

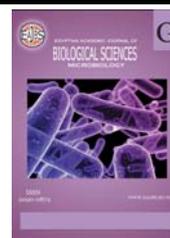
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## Antibacterial activities of crude extracts of nigerian spices and herbs on enteropathogens

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### ARTICLE INFO

#### Article History

Received: 29/11/2014

Accepted: 29/12/2014

#### Keywords:

Antimicrobial  
Enteric pathogens  
Herbs  
Spices  
Nigeria

### ABSTRACT

**Aim:** This study was designed to evaluate the antibacterial activities of water and ethanolic extracts of Nigerian herbs and spices against enteric pathogens.

**Methodology:** Crude extracts of fresh leaves of *Ocimum gratissimum*, *Psidium guajava*, *Vernonia amygdalina*, *Kigelia africana*, *Azadirachata indica*, *Pistia stratiotes*, *Euphorbia hirta*; bulb of *Allum sativum* and rhizomes of *Zingiber officinale* and *Curcuma longa* were evaluated using the agar diffusion assay method and minimal inhibitory concentration (MIC) to determine the antibacterial activities against *Vibrio cholerae*, *Escherichia coli* and *Salmonella sp.* Gentamicin (28 mg/ml) was used as antibiotic control.

**Results:** Antimicrobial sensitivity test indicated that while *Salmonella sp.* was not inhibited by ethanolic extracts of *Euphorbia hirta* and *Curcuma longa*, both water and ethanolic extracts of others inhibited the growth of *Vibrio cholerae*, *Escherichia coli* and *Salmonella sp.* to varying degree. The minimal inhibitory concentrations (MIC) determined for the crude extracts of the various herbs and spices, using water and aqueous ethanol inhibited the test isolates at high dilutions.

**Conclusion:** This study has shown the antibacterial potential of the herbs and spices against the tested enteric pathogens. The antibacterial activities of all the herbs and spices observed in this study justify their use in alternative medicine.

### INTRODUCTION

Medicinal plants have been used for centuries before the advent of orthodox medicine. Leaves, flowers, stems, roots, seeds, fruit, and bark can all be constituents of herbal medicines. The medicinal values of these plants lie in their component phytochemicals, which produce definite physiological actions on the human body. The most important of these phytochemicals are alkaloids, tannins, flavonoids and phenolic compounds (Akinmoladun *et al.*, 2007; Doughari and Manzara, 2008).

Medicinal plants are distributed worldwide, but they are most abundant in tropical countries (Calixto, 2000; Lewis, 2001).

The use of medicinal plants as herbal remedies to prevent and cure several ailments differ from community to community (Sharif and Banik, 2006; Kubmarawa *et al.*, 2007).

The objective of this research work was to determine the antibacterial properties of some indigenous medicinal plants and spices on certain enteric pathogen known to be responsible for dysentery and diarrhoea.

## MATERIALS AND METHODS

### Collection of medicinal plants and spices

Fresh leaves of *Ocimum gratissimum*, *Psidium guajava*, *Vernonia amygdalina*, *Azadirachta indica*, *Kigelia africana* and *Ficus exasperata*, were collected from a farm in Abeokuta while the fresh leaves of *Pistia stratiotes* was collected from the fish pond of the Department of Fisheries and Aquaculture Management, University of Agriculture, Abeokuta. Fresh plant of *Euphorbia hirta* was collected from the garden of the Department of Forestry and Wild life Management, University of Agriculture, Abeokuta. Fresh bulb of *Allium sativum*, fresh rhizome of *Zingiber officinale*, *Curcuma longa* and dried leaves of *Nymphae lotus* were purchased from a local market in Abeokuta. However, the method adopted for the extraction of herbs and spices extracts in this research work was based on how the various plants and spices are being used locally.

### Extraction of plant and spice samples

#### Water extracts of herbs and spices

A hundred gram (100g) each of *Ocimum gratissimum*, *Vernonia amygdalina*, *Psidium guajava* and spices *Allium sativum*, *Curcuma longa* and *Zingiber officinale* were weighed, cut into pieces and mashed separately. The liquids were filtered out using sieve from the mashed samples and the volume of each extract obtained was recorded and stored at 4°C. Decoctions of *Nymphae lotus*, *Euphorbia hirta*, *Ficus exasperata*, *Azadirachta indica*, *Kigelia africana* and *Pistia stratiotes* were prepared by weighing (100g) into 100ml of distilled water, followed by cooking in earthen pots.

### Ethanolic extraction of herbs and spices

Ethanol extraction of the medicinal plant and spices was done by adding 100g of each sample into 100ml of 50% aqueous ethanol. The extractions were allowed to stand for 48 hours after which they were filtered to obtain the filtrates. The filtrates were placed in a water bath at 60°C to evaporate the ethanol fractions. The concentrations (mg/ml) of each plant extract was quantified by measuring 1ml of filtrate into a pre-weighed glass dish and dried in hot air oven at 60°C.

### Collection of bacterial Isolates

Clinical isolates of *Escherichia coli* and *Salmonella sp.* were collected from the University College Hospital (UCH) Ibadan, while epidemic strain of *Vibrio cholerae* was collected from the stock culture of Department of Microbiology, Federal University of Agriculture, Abeokuta. Cultures of these bacteria were grown on a Nutrient Agar slant at 37°C for 24 hours, from which they were subjected to morphological and biochemical tests to authenticate the bacterial isolates.

### Antibacterial activities of plants on test isolates

The agar diffusion method described by Ver-poorte *et al.* (1988) was used. Inocula of test organisms obtained from source were prepared by growing each pure isolate in Nutrient broth for 18 h at 37 °C. The overnight broth culture was matched with McCfarland turbidity standard at 0.100 at 600nm. One milliliter (1 ml) of the standardized broth culture was then used to seed Nutrient agar medium which had been allowed to cool and then poured into sterile petridishes. Crude extracts (0.1ml) were delivered into wells (18 mm in diameter) bored unto the surface of the already seeded Nutrient Agar plates. Gentamicin (28µg) was used as the control. The plates were later incubated at 37°C for 18 h. After incubation, zone of inhibition around the wells were measured and recorded.

### Determination of minimum inhibitory concentration (MIC)

The crude extracts were incorporated into Nutrient Broth at concentrations ranging from 1:2, 1:4, and 1:8. A positive control containing the growth medium, each of the test isolates and 28µg of gentamicin was also set up for both the water and aqueous ethanolic extracts. For the negative control, only 0.1ml of the standardize broth culture without the plant and spice extract was used. These were incubated at 37°C for 24hrs. The MIC of the extract was regarded as the lowest concentration that did not permit growth of test organisms.

### RESULTS

#### Antibacterial activities of crude extracts of herbs and spices

Both the water and aqueous ethanolic extracts of *Ocimum gratissimum*, *Vernonia amygdalina*, *Psidium guajava* and spices *Allium sativum*, *Curcuma longa* and *Zingiber officinale*, *Nymphae lotus*, *Euphorbia hirta*, *Ficus exasperata*, *Azadirachta indica*, *Kigelia africana* and *Pistia stratiotes* showed varied degree of antibacterial activities against clinical *Escherichia coli* and *Salmonella sp.* and the epidemic strain of *Vibrio cholerae* tested in this study (Table 1).

Table 1:Antibacterial activities of crude extracts of herbs and spices

Herbs and spices	<i>Vibrio cholerae</i>		<i>Escherichia coli</i>		<i>Salmonella sp.</i>	
	Aqueous ethanolic extract	Water extract	Aqueousethanolic extract	Water extract	Aqueous Ethanolic extract	Water extract
<i>Euphorbia hirta</i>	14.0	8.5	16.0	9.0	0.0	9.5
<i>Vernonia amygdalina</i>	7.5	9.0	14.0	10.5	6.0	10.0
<i>Ocimum gratissimum</i>	8.5	7.0	7.5	12.5	6.5	9.5
<i>Psidium guajava</i>	13.0	7.5	13.0	11.5	8.0	12.0
<i>Nyphae lotus</i>	13.0	6.5	11.5	9.0	10.5	8.0
<i>Kigela Africana</i>	7.0	8.5	12.5	10.5	5.5	11.0
<i>Ficus exasperate</i>	14.0	8.5	13.0	10.0	10.0	10.5
<i>Azadirachta indica</i>	12.5	4.5	12.5	6.5	5.0	5.5
<i>Pistia stratiotes</i>	13.5	5.5	9.0	7.5	6.5	7.0
<i>Allium sativum</i>	14.5	9.0	132	12.5	5.0	11.5
<i>Zingiber officinales</i>	12.0	10.5	10.5	11.5	8.0	11.0
<i>Curcuma longa</i>	13.0	10.5	12.5	11.5	0.0	10.5
Gentamycin	13.2	13.2	10.6	10.6	9.5	9.5

#### Minimal Inhibitory Concentrations of crude extracts of herbs and spices

The minimal Inhibitory concentrations (MIC) determined for the crude extracts of

the various herbs and spices, using water (Table 2) and aqueous ethanol (Table 3) inhibited the test isolates at high dilutions.

Table 2:Minimum Inhibition Concentration of Water Extracts at 540 nm

Herbs and Spices		<i>Vibrio cholerae</i>			<i>Escherichia coli</i>			<i>Salmonella sp.</i>		
		1:2	1:4	1:8	1:2	1:4	1:8	1:2	1:4	1:8
1	OG	0.416	0.629	1.036	0.328	0.790	1.284	0.382	0.872	1.382
2	PG	0.382	0.613	0.963	0.302	0.641	0.093	0.417	0.914	1.572
3	VA	0.324	0.762	1.148	0.361	0.830	1.352	0.260	0.893	1.475
4	KA	0.368	0.830	1.173	0.414	0.874	1.268	0.472	0.972	1.684
5	NL	0.395	0.624	1.314	0.386	0.720	1.276	0.488	0.921	1.359
6	FE	0.411	0.740	1.204	0.406	0.823	1.318	0.423	0.879	1.493
7	AI	0.439	0.894	1.469	0.482	0.911	1.448	0.492	1.032	1.923
8	PS	0.390	0.973	1.632	0.397	0.887	1.420	0.520	1.129	2.031
9	EH	0.342	0.635	1.159	0.383	0.629	1.130	0.436	0.972	1.586
10	AS	0.314	0.372	0.693	0.328	0.712	1.109	0.398	0.918	1.485
11	ZO	0.406	0.793	1.520	0.356	0.698	1.214	0.476	1.185	2.147
12	CL	0.418	0.864	1.638	0.432	0.914	1.362	0.492	1.229	2.198

OG = *Ocimum gratissimum*; PG = *Psidium guajava*; VA = *Vernonia amygdalina*; KA = *Kigelia africana*; NL = *Nymphae lotus*; FE = *Ficus exasperata*; AI = *Azadirachta indica*; PS = *Pistia stratiotes*; EH = *Euphorbia hirta*; AS = *Allium sativa*; ZO = *Zingiber officinale* CL = *Curcuma longa*

Table 3: Minimum Inhibitory Concentration of aqueous ethanolic extracts at 540nm

Herbs and Spices		<i>Vibrio cholerae</i>			<i>Escherichia coli</i>			<i>Salmonella sp.</i>		
		1:2	1:4	1:8	1:2	1:4	1:8	1:2	1:4	1:8
•	OG	0.396	0.897	1.762	0.403	0.836	1.723	0.448	0.858	1.069
2	PG	0.349	0.786	0.693	0.362	0.970	1.864	0.397	0.732	1.738
3	VA	0.426	1.139	2.073	0.341	0.782	1.659	0.433	0.946	1.792
4	KA	0.489	0.932	1.931	0.392	0.843	1.924	0.526	0.987	1.843
5	NL	0.372	0.863	1.672	0.429	0.968	1.862	0.412	0.936	1.753
6	FE	0.384	0.872	1.634	0.389	0.798	1.713	0.396	0.951	1.862
7	AI	0.411	1.062	1.173	0.409	0.912	1.834	0.529	1.238	2.673
8	PS	0.428	1.118	1.971	0.472	1.283	1.969	0.507	1.039	2.218
9	EH	0.379	0.854	1.689	0.362	0.792	1.818	0.584	1.976	1.756
10	AS	0.486	0.921	0.838	0.397	0.773	1.842	0.516	0.942	2.219
11	ZO	0.459	0.60	1.867	0.418	0.937	1.861	0.534	1.136	1.920
12	CL	0.434	0.981	1.826	0.462	0.952	1.932	0.689	1.319	2.401

OG = *Occimum gratissimum* ; PG = *Psidium guajava* ; VA = *Vernonia amygdalina*; KA = *Kigelia africana*; NL = *Nymphae lotus*; FE = *Ficus exasperata*; AI = *Azadirachta indica*; PS = *Pistia stratiotes*; EH = *Euphorbia hirta*; AS = *Allium sativa*; ZO = *Zingiber officinale* CL = *Curcuma longa*

### DISCUSSION

In this study, the results obtained indicated that the ethanolic extract of *Euphorbia hirta* was more active than its water extract in inhibiting the growth of *Vibrio cholerae* and *Escherichia coli*. On the other hand, the water extract of *Euphorbia hirta* was active in inhibiting the growth of *Salmonella sp.* where the ethanolic extract showed no inhibition. This therefore showed that the extract contains substance (s) that can inhibit the growth of pathogens. The observed antibacterial effects on the isolates is believed to be due to the presence of alkaloids, tannins and flavonoids which have been shown to possess antibacterial properties (Cowan, 1999; Draughon, 2004). The observed antibacterial properties corroborate its use in traditional medicine. Traditionally, extracts of the plant are used in the control of diarrhea and dysentery (Kokwaro, 1993; Igoli *et al.*, 2005). The growth of inhibition against *Vibrio cholerae* and *Escherichia coli* justifies its use in the control of diarrhoea and dysentery. The zones of inhibition exhibited by the water against *Escherichia coli* and *Vibrio cholerae* are of significance since *Escherichia coli* and *Vibrio cholerae* are common cause of diarrhoea in developing countries. Also, the zones of inhibition exhibited by the water extract against *Salmonella sp.* is also significance since they are major cause of enteric fever. The relatively high zones of inhibition

exhibited by the ethanolic extract against *Vibrio cholerae* and *Escherichia coli* except *Salmonella sp.* which has no inhibition can be attributed to the fact that *Vibrio cholerae* and *Escherichia coli* are susceptible to the ethanolic extract. The result obtained with the ethanolic extract on *Salmonella sp.* is similar to that obtained by Ogbulie *et al.* (2007).

It can also be inferred from the result that the ethanolic extract of *Vernonia amygdalina* was more active than its water extract in inhibiting the growth of *Vibrio cholerae* and *Escherichia coli* but contrary to *Salmonella sp.* in which the water extract showed that the extract contains substance(s) that can inhibit the growth of pathogen either in the aqueous ethanolic state. Iwalokun *et al.* (2003) determined the antibacterial potential of *Vernonia amygdalina* using a panel multi drug resistant gram negative and gram positive bacteria and standard strains: *Escherichia coli* ATCE 25922 and *Staphylococcus aureus* ATCC 25923. Using agar-well and disc-diffusion assays, aqueous extract of *Vernonia amygdalina* leaves was found to produce growth inhibitory zones against *Escherichia coli*, *Salmonella typhi*, *Shigella sp.*, *Bacillus sp.* and *Streptococcus sp.* Vernodalin, Vernomygdin (Kupchan *et al.*, 1969) and saponin which are constituents of *Vernonia amygdalina* could be attributed for the antimicrobial activities. The observed antibacterial properties explain its use in

traditional medicine. Traditionally, extracts of the leaves are used as a remedy for stomach ache, in itching conditions, ringworms, antipyretic, as laxative, in gingivitis, tooth ache to mention but few (Gill, 1992).

The result from this study indicated that the water extract of *Ocimum gratissimum* was more active than its ethanolic extract in inhibiting the growth of *Escherichia coli* and *Salmonella sp.* It could be inferred that the extracts contain substance(s) that can inhibit the growth of microorganisms either in the aqueous or ethanolic state. Substances such as Terpenoids-eugenol, thymol (Sainsbury and Sofowora, 1971), saponins, alkaloid (Gill, 1992). The antimicrobial property present in the plant that is probably responsible for this observation is likely to be eugenol. This component has been demonstrated to have both antibacterial (Nakaruma *et al.*, 1999) and antihelmintic activities (Pessoa *et al.*, 2002). Antibacterial activity of different extracts from the leaves of *Ocimum gratissimum* was tested against selected diarrhoea causing bacteria in southwestern Nigeria (Adebolu and Oladimeji, 2005). The selected bacteria included *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhi* and *Salmonella typhimurium*. Cold water extract (CWE), hot water extract (HWE) and steam distillation extract had inhibitory effects on the selected bacteria. The cold water extract exhibited no effect on the test organisms, unlike the method used in extracting the leaves of *Ocimum gratissimum* in this study in which the fresh leaves was mashed in mortar and pestle and sieved without adding water. This could be attributed to the reason why the extract obtained in this study was effective on the test isolates as compared to the one used by Adebolu and Oladimeji (2005) in which the fresh leaves were macerated and sieved with sterile cheese cloth. The antibacterial properties exhibited by *Ocimum gratissimum* explain its use in traditional medicine.

Also, from this study, the result indicated that the ethanolic extract of *Psidium guajava* leaves is more active than the water extract in inhibiting the growth of *Vibrio cholerae* and *Escherichia coli*. As for *Salmonella sp.*, the water extract is more effective than the ethanolic extract in inhibiting the test isolate. The antibacterial activity of *Psidium guajava* leaves could be attributed to certain substance(s) present in the plant. Flavonoids (derivative of phenyl chromosome ring) are a group of compounds naturally occurring in higher and lower plants. Flavonoids have been shown to be able to affect various biological functions: capillary permeability, cellular secretory processes involved in the inflammatory response and inhibition of enzymes, receptors and carriers (Torel, 1983; Middleton, 1984; Afanas'ev *et al.*, 1989). The inhibitory activities of flavonoids against bacteria and yeast have been investigated by Hernandez *et al.* (2000) and Jussi-Pekka *et al.* (2000). Olajide *et al.* (1999) reported that leaves of *Psidium guajava* contain an essential oil rich in cineol, tannins and triterpenes. Gnan and Demello (1999) reported a complete inhibition of growth of *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Salmonella typhimurium* caused by aqueous guava leaf extract at a concentration of 8mg/ml. This was corroborated by this research work except for the difference in the test isolates used and that water was not added to the leaf extract. Vieira *et al.* (2001) reported that microbicidal effect of guava sprout extract (ethanol, acetone and water) upon toxigenic *Staphylococcus aureus* and *Escherichia coli* performed using radial diffusion. Extracts prepared with 60% alcohol and 60% acetone produced the largest halos for both species of bacteria. The result obtained from this research work also show similar activity. The 50% ethanolic extract shows a remarkable effect on *Salmonella sp.* The antimicrobial properties exhibited by *Psidium guajava* explain its uses in traditional medicine. Traditionally,

the decoction of the fresh leaves is used as a remedy for stomach-ache and diarrhea, fever and as a laxative (Gill, 1992).

The result obtained from this study indicated that the ethanolic extract of *Nymphae lotus* is more active than its water extract in inhibiting the growth of *Escherichia coli*, *Salmonella* sp. and especially *Vibrio cholerae* which shows a significant effect. This could be due to its constituents such as alkaloid nupharine, nympheine, nelombine and nupharidine (Gill, 1992). The plant is used as astringent, antiseptic, demulcent, sedative and sores; but with the antibacterial activities exhibited by this plant it could also be used as an alternative to orthodox antibiotics in the treatment of infections caused by these microbes, especially as they frequently develop resistance to known antibiotics (Singleton, 1999).

The ethanolic extract of *Kigelia africana* is more active in inhibiting *Escherichia coli* while the water extract of the leaves is more effective in inhibiting *Vibrio cholerae* and *Salmonella* sp. as compared to the ethanolic extract. The effect of the water extract inhibiting *Salmonella* sp. as compared to the ethanolic extracts of *Kigelia africana* contain substance(s) that can inhibit the growth of microorganisms. Substances like saponins, tannins, insulins, B-amyrin (Msonthi, 1986). Studies on the antibacterial and antifungal activities of the stem bark of *Kigelia africana* was carried out by Omonkhelin *et al.* (2007), using agar diffusion technique, the results revealed that the crude ethanolic extract exhibited antibacterial and antifungal activities against *Staphylococcus aureus* and *Candida albicans*. The ethanolic extract exhibited no inhibition against *Escherichia coli* and *Pseudomonas aeruginosa*. In contrast, the result obtained through this research work revealed that the aqueous ethanolic extract has moderate activity against *Vibrio cholerae*, *Salmonella* sp. and significant activity against *Escherichia coli*. Thus, the antimicrobial property exhibited by *Kigelia africana* demonstrates its use in unorthodox

medicine. In which it is being used in conjunction with another plant to cure gonorrhoea. Also for post partum haemorrhage, spleen infection, malaria fever, kidney disorders, stomach troubles, dysentery and for softening of wounds (Gill, 1992).

The aqueous ethanolic extract of *Ficus exaseperata* in inhibiting the growth of *Vibrio cholerae* and *Escherichia coli* is more effective than its water extract. While there is no significant difference in the activity exhibited by the aqueous ethanolic extract and water extract against *Salmonella* sp. This antibacterial properties could be attributed to the presence of certain constituents just like the other members of the family Moraceae that possess tannins. The antibacterial activity exhibited by the aqueous ethanolic and water extracts of *Ficus exaseperata* against *Salmonella* sp. and *Vibrio cholerae* and most especially *Escherichia coli* justifies its use traditionally in the treatment of dysentery. Just like the other members of the family such as *Ficus capensis*, *Ficus selegans*, *Ficus valis choudae*, *Ficus vogeliana* (Gill, 1992) and *Ficus* sp. (Adeniji, 2003) used in the treatment of diarrhea and dysentery.

The ethanolic extract of *Azadirachta indica* was more effective than its water extract inhibiting the growth of *Vibrio cholerae* and *Escherichia coli* unlike *Salmonella* sp. in which there was no remarkable difference between the activities of the ethanolic extract and water extract. *Azadirachta indica* is an indigenous plant widely distributed in Nigeria. The medicinal properties of *Azadirachta indica* were studied by several workers. The antipyretic effect (Okpanyi and Ezeukwk, 1981; Khattak *et al.*, 1985); antimalaria effect (Tella, 1977; Rochankij *et al.*, 1985); anti-tumour effect (Fujiwara *et al.*, 1982); anti-ulcer effect (Pillai and Santhakuman, 1984; Singh *et al.*, 1987) and cardiovascular effect (Thompson and Anderson, 1978) were some of the studies of the earlier workers.

Aqueous ethanolic extracts of *Pistia stratiotes* showed a better antibacterial activity against *V. cholerae* and *E. coli* than

water extracts while for *Salmonella* sp., the difference in activity was not much. *P. stratiotes* leaves are used in traditional medicine for the treatment of ringworm infection of the scalp, syphilis eruptions, skin infections, boils and wounds. Kirtikar and Basu (2000) reported that the oil extract of *P. stratiotes* is used in the treatment of worm infestations, tuberculosis, asthma and dysentery, and is applied externally to treat skin diseases, inflammation, piles, ulcers, syphilitic infections and burns. Premkumar and Shyamsundar (2005) also reported the antidermatophytic activity of *Pistia stratiotes*.

Both aqueous ethanolic and water extracts of *Allium sativum* showed activity against the tested pathogens. Okorundu *et al.* (2006) evaluated *A. sativum* against *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhi* and *Pseudomonas aeruginosa* while Eja *et al.* (2006) evaluated the antibacterial sensitivity of the water and ethanolic extracts of *A. sativum* on *Vibrio cholerae*, *Escherichia coli* and *Salmonella* sp. For several centuries, man has used garlic (*A. sativum*) for dietary and medicinal purposes and several studies have established that garlic has antimicrobial effect (Ross *et al.*, 1993; Reuter *et al.*, 1996; Lawson, 1998). Garlic has also been known to be capable of a broad spectrum antibiotic activity inhibiting the growth of both gram positive and gram negative bacteria (Pai and Platt, 1992; Ross *et al.*, 2001). It was also reported to be effective against diverse types of fungi, yeasts and viruses such as herpes virus (Pamplona-Roger, 1999). The use of garlic as alternative to existing antimicrobial drug is a promising one, as no resistance to garlic by microorganisms has been reported (Sivam *et al.*, 1997).

Extracts of *Zingiber officinale* showed activity against the tested pathogens. Antimicrobial activity of *Zingiber officinale* had been demonstrated by various workers. Auta *et al.* (2011) demonstrated the antimicrobial properties of the ethanolic extracts of *Zingiber officinale* on *Escherichia*

*coli* and *Pseudomonas aeruginosa*. Both fresh and dry ginger oils have been shown to possess antimicrobial activity on some bacteria, yeast and molds, yielding zingiberene as the major compounds (Sasidharan and Menon, 2010). However, Kaushik and Goyal (2011) observed that the methanol extract of the rhizome was most active against maximum number of bacterial species tested, yielding the presence of terpenoids, flavonoids, alkaloids and tannins in phytochemical screening. Important secondary metabolites that have been found in the rhizome are curcumene, non-volatile hydroxyaryl compounds e.g. zingerone, gingeroles and shogaols (phenylalkanones), volatile sesquiterpenes (e.g. zingiberene and bisabolene) and mono-terpenoids (e.g. citral).

While the water extract of *Curcuma longa* displayed antimicrobial activity against all the tested pathogen, the ethanolic extract did not show inhibitory activity against *Salmonella* sp. Kim *et al.* (2005) investigated the antimicrobial activity of ethyl acetate, methanol and water extracts of *Curcuma longa* L. against Methicillin-resistant *Staphylococcus aureus* (MRSA) and found that the ethyl acetate extract of *C. longa* demonstrated a higher antibacterial activity than the methanol extract or water extract. Naz *et al.* (2010) studied crude extracts of curcuminoids and essential oil of *Curcuma longa* varieties for their antibacterial activity against 4 bacterial strains viz., *Bacillus subtilis*, *Bacillus macerans*, *Bacillus licheniformis* and *Azotobacter*. Both Curcuminoids and oil showed zone of inhibition against all tested strains of bacteria. De *et al.* (2009) demonstrated the antimicrobial activity of curcumin against *Helicobacter pylori*.

The results from this study showed the antibacterial potential of the herbs and spices against the tested enteric pathogens. The antibacterial activities of the tested herbs and spices observed in this study are indicating that extracts of herbs and spices can be considered for use in alternative medicine.

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