols and flavonoids at varying concentrations, helping to deactivate and absorb free radicals. Thus, both 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. This plant also exhibited antibacterial potential against *Salmonella typhi* but inactive on *Escherichia coli*, *Listeria monocytogenes* and *Staphylococcus aureus*. Amount of phytochemicals, antioxidant and antibacterial activities were observed more in ethanol extract compared to aqueous extract. The study suggests the therapeutic actions of the plant extract in salmonellosis and its potentials in nutraceuticals as well as boosting the research in the development of herbal medicine for remedial oxidative effects and microbial infections.

**Keywords:** Bioactive constituents, materia medica, free radicals, antibacterial activity

**Introduction**

Plants have immense impact on the nutrition and health of human exhibiting curative tendency for ailments. Plants contain a wide range of biochemically active compounds that remain the primary source of nutrition and various medicines. In conventional medicines, plants are used as effective raw materials (Sharma and Gupta, 2008). The utilization of these wild plants, mainly those recognized as under-utilized, are known to improve health and nutrition, livelihoods and environmental sustainability. These plants provide vitamins, trace elements and minerals, which are the source of nutraceuticals (Leonti, 2012). Medicinal plants typically contain several different pharmacologically active compounds that may act individually or synergistically to improve health as well as play significant role in the functioning of the body and growth (Afolayan and Jimoh, 2009). Traditionally, these plants are used as food as well as medicines (Ubwa *et al*., 2014). Many ethnobotanical studies suggested that medicinal plants play major role in maintenance of life, especially of the rural community as they are used as drugs and food (Verma and Kaushal, 2014). Researcher enthusiasm lies to re-examine each plant with a new approach regarding their probable use for food and medicine. Primary metabolites such as carbohydrate, proteins, vitamins, sterols and lipids occur in plants and provide food with nutrition (Verma and Kaushal, 2014), while secondary metabolites, such as phenols, flavonoids, tannins, alkaloids, terpenoids, lignin, quinones, coumarins and amines are the best antioxidants (Zheng and Wang, 2001). Similarly, many wild or domesticated plants provide essential biochemical and energy, besides supplementary resources of vitamins and minerals that sustain the suitable physiological equilibrium of the body. However, it has been reported that sometimes nutritional potential of uncultivated plant species is superior compared to the cultivated variety (Ebert, 2014).

Recently, several ethno pharmacological researches focused on wild edibles as nutraceuticals used for the cure of several diseases such as jaundice, diabetes, wounds, and cancer (Mir, 2014). Foods which are obtained from plant are abundant resources of bioactive compounds which have been found to possess a great variety of biological activities including antioxidant potential. Epidemiological studies revealed that the utilization of fruits and vegetables as food is coupled with decline possibility of chronic and neurodegenerative diseases, mostly due to the occurrence of antioxidants (phenolic compounds and tocopherols) that are concerned in the 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. Antibacterials obtained from plants are safer as compare to synthetic drugs due to their natural source. Secondary metabolites of plants such as tannins, flavonoids, quinones, coumarins, terpenoids, alkaloids and polypeptides are frequently responsible for their antimicrobial activity (Savoia, 2012). From native accounts, it has been revealed that holistic healing is found and recorded in the use of natural substances, particularly of plant origin, for preventive and curative potentialities. This is as a result of the phyto-compounds endowed with medicinal plants at diverse range of qualitative and quantitative concentrations. One of the many medicinal plants possessing such healing potentials as indigenously claimed by the practitioners of traditional medicine is *Cymbopogon citratus.*

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

**Materials and Methods**

***Plant material and authentication***

Fresh roots of *Cymbopogon citratus* (Lemon grass) was obtained from Igboegunrin Community in Ilaje Local Government Area of Ondo State, Nigeria and authenticated at the Herbarium of Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria. A voucher specimen number, OAUSTECH/104 was assigned and 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 the Excel Medical Laboratory, Okitipupa, Nigeria. Purity and identity of isolates were confirmed using standard microbiological procedures (Cowan and Steel, 1991).

***Preparation of plant extract***

Root of plant specimen was cut into small pieces and air dried to constant weight at room temperature. The dried sample was ground to powder with mechanical blender machine (model AA255FS, Agilent Technologies, U.S.A). Twenty gram (20 g) of powdered sample was macerated (with occasional shaking) and extracted with 100 ml of 70% ethanol and water, thereafter filtered and the filtrate concentrated to eliminate the ethanol and water under reduced pressure using rotary vacuum evaporator (model AA215FS, Agilent Technologies, U.S.A). Both powdered sample and evaporated extracts were then transferred into airtight containers and stored in a refrigerator at 4˚C until required for use in this study.

***Organoleptic evaluation***

Organoleptic evaluations of the plant root extracts were determined according to the procedural protocols of Gami and Parabia (2010).

***Determination of biomolecules constituent of* *Cymbopogon citratus* *root***

The proximate composition (fiber, moisture, protein, lipid, ash and carbohydrates) of *Cymbopogon citratus* root was determined according to AOAC (2010) procedures, while gross energy value (kcal/100 g) of the sample was determined by multiplying the protein content and carbohydrate contents by 4 and fat content by 9 (AOAC, 2010) i.e.,(Crude protein × 4) + (Total carbohydrate × 4) + (Crude fat × 9).

The minerals present in *Cymbopogon citratus* root were equally determined using standard analytical method described by AOAC (2010). 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 dissolved in 10 ml of 10% HNO3 and heated slowly for 20 minutes and thereafter filtered and 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 following the conditions recommended by the manufacturer.

Ethanol and aqueous extracts of *Cymbopogon citratus* root were made. These were screened for secondary metabolites such as saponins, alkaloids, flavonoids, tannins, steroids, phenolics, cardiac glycosides, anthraquinones, cardenolides and dienolides, chalcones, phlobatannins and terpenes using the procedure described by Harborne (1998).

***In-vitro antioxidant evaluation***

The radical scavenging ability, 1,1-dipheny l- 2 picrylhydrazyl (DPPH) and hydrogen peroxide scavenging activity (HPSA) were tested using the standard analytical method described by Singh *et al*. (2002) while ferric reducing antioxidant power (FRAP), superoxide scavenging activity (SSA) and nitric oxide scavenging activity (NO) were determined as described by Zhao *et al*. (2008). The ability to scavenge hydroxyl radical (HRSA) was measured by the reduction in nitro blue tetrazolium (NBT) according to a previously described method (Hazra *et al*., 2008).

***Antimicrobial activity (Preparation of inoculum)***

Pure culture (one loop) of test organisms *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhi* and *Listeria monocytogenes* were inoculated separately into sterile nutrient broth (3 ml) in Bijou bottle and incubated at 37OC for 24 hr.

***Antibacterial Activities of Cymbopogon citratus root******extract***

Antimicrobial activity of the extracts of *Cymbopogon citratus* root on 24 hr old broth culture of test organisms were determined by agar-well diffusion method. 0.1 ml 24 hr old culture of each culture was introduced to 9.9 ml distilled water to prepare a 1: 100 dilution of each organism (Ogunmefun *et al*., 2016). 20ml of sterile molten MHA prepared in a MacCarthney bottle and cooled to 45oC was inoculated with an aliquot (0.1) ml from the dilution and then shaken to allow thorough mixing. The medium (MHA) - culture mixture was poured into a well-labelled Petri dish and allowed to solidify. The extracts were filtered using 0. 22 micron 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 of the agar. Sterile olive oil was also introduced to fill separate well to serve as negative control (Ogunmefun *et al*., 2016) while standard antibiotic disc (BIOMARK) served as positive control. Triplicate seeded plates with test extracts and controls were allowed to stay on Laboratory bench for 1 hr to allow diffusion of extracts and then incubated at 37OC for 24 hr. This procedure was repeated for each test isolates for ethanol and aqueous extracts. The plates were then observed for zones of inhibition around each well and measured to determine antibacterial activity expressed as R: Resistant (<14mm), M: Mild (14-16mm) and S: Sensitive (>16mm).

***Statistical analysis***

The results of this study were assessed, and data ex-pressed in percentage (%). The Statistical Package for Social Sciences (SPSS) computer software (version 20) and Microsoft Excel (2013) software were used for data analysis.

**Results**

The organoleptic properties of both the ethanol and aqueous extracts of *Cymbopogon citratus* roots, in terms of color, taste, odor and texture were observed and determined. Both the ethanol and aqueous extracts exhibited uniqueness in physicochemical 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 smell |
| Texture | Crystalline | Crystalline |

The amount of carbohydrates, ash and crude fibre were higher than fat and crude proteins in *Cymbopogon citratus* roots. The abundance (%) of the parameters assessed were carbohydrates > ash > crude fibre > moisture > fat > crude proteins order as shown in Figure 1.

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

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

Table 3 presents the results of the quantitative phytochemical composition of the test plant root extracts. The quantitative phytochemical screening of the root extracts of *Cymbopogon citratus* revealed the presence of a variety of plant secondary metabolites such as alkaloids, saponins, tannins, anthraquinones, steroids, flavonoids, and phenols in varying concentrations. The ethanol extract shows higher concentrations of plant 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 antioxidant activity *in vitro* results 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**: Nitic 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-prycryl hydrazyl).

The results of antibacterial activity of the extracts against *E. coli, S. aureus and L. monocytogenes* show the ethanol extract inhibits only the growth of *S. typhi* at various dose levels; with the 60 mg/ml of the extract showing pronounced inhibition while the growth of *E. coli, S. aureus and L. monocytogenesis* were not inhibited (Table 4). The aqueous *Cymbopogon citratus* root extract has no inhibitory effect on the growth of test isolates. Inhibition created by conventional antibiotics used as positive control is shown in Table 4c. The test isolates show varying degree of resistance and sensitivity to the conventional antibiotics ranging from 0 -12 mm (resistant) and 16 – 28 mm (sensitive). Highest inhibition of 28 mm each was exhibited against *Staph. aureus* by ciproflox followed 26 mm exhibited on *L. monocytogenes*. *E. coli* and *Salmonella typhi* also show susceptibility of 24 mm and 21 mm respectively to CIP. The susceptibility of *L. monocytogenes* to the antibiotics was in the order AMP > GEN > ERY > VAN.

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

**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 |
| *Escherichia coli* | 0 | 0 | 0 | 0 | 0 |
| *Staph. aureus* | 0 | 0 | 0 | 0 | 0 |
| *Salmonella typhi* | 0 | 0 | 0 | 0 | 0 |
| *Listeria monocytogenes* | 0 | 0 | 0 | 0 | 0 |

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

**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** |
| *Escherichia coli* | 0 | 0 | 0 | 0 | 8 | 2 | 5 | 24 | 0 | 0 | 7 | 0 | 0 | 8 | 16 | 22 |
| *Staph. aureus* | 12 | 0 | 6 | 0 | 0 | 0 | 7 | 28 | 6 | 0 | 5 | 0 | 0 | 0 | 0 | 0 |
| *Salmonella typhi* | 0 | 0 | 6 | 6 | 6 | 0 | 4 | 21 | 0 | 0 | 0 | 0 | 6 | 12 | 0 | 18 |
| *L.monocytogenes* | 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: Augumentin, VAN: Vancomycin, CPZ: Ceflazidime, CP: Cephaiexin, CHL: Chloramphenicol, CTR: Ceftriaxone, CTX: Cefotaxime, AMK: Amikaein.

**Discussion**

The indiscriminate use of antibiotics in the treatment of bacterial infections ravaging the human race has led to the emergence and spread of multidrug resistant strains constituting a global threat and concern to human health. Plants used in the treatment of diseases contain bioactive principles with biological activity some of which are responsible for the characteristic odor, pungency and color of plants, while others give the particular plant its culinary, medicinal or poisonous virtue (Evans, 2002; Gami and Parabia, 2010). This study provides information about proximate, mineral, anti-nutrient and *in vitro* biological activities of underutilized part of plant species. Almost all human foods are plants or organisms that eat plants. Plants are irreplaceable food sources for humans. Synthetic chemicals and petroleum derivatives can replace many plant-derived medicines, fibers, and dyes; metals, brick, and concrete can replace wood; but there is no substitute for plant-derived foods. The proximate composition of food is a major index of nutritious potentials of plants. This study showed higher carbohydrate and ash contents in the roots of *Cymbopogon citratus* than fibre, moisture, fat, and protein. The crude fiber contents of the plant material showed quantifiable percentage enough to keep the digestive system healthy as the major role of the crude fiber in the human system (Adaji *et al*., 2020). The data obtained show that *Cymbopogon citratus* roots compares favourably with other fast energy giving food stuffs.

The results obtained for nutritionally important mineral constituents such as potassium, calcium, magnesium, sodium and manganese are nutritionally important were in reasonable amount while iron, zinc, phosphorus and selenium were in minimal amount. Their values are comparable with values reported for some other medicinal plants (Adaji *et al*., 2020); and that the roots of *Cymbopogon citratus* contain almost all the minerals needed for proper enhancement of body system functions such as regulation of fluid balance, send nerves signals and regulation of muscle and heart contractions. Adaji *et al*. 2020) reported that these minerals are also known to help reduce blood pressure, help in protection against stroke. Hence, the regular intake of *Cymbopogon citratus* could help in the enhancement of these minerals for body physiological functions. Calcium present was 24.2 mg/100g which make the plant suitable in maintaining strong bones and tooth, it also helps the blood vessel to move blood throughout the body and help releases hormones and enzymes that affect almost every function in the human body (Adaji *et al*., 2020). The minerals such as Mg, P and Ca (mg/100 g) contents of *Cymbopogon citratus* roots were lower than Mg (90.62), P (207.50) and Ca (110.17) contents of cocoyam reported by Ndabikunze *et al*. (2011). The present study showed that roots of *Cymbopogon citratus* is rich in minerals; and according to Njoku and Ohia (2007), consumption of nutrient rich foods such as *Cymbopogon citratus* help the body to utilize protein, carbohydrates and other nutrients. Potassium was found to be the most abundant 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 their habitat. Minerals generally in the diet are required for metabolic reactions, transmission of nerve impulses, rigid bone formation and regulation of water and salt balance among others.

Phytochemicals are classified as primary or secondary constituents, depending on their role in plant metabolism. Primary constituents include the common sugars, amino acids, proteins, purines and pyrimidines of nucleic acids, chlorophyll’s etc. Secondary constituents are the remaining plant chemicals such as alkaloids (derived from amino acids), terpenes (a group of lipids) and phenolics (derived from carbohydrates) (Krishnaiah *et al*., 2007). The evidence-based study about metabolomics of medicinal plants is an emerging approach to develop a new group of phytotherapeutics (Shyur and Yang, 2008). The therapeutic potential of plant secondary metabolites has augmented an interest in pharmaceutical research for the development of novel therapeutic agents. Phytochemical screening of this medicinal plant revealed the presence of saponins, alkaloids, flavonoids, phenols, tannins, steroids, anthraquinones which varies quantitatively from low to highly present among the extraction solvent used. However, more concentrations were found in the ethanol extract compared to the aqueous extract. Polyphenolic compounds and antioxidant activity in the present study, the quantitative phytochemical analysis of ethanol and aqueous 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 percentage concentrations of phenols and flavonoids percentage contributed the anti-oxidant activities of the plant extracts. The maximum antioxidant capacity of the ethanol and aqueous extracts of *Cymbopogon citratus* roots could be due to the presence of phenolic plant secondary metabolites and more importantly, the capacity exhibited was found pronounced with the ethanol extract thereby suggesting that polyphenol compounds remains the primary contributors to the antioxidant capacity/ability possessed by *Cymbopogon citratus* roots.

It is known that saponins inhibit Na+ efflux by blockage of the influx of concentration in the cells, activating a Na+ – Ca2+ antiporter in cardiac muscles. The increase in Ca2+ influx through this antiporter strengthens the contraction of heart muscles (Schneider and Wolfling, 2004). The valuable pharmaceutical properties of *Cymbopogon citratus* may also be attributed to the presence of alkaloids which has been reported to have a stimulating effect, act as topical anaesthetic in ophthalmology, powerful pain reliever, antipuretic action among other uses (Edeoga and Enata, 2001). High Flavonoids level may help provide protection against oxidative stress induced diseases by contributing along with other antioxidant vitamins, and enzyme to the total antioxidative defense system of the human body. Many studies have attributed that antioxidant properties are due to the presence of flavonoids (Harborne and Williams, 2000), hence, that may be a reason for the high lipid peroxidation inhibition found in certain species of the studied botanic. The medicinal values of *C. citratus* therefore may be attributed to the presence of these phytochemicals.

Antioxidants are secondary constituents or metabolites found naturally in the body and in plants such as fruits and vegetables. They are regarded as anything that inhibits or prevents oxidation of a susceptible substrate. Plants produce a very impressive array of antioxidant compounds that includes phenols, carotenoids, flavonoids, cinnamic acids, benzoic acids, folic acid, ascorbic acid, tocopherols and tocotrienols to prevent oxidation of the susceptible substrate (Hollman, 2001). These plant-based antioxidative compounds are believed to have an important role in the maintenance of human health because our endogenous antioxidants provide insufficient protection against the constant and unavoidable challenge of reactive oxygen species (ROS; oxidants) (Fridovich, 1998). The antioxidant profiling of the test medicinal plants (*Cymbopogon citratus* root) was explored through DPPH, HPSA, FRAP, SSA, NO and HRSA protection assays. The antioxidative potential of this medicinal plant was found to be efficacious subject to the various extraction solvent used; and this was found to be more pronounced with ethanol extract. The effectiveness in response of various medicinal plants for antioxidative potential has already been reported by many researchers (Soni and Sosa, 2013). The increased antioxidant potential with high efficacy of medicinal plants may be due to positive correlation with high quantity of powerful chain-breaking antioxidants like phenolics and other phytoconstituents (Sahu *et al*., 2013). 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 death particularly among rural dwellers due the lack of access to potable water and the consumption of under processed food, contaminated fruits and vegetables and inefficient or inadequate healthcare delivery. Antibiotic resistance is a concern that continues to challenge the healthcare sector in a large part of the world in both developing and developed countries. The emergence and spread of multidrug resistant pathogens have substantially threatened the current antibacterial therapy. This has necessitated a search for a new source of antimicrobial substances such as plants as they produce a variety of bioactive compounds of known therapeutic properties. This study has been conducted to assess the antibacterial activity of *Cymbopogon citratus* root extract against food and water-borne human pathogens. Although some plant extracts are known to exhibit a good antibacterial activity towards 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 plant extracts exhibited a limited antibacterial activity against the test bacterial isolates as judged by their MIC values. The ethanol extract of *C. citratus* root showed maximum activity against *S*. *typhi* compared to the aqueous extract. The susceptibility of *S. typhi* to ethanolextract at 30 - 60 mg/ml compares favourably with AMK (18 mm) and CIP (21 mm).This result was similar to those of other studies that reported antibacterial activity of methanol extract of *Oxalis corniculata* (Raghavendra *et al*., 2006)*.* However, contrary to our result, they also reported antibacterial activity against *S. aureus*. The difference in result could be due 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). Mohan and Pandey (2016) also reported that *Oxalis corniculata* is effective against *S. aureus*. This difference in result may be due to the use of different solvent system (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. The mechanism of action of the ethanol extract seems to be dose-dependent similar to the reported by Oboh (2001).

From the present study, it could be seen that ethanol extract of *Cymbopogon citratus* roots exhibits antibacterial activity against *S. typhi*. Hassan *et al*. (2016) detected the antimicrobial activity of *C. tamala* against a number of organisms. They found different degrees of antimicrobial activity against all tested gram positive and gram negative bacteria contrary to our result where only *S. typhi* was found to be sensitive. The emergence of multidrug resistant *S. typhi* is posing the greatest threat to mankind. The significant activity shown by the extract of *C. citratus* root against *S. typhi* suggests that it could be an important alternative to fight Salmonellosis.

It has been widely observed and accepted that the medicinal value of plants lies in the bioactive phytocomponents present in the plants that dissolve in different solvent systems (Cowan, 1999).. It is oblivious from the findings that the ethanol extract was more potent than the aqueous extract. It may be due to the occurrence of different phenolic and polyphenolic compounds as earlier reported by (Cowan, 1999). The non-exhibition of antibacterial bacterial activity of aqueous extract of the test plant extract as observed in this study, may be due to the insolubility of the various organic compounds in water which were responsible for antimicrobial activities (Aiyegoro *et al*., 2008). Phytochemicals such as flavonoids, terpenoids, tannins, and alkaloids present in extract of herbal plants has been reported to possess antihelminthic, antidiarrhoeal, and antimicrobial activities (Cowan, 1999). Although a certain number of extracts exhibited good antibacterial potency. In contrast to our expectation, a limited antibacterial potency of some plants suggests that there is no complete agreement between the traditional uses of medicinal plants in the crude form for the remedy of infectious diseases. Further study, however, is still warranted to explore their effectiveness in inhibiting the growth of parasites, viruses, and/or fungi. Another possibility for the limited antibacterial potency of some plants may be due to the cold percolation extraction method and the use of crude extracts.

**Conclusion**

This study has shown that *Cymbopogon citratus* roothas an appreciable amount of diverse biomolecules, with exhibitory antibacterial activity in the ethanol extract against *S. typhi* in a dose dependent manner. As a result, this important plant can be harnessed as a resourceful bioceutical and neutraceutical material, and as a potent antibacterial compound against salmonellosis.

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**Competing interests**:None

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