



## **Comparative Antimicrobial Activity of Lemon Grass (*Cymbopogon citratus*) and Garlic (*Allium sativum*) Extracts on *Salmonella typhi***

O. F. Olukunle<sup>1</sup> and O. J. Adenola<sup>1\*</sup>

<sup>1</sup>Department of Microbiology, Federal University of Technology, Akure, Nigeria.

### **Authors' contributions**

This work was carried out in collaboration between both authors. Author OJA designed the study, performed the statistical analysis. Author OFO wrote the protocol. Author OJA wrote the first draft of the manuscript. Author OFO managed the analyses of the study. Author OJA managed the literature searches. Both authors read and approved the final manuscript.

### **Article Information**

DOI: 10.9734/JAMPS/2019/v20i230104

#### Editor(s):

(1) Dr. Palmiro Poltronieri, National Research Council of Italy, CNR-ISPA Institute of Sciences of Food Productions, Operative Unit in Lecce, Rome, Italy.

#### Reviewers:

(1) Vivek Kumar Singh, Nepal.

(2) T. Ullaiyah, Sri Krishnadevaraya University, India

Complete Peer review History: <http://www.sdiarticle3.com/review-history/47866>

**Original Research Article**

**Received 30 November 2018**

**Accepted 07 March 2019**

**Published 28 March 2019**

### **ABSTRACT**

In the genesis of using plants for treatment of diseases, Garlic and lemon grass were some of the earliest plants that have proven effective. In this study the antimicrobial effect of *Cymbopogon citratus* (lemon grass) and *Allium sativum* (garlic) extracts on clinical isolate of *Salmonella typhi* was examined. Water, ethanol and methanol were used as extraction solvent. Antimicrobial effects of conventional antibiotics was assayed using disc diffusion method while antimicrobial activity of lemon grass and garlic extracts were carried out using agar well diffusion method and the zones of inhibition was measured in millimeter (mm). Comparatively, the highest percentage yield of extract was observed in water extract of garlic (21.83%) and lemon grass (6.67%). Ciprofloxacin and Perfloxacin have the highest zones of inhibition of 19.73±0.24mm and 14.47±0.31mm respectively against the clinical isolates of *Salmonella typhi*. Two out of the twelve clinical isolate of *Salmonella typhi* used were multi drug resistant. Lemon grass extracts did not show any antimicrobial effects on the clinical isolates of *Salmonella typhi* while garlic extracts showed antimicrobial effect at the

\*Corresponding author: E-mail: adenolajesse@gmail.com;

concentration of 800 mg/ml, water extract of garlic has the highest zone of inhibition (14.00 mm) against the tested isolates. Therefore garlic extract could be used for the formulation of drug and treatment of *Salmonella typhi* infection.

**Keywords:** *Salmonella typhi*; *Cymbopogon citrates*; *Allium sativum*; antimicrobial effects.

## 1. INTRODUCTION

*Salmonella* remains a primary cause of food poisoning worldwide, and massive outbreaks have been witnessed in recent years. *Salmonella* spp. are Gram negative, heterotrophic, mesophilic bacteria that present in warm-blooded animal hosts and are an important human pathogen associated with poultry and poultry products. Up to now, *Salmonella* is the most commonly identified bacterial agent causing illnesses, such as typhoid fever in humans [1]. Typhoid fever still causes substantial illness and deaths in many parts of the world, especially in developing nations [2]. According to a report published in World Health Organization bulletin in 2000, the estimated global incidence of typhoid fever was about 21.6 million and mortality rate was up to 216,000 per year. The highest incidence rate of typhoid fever (more than 100/100,000 cases per year) has been reported in south-central Asia and south-east Asia [3]. In 2008, it was reported that the incidence of typhoid fever is 451/100,000 per year in Pakistan [4]. Multi drug resistant (MDR) *Salmonella typhi* showed resistance to all three first line drugs {Ampicillin (AMP), Chloramphenicol (C), and Trimethoprim-sulfamethoxazole (SXT)} [5]. MDR *Salmonella typhi* emerged somewhere in the mid 1990s and are now reported in different regions of the world [6,7]. Under these circumstances, third generation cephalosporin namely, ceftriaxone (CRO) appears to be the most reliable choice for MDR and nalidixic acid resistant isolates of *Salmonella typhi* (NARST) [8,9]. This continuous spread of MDR pathogens and cost effectiveness of drug regimen has become a serious threat to public health and infection control practitioners. The multiple and repeated difficulties with antibiotics has prompted researchers to explore alternate agents. The plant world is an immense store of pharmacologically active chemical compounds which exist as secondary phytoconstituents. The beneficial medicinal effect of plant materials typically result from the combination of secondary products present in the plant. The medicinal action of plants are unique to particular plant species or a related group [10,11,12,13,14]. This concept is consistent with the fact that the

combinations of secondary products in a particular plant are often taxonomically distinct. The secondary products can have a variety of functions in plants at the cellular level as plant growth regulators, modulators of gene expressions, in signal transduction and also have protective actions in relation to abiotic stresses [15]. So, it is likely that their ecological function may have some bearing on potential medicinal effects for humans and animals as well. The antimicrobial properties of *Cymbopogon citratus* (lemon grass) and garlic (*Allium sativum*) extract has led to the selection of these plants for these research. Lemon grass belongs to the section of *Andropogon* called *Cymbopogon* of the family Graminae. A very large genus of the family, including about 500 described species out of which eight species occur in Iraq. Due to the production of lemon grass oil as major component, two of the species i.e. *Cymbopogon citratus* and *Cymbopogon flexuosus* are generally called Lemon grass [16]. Medicinal use of lemon grass is known to mankind since antiquity. Its oil has been used to cure various ailments like cough, cold, spitting of blood, rheumatism, lumbago, digestive problems, bladder problems, leprosy, and as mouth wash for the toothache and swollen gums. It is also been claimed to be stimulating, diuretic, anti-purgative and sudorific to reduce fever [17]. Similarly pharmacological investigation on the essential oil of *C. citratus* revealed that it has a depressant effect on the Central Nervous System [18]. It has analgesic and antipyretic properties. The extract juice from the lemon grass contains inhibitor of the promotion stage of carcinogenesis induced by cotton oil. It is an oral anti tumor drug for the cancer and in combination with cyclodextrin lengthened the survival time [19] and [20]. Gallstone dissolving preparations have been made of oil [21]. The lemon grass contains high percentage of Vitamin C, which is a characteristic of plants used as drug e.g., belladonna and jaborandi. Lemon grass oils show activity towards the phyto pathogenic fungi. Phytotherapeutic agents like garlic (*Allium sativum*) which is frequently used in alternative medicine has gained immense interest in medical literature [4,22]. Recently, garlic has been found to be an effective agent for its

application as anti-tumor, anti-oxidant, anti-viral, anti-fungal, anti-microbial, anti-thrombotic, anti-inflammatory, hypoglycemic, immune modulatory effects [23]. Garlic holds up the highest concentration of sulfur compounds like allicin and others having biological activities. These are responsible for not only its pungent smell but also for its medicinal value [24]. The thiosulfate allicin has effective anti-microbial properties and other non-sulphur constituents like proteins, saponins and phenolic compounds may also contribute to its anti-microbial activity [25]. Garlic is present in various forms namely, raw juice, garlic oil, garlic powder, and many types of extracts like, aged garlic extract, aqueous garlic extract (AGE), methanolic extract, ethanolic extract and many more [24]. Different garlic extract preparations demonstrated their *in-vitro* activity against Gram-negative and Gram-positive bacteria including species of *Escherichia*, *Staphylococcus*, *Streptococcus*, *Klebsiella*, *Proteus*, *Bacillus*, *Clostridium* and even acid fast bacilli (AFB) such as *Mycobacterium tuberculosis* (MTB). It is also effective against antibiotic resistant isolates like methicillin-resistant *Staphylococcus aureus* (MRSA) as well as other MDR enterotoxigenic isolates of *Escherichia coli* (ETEC), *Salmonella Goldcoast* and *Klebsiellae* [26] and also MDR MTB [24]. Garlic having multiple biological properties; inspired to investigate local cultivated garlic (small cloves) for its anti typhoid effects against sensitive and MDR *Salmonella typhi* isolates which might be helpful in combating this public health concern issue.

## 2. MATERIALS AND METHODS

### 2.1 Source and Identification of Test Microorganism

Stock cultures of *Salmonella typhi* used in this study were collected from Don Bosco Hospital, Akure, Ondo State, Nigeria. Each isolates were sub-cultured on salmonella shigella agar (SSA) and identified based on their colonial, morphology and specific biochemical reactions.

The suspected colonies of *Salmonella typhi* that developed on Salmonella Shigella Agar were sub cultured by streaking on a freshly prepared nutrient agar plates until pure colonies were obtained according to the conventional procedure as highlighted by [27]. This was followed by characterization of the isolates using [28]. *Salmonella typhi* colonies that identified were cultured on double strength nutrient agar

slant and incubated at 37°C for 24 hours, growth was observed and the slants were stored in the refrigerator to preserve the bacterial isolate. The isolate on slants were sub cultured on freshly prepared double strength nutrient agar slant subsequently.

### 2.2 Source of Plants Used in this Study

Fresh garlic (*A. sativum*) was purchased from Oba's market, Akure, Ondo State, Nigeria while Lemon grass was collected within FUTA South Gate area. The lemon grass were separated from stems, washed in clean water and dried at room temperature. The dried grasses were milled to a fine powder, and stored in an airtight container at room temperature until when required. The cloves of garlic were separated and peeled to obtain the edible portion. Four hundred and thirty five grams of the edible portion of garlic was chopped using pestle and mortar and was divided into three equal weights.

### 2.3 Preparation of Water, Ethanol and Methanol Extracts of Lemon Grass and Garlic

Dried lemon grasses were extracted by weighing samples of 264 g of finely grounded dried lemon grass into three equal sizes. Each portion was homogenized in 900 ml of sterile distilled water, ethanol and methanol. The homogenate were kept in a covered sterile container for three days. The garlic extracts were prepared according to the methods of [22], four hundred and thirty-five grams of the edible portion of garlic was chopped using pestle and mortar and was divided into three equal weights. Each of the three weighed chopped garlic was homogenized in 700 mls of sterile distilled water, ethanol and methanol respectively in a blender. Sterile muslin cloth was used to remove the large particles from the homogenate and then filtered using Whatman No. 1 filter paper. Extracts obtained were then concentrated in vacuum using rotary evaporator to remove the solvents [29]. The extraction efficiency was quantified by determining and comparing the weight of each of the extracts yield.

### 2.4 Standardization of Inoculum Using McFarland Turbidity Standard

McFarland turbidity standard which was used to measure the density of bacterial cells was prepared according to the method of [30]. The

standardized inoculum was used for antibacterial assay.

### 2.5 Antimicrobial Susceptibility Test for *Salmonella typhi*

Antibiotic susceptibility patterns of *Salmonella typhi* was determined by disc diffusion method with the use of Mueller-Hinton agar, according to the Bauer-Kirby method [31]. The following clinical antibiotics, with their concentrations given in parentheses were used as recommended by [32]; Tarivid Ofloxacin (30 µg), Gentamicin (20 µg), Chloramphenicol (30 µg), Augmentin (30 µg), Ciprofloxacin (10 µg), Amoxicillin (30 µg), Streptomycin (10 µg), Sparfloxacin (10 µg), Septrin (30 µg), and Pefloxacin (10 µg). The zone of inhibition was noted and recorded in millimeter.

### 2.6 Antibacterial Activity of Plant Extracts

Each of the plant extracts was screened for antimicrobial activity by performing agar well diffusion assay following the method of [33]. The recovered plant extracts were being reconstituted using 30% v/v Dimethyl sulfoxide and sterilized (by filtration) using autoclavable sterile injection filters of 0.22 µm pore size. The various plant extracts to be screened were reconstituted to

concentration of 800 mg/ml and about 0.5 ml each were introduced to the agar wells in each of the seeded agar. The negative control for the experiment was 30% aqueous DMSO while Ciprofloxacin (50 mg/ml) was used as the positive control. All the plates were incubated at 37°C for 24 hours after which the zone of inhibition was measured.

### 2.7 Data Analysis

Data were statistically analyzed using SPSS (Statistical Package for Social Science) version 20, mean zones of inhibitions were separated using new Duncan’s Multiple Range Test and significant differences were value at  $p \leq 0.05$ .

## 3. RESULTS

### 3.1 Morphological, Biochemical Characterization and Identification of the Clinical Isolates

All bacterial isolates showed different biochemical reactions and were characterized and identified. Thirty eight [34] isolates were identified as *Salmonella* species in which twelve [12] were *Salmonella typhi* and twenty six [26] were identified as other *Salmonella* species.

Table 1. Effects of extraction solvent on percentage yield of plant extract

Solvents	Garlic (%)	Lemon grass (%)
Methanol	16.48±0.01 <sup>a</sup>	4.15±0.08 <sup>b</sup>
Ethanol	16.31±0.57 <sup>a</sup>	3.69±0.12 <sup>a</sup>
Water	21.83±0.58 <sup>b</sup>	6.67±0.11 <sup>c</sup>

Values are presented as % mean ± SE, values in the same column with same superscript are not significantly different according to Duncan’s multiple range test at  $p \leq 0.05$ ; Key: SE- Standard Error, %: Percentage

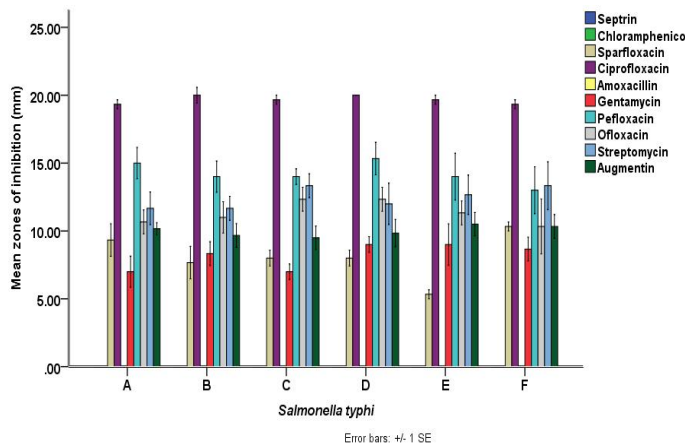


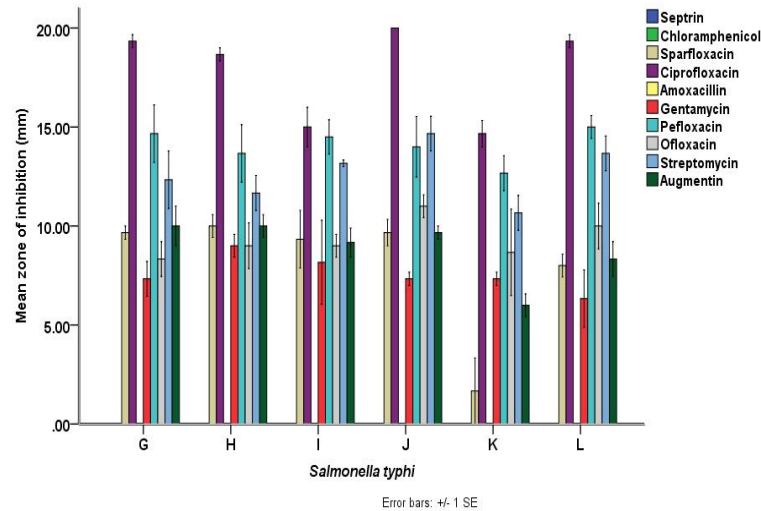
Fig. 1. Antibiotics susceptibility test of clinical isolates *Salmonella typhi* (isolates A-F)

**Table 2. Antimicrobial susceptibility test of the plants extracts**

<i>Salmonella</i> isolates	Zones of inhibition (mm)						
	Ciprofloxacin (50 mg/ml)	GM (800 mg/ml)	GE (800 mg/ml)	GW (800 mg/ml)	LM (800 mg/ml)	LE (800 mg/ml)	LW (800 mg/ml)
I	7.00±0.17 <sup>d</sup>	4.50±0.18 <sup>c</sup>	2.50±0.00 <sup>b</sup>	7.00±0.63 <sup>d</sup>	0.00±0.00 <sup>a</sup>	0.00±0.00 <sup>a</sup>	0.00±0.00 <sup>a</sup>
K	7.00±0.57 <sup>c</sup>	0.00±0.00 <sup>a</sup>	1.00±0.58 <sup>b</sup>	10.00±0.05 <sup>d</sup>	0.00±0.00 <sup>a</sup>	0.00±0.00 <sup>a</sup>	0.00±0.00 <sup>a</sup>

Values are presented as mean ± SE, values in the same row with same superscript are not significantly different according to Duncan's multiple range test at  $p \leq 0.05$

Key: GM- Methanol extract of Garlic, GE- Ethanol extract of Garlic, GW- Water extract of Garlic, LM- Methanol extract of Lemon grass, LE- Ethanol extract of Lemon grass, LW- Water extract of Lemon grass and SE-Standard Error



**Fig. 2. Antibiotics susceptibility test of clinical isolates *Salmonella typhi* (isolates G-L)**

**Table 3. Minimum inhibitory concentration (MIC) of plants extracts on clinical isolate of *Salmonella typhi***

<i>Salmonella</i> isolates	MIC (mg/ml)						
	Ciprofloxacin	GM	GE	GW	LM	LE	LW
I	50.00	450.00	550.00	150.00	1300	1300	1400
K	50.00	600.00	500.00	150.00	1300	1350	1450

Key: GM- Methanol extract of Garlic, GE- Ethanol extract of Garlic, GW- Water extract of Garlic, LM- Methanol extract of Lemon grass, LE- Ethanol extract of Lemon grass, LW- Water extract of Lemon grass

**Table 4. Minimum bactericidal concentration (MBC) of plants extracts on clinical isolate of *Salmonella typhi***

<i>Salmonella</i> isolates	MBC (mg/ml)						
	Ciprofloxacin	GM	GE	GW	LM	LE	LW
I	100.00	500.00	600.00	200.00	1350	1400	1500
K	100.00	650.00	550.00	200.00	1400	1400	1500

Key: GM- Methanol extract of Garlic, GE- Ethanol extract of Garlic, GW- Water extract of Garlic, LM- Methanol extract of Lemon grass, LE- Ethanol extract of Lemon grass, LW- Water extract of Lemon grass

### 3.2 Percentage Yield of the Extracts for Each Solvent

Mean percentage yield of the extracts are shown in Table 1. The result revealed that there was significant difference ( $p \leq 0.05$ ) in the percentage yield of the extracts for the solvents ranging from 16.31% to 21.83% (Garlic) and 3.69% to 6.67% (Lemon grass). Percentage yield of water extract was significantly ( $p \leq 0.05$ ) higher than the yield from methanol and ethanol respectively in both plants.

### 3.3 Antibiotics Susceptibility Test of Clinical Isolates of *Salmonella typhi*

The antibiotics susceptibility test of clinical isolates of *Salmonella typhi* were carried, the zones of inhibition of commercially available antibiotics were measured in millimeter (Figs. 1 and 2). Ciprofloxacin has highest mean zone of inhibition ranging from  $19.33 \pm 0.33$  to  $20.00 \pm 1.00$  mm followed by Pefloxacin having mean zone of inhibition ranging from  $13.00 \pm 0.58$  to  $15.00 \pm 1.7$  mm while Septrin, Chloramphenicol and Amoxicillin has no zone of inhibition against all the tested isolates. The zones of inhibition of all antibiotics used were significantly ( $p < 0.05$ ) low against isolates I and K.

### 3.4 Antimicrobial activity of plant extracts on *Salmonella typhi*

The result revealed that there was significant difference ( $p \leq 0.05$ ) in the inhibition of growth of *Salmonella typhi* (Table 2). Significant inhibition was observed in garlic extracts at concentration of 800 mg/ml on *Salmonella typhi*. Garlic

extracts inhibited the growth of isolates, 4.50, 2.50 and 7.00 mm for methanol, ethanol and water extracts respectively. There was no significant inhibition observed in lemon grass extracts at same concentration.

### 3.5 Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of Plants Extracts on *Salmonella typhi*

The result revealed that there were significant differences ( $p \leq 0.05$ ) in the MIC and MBC of the plants extracts from various solvents against *Salmonella typhi* (Tables 3 and 4). The MIC of the methanol, ethanol and water extracts of garlic for *Salmonella typhi* isolate I and K were (450.00 mg/ml, 550.00 mg/ml and 150.00 mg/ml) and (600.00 mg/ml, 500.00 mg/ml and 150.00 mg/ml) respectively while the MBC were (500.00 mg/ml, 600 mg/ml and 200 mg/ml) and (650.00 mg/ml, 550 mg/ml and 200.00 mg/ml) respectively. The MIC of the Methanol, ethanol and water extracts of lemon grass for *Salmonella typhi* isolate I and K were higher than what was observed in garlic extracts.

## 4. DISCUSSION

The results obtained in this study validate that the disease caused by antibiotic resistant *Salmonella typhi* can be treated with natural products such as garlic. Garlic and lemon grass were extracted with methanol, ethanol and water. Percentage yield from water was significantly ( $p \leq 0.05$ ) higher than the yield from methanol and ethanol, which it is in accordance with the findings of [35]. In this study the zone of inhibition

of commercially available antibiotics to clinical isolates of *Salmonella typhi* were measured in millimeter. Methanol, ethanol and water extract of garlic shows antimicrobial activity against the isolate of *Salmonella typhi*. Aqueous extract of garlic has the maximum inhibition against the isolates of *Salmonella typhi* followed by methanol and ethanol extracts. This is in agreement with the findings of [36] who reported that crude extract of garlic clove has maximum inhibition against *Salmonella typhi* followed by methanolic extract of garlic clove. This is also similar to the findings of [37] in the *in vitro* use of garlic, as antibacterial agent against *Salmonella typhi*. It showed that garlic has antibacterial activities against *Salmonella typhi*. There was no significant inhibition for lemon grass extracts at concentration of 800 mg/ml. Methanol, ethanol and water extracts of lemon grass shows no antimicrobial activity. This is in line with the study carried out by [38], who also reported that ethanol extract of lemon grass had no antimicrobial activity on the test organisms. However, the findings of [34], showed that chloroform extract of lemon grass demonstrated antimicrobial activity against isolate of *Salmonella typhi*. The inhibitory activities of the chloroform lemon grass extract on the test organisms indicate that the plant possess high active ingredients which may be chloroform soluble [34]. The result revealed that there was significant difference ( $p \leq 0.05$ ) in the MIC and MBC of the two plants extracts from various solvents against *Salmonella typhi*. The MIC and MBC of the Methanol, ethanol and water extracts of lemon grass for *Salmonella typhi* isolates I and K were on the high side. This may be due to low antimicrobial properties present in water, ethanol and methanol extracts of lemon grass [34].

## 5. CONCLUSION

This study has shown that water extract of garlic could be incorporated to established treatment of *Salmonella typhi* infection. However, further research should be carried out on garlic for its effectiveness.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Agnieszka C, Katarzyna Ś. Campylobacteriosis, salmonellosis, yersiniosis, and Listeriosis as Zoonotic Foodborne Diseases: A review. International Journal of Environmental Research and Public Health. 2018;15(5): 863.
2. Radhakrishnan A, Als D, Mintz ED, Crump JA, Stanaway J, Breiman RF, Bhutta ZA, Introductory article on global burden and epidemiology of typhoid fever. American Journal of Tropical Medicine and Hygiene. 2018;99(Suppl 3):4–9.
3. Akinyemi KO, Oyefolu AO, Mutiu WB, Iwalokun BA, Ayeni ES, Ajose SO, Obaro SK. Typhoid fever: Tracking the trend in Nigeria. American Journal of Tropical Medicine and Hygiene. 2018;99(Suppl 3): 41-47.
4. Saima I, Faiza J, Farhan R, Abdul Hannan, In-Vitro Synergy of Aqueous Garlic Extract with Ciprofloxacin Against Clinical Isolates of *Salmonella typhi*. Annals of PIMS-Shaheed Zulfiqar Ali Bhutto Medical University, Islamabad, Pakistan. [S.I.]. 2018;14(2):111-116. ISSN: 1815-2287.
5. Rajesh DJ, Sachin K, Deepak MJ, Basudha S, Ganesh D, Kiran PA, Sanjit S, Yashad D. Antimicrobial sensitivity trend in blood culture positive enteric fever at Kathmandu Model Hospital. Journal of Nepal Health Research Council. 2018; 16(2).
6. Ward LR, Threlfall EJ. Decreased susceptibility to ciprofloxacin in *Salmonella enterica* serotype Typhi in the United Kingdom. Emerging Infectious Disease Journal. 2001;7:448-450.
7. Parry CM, Hien TT, Dougan G. Typhoid fever. The New England Journal of Medicine. 2002;347(22):1770-82.
8. Bandyopadhyay R, Balaji V, Yadav B, Jasmine S, Sathyendra S, Rupali P, Effectiveness of treatment regimens for Typhoid fever in the nalidixic acid-resistant *Salmonella typhi* (NARST) era in South India. Tropical Doctor. 2018;1-7.
9. Bhutta ZA. Current concepts in the diagnosis and treatment of typhoid

- fever. British Medical Journal. 2006; 333:78–82.
10. Archana S, Abraham J. Comparative analysis of antimicrobial activity of leaf extracts from fresh green tea and black tea on pathogens. Journal of Applied Pharmaceutical Science. 2011;8:149-152.
  11. Umashanker M, Shruti S. Antipyretic, antiulcer, anti-diabetic and anticancer: A review. International Journal of Research in Pharmacy and Chemistry. 2011;1(4): 1152–1159.
  12. Mahima, Verma AK, Kumar A, Rahal A, Kumar V, Roy D. Inorganic versus organic selenium supplementation: A review. Pak. Journal of Biological Sciences. 2012;15: 418-425.
  13. Midrarullah H, Attaullah Samiullah, Sikandar, Ali MS. Traditional uses of medicinal plants for the treatment of livestock ailments in Udigram Swat, Khyber Pakhtunkhwa, Pakistan. Research Opinions in Animal and Veterinary Sciences. 2014;4:138-141.
  14. Rahal A, Mahima A, Verma K, Kumar A, Tiwari R. A phytonutrients and nutraceuticals in vegetables and their multi-dimensional medicinal and health benefits for humans and their companion animals: A review. Journal of Biology and life Science. 2014a;14:1-19.
  15. Rahal A, Kumar A, Singh V, Yadav B, Tiwari R, Chakraborty S, Dhama K. Oxidative stress, prooxidants and antioxidants: The interplay. BioMed Research International; 2014b. DOI: 10.1155/2014/761264
  16. Lawal OA, Ogundajo AL, Avoseh NO, Ogunwande IA. Cymbopogon citrates. Medicinal spices and vegetables from Africa. Therapeutic Potential against Metabolic, Inflammatory, Infectious and Systemic Diseases. 2017;397–423.
  17. Venzon L, Mariano LB, Somensi LB. Essential oil of *Cymbopogon citratus* (lemongrass) and geraniol, but not citral, promote gastric healing activity in mice. Biomed Pharmacother. 2018;98: 118-124.
  18. Ayandele AA. The phytochemical analysis and antimicrobial screening of extracts of *Olax subscorpioidea*. African Journal of Biotechnology. 2007;6(7):868-870.
  19. Mostafa AA, Al-Askar AA, Almaary KS, Dawoud TM, Sholkamy EN, Bakri MM. Antimicrobial activity of some plant extracts against bacterial strains causing food poisoning diseases. Saudi Journal of Biological Sciences. 2018;25(2):361–366.
  20. Parekh J, Chanda S. *In vitro* screening of antibacterial activity of aqueous and alcoholic extracts of various Indian plant species against selected pathogens from Enterobacteriaceae. African Journal of Microbiology Research. 2007;1(6):92-99.
  21. Elastal ZY, Aera A, Aam A. Antimicrobial activity of some medicinal plant extracts in Palestine. Pakistan Journal Medical Sciences. 2005;21(2):187.
  22. Iwalokun BA, Ogunledun A, Ogbolu DO, Bamiro SB, Jimi-Omolaja J. *In vitro* antimicrobial properties of garlic extract against multidrug-resistant bacteria and candida species from Nigeria. Journal of Medicinal Food. 2004;7:327-3.
  23. Abraham AB, Montserrat TG, Omegar S R, Fernando GA, Raúl AG, Edilia T, Laura G S, Horacio O. Immunomodulatory Effects of the Nutraceutical Garlic Derivative Allicin in the Progression of Diabetic Nephropathy. International Journal of Molecular Sciences. 2018;19(10):3107.
  24. Sani I, Umar R, Hassan S. Potential alternatives for resolving bacterial antibiotic resistance. European Journal of Pharmaceutical and Medical Research. 2018;5:2018.
  25. Awan K, Butt M, Ashfaq F, Munir H, Suleria H, Ansar R. Prophylactic potential of conventional and supercritical garlic extracts to alleviate diet related malfunctions. Recent Patents on Food, Nutrition & Agriculture. 2018;10(10): 2174.
  26. Lee SN, Sang HL, Hyun JS, Song-Ee LH. Antibacterial activity of aqueous Garlic extract against *Escherichia coli* O157:H7, *Salmonella typhi* murium and *Staphylococcus aureus*. Journal of Food Hygiene and Safety. 2015;30:210-216.
  27. Fawole MO, Oso BA. Laboratory manual of microbiology Revised Edition. Spectrum Books Limited, Ibadan, Nigeria. 2001;127.
  28. Holt JG, Kreig NR, Sneath PH, Staley J T, Williams ST. Bergey's Manual of determinative bacteriology; 9<sup>th</sup> Edition. Williams and Wilkins, Baltimore, USA; 1994.
  29. Oluduro AO. Evaluation of antimicrobial properties and nutritional potentials of *Moringa oleifera* Lam. leaf in South Western Nigeria, Malaysian Journal of Microbiology. 2012;8(2):59-67.



30. Cheesbrough M. District laboratory practice in tropical countries. 2<sup>nd</sup> Edition., Cambridge University Press, Cambridge, UK; 2006. ISBN: 13:9781139449298.
31. Bauer AW, Kirby WM, Sherris JC. Antimicrobial susceptibility testing by standardized single disc method. America Journal of Clinical Pathogenicity. 1966; 45:493-496.
32. Committee for Clinical Laboratory Standards Interpret Chart Performance Standards for Antimicrobial Susceptibility Testing; Twenty-Fourth Informational Supplement. CLSI document M100-S24 Wayne, PA. 2014;34(1):50-98. ISBN: 1-56238-898-3.
33. Abdelbasset M, Djamila K. Antimicrobial activity of autochthonous lactic acid bacteria isolated from Algerian traditional fermented milk "Riab". African Journal of Biotechnology. 2008;7(16):2908-2914.
34. Ewansiha J, Garba S, Mawak J, Oyewole, O. Antimicrobial Activity of *Cymbopogon citratus* (Lemon Grass) and It's Phytochemical Properties. Frontiers in Science. 2012;2(6):214-220.
35. Mona E, Safinaz ME. Scavenging activity of different Garlic extracts and Garlic powder and their antioxidant effect on heated sunflower oil. American Journal of Food Technology. 2015;10:135-146.
36. Gaherwal S, Johar F, Wast N, Prakash M. Anti-bacterial activities of *Allium sativum* against *Escherichia coli*, *Salmonella* Ser. Typhi and *Staphylococcus aureus*. International Journal of Microbiological Research. 2014;5(1):19-22.
37. Adebolu T, Adeoye O, Oyetayo V. Effect of Garlic (*Allium sativum*) on *Salmonella typhi* Infection, Gastrointestinal Flora and Hematological Parameters of Albino Rats. African Journal of Biotechnology. 2011;10(35): 6804-6808.
38. Akiyama H, Fujii K, Yamasaki O, Oono T, Iwatsuki K. Antibacterial action of several tannins against *Staphylococcus aureus*. Journal of Antimicrobials Chemotherapy. 2001;48(4):487-91.

© 2019 Olukunle and Adenola; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

The peer review history for this paper can be accessed here:  
<http://www.sdiarticle3.com/review-history/47866>