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The Antimicrobial Effects of Local Spices:Onions (*Allium Cepa*, Garlic (*Allium Sativum)*, Ginger (*Zingiber Officinale)*, and Pepper (Piper Guineense) on Selected Pathogenic Bacteria and Fungus

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Abstract:
The toxicity of garlic, ginger, pepper, and onion was studied on some clinical isolates. The isolates include: Escherichia coli, Staphylococcus aureus, Salmonella typhi, Bacillus species, and Candida albicans. The crude extracts of the spices were obtained using 99% ethanol, 99% methanol, and hot water (100oc).Different graded concentrations of the extracts (aqueous and alcoholic) were prepared by pipetting one mill of the extract which yielded 100%, one mill of the extract plus one mill of water which yielded 50%, one mill of the extract plus 2 mills of distilled water which yielded 33.3%.The growth inhibitory effects of the aqueous and alcoholic extracts were examined using agar well diffusion method. The extracts were found to possess antimicrobial effects on the isolates by inhibiting their growths on the agar plates used. Hot water extracts of onion exhibited growth inhibitions on Salmonella typhi, Escherichia coli, Staphylococcus aureus, Bacillus species and Candida albicans with a mean of 11mm, 9.67mm, 4.67mm, 7.67mm, and 7mm respectively. Ethanol extracts of garlic exhibited growth inhibitions on Salmonella typhi, Escherichia coli, Staphylococcus aureus, Bacillus species and Candida albicans with a mean of 9.33mm, 7mm, 9.67mm, 9mm, and 11.33mm respectively etc. Organic extracts of methanol exhibited a higher growth inhibition when compared to organic extracts of ethanol, and aqueous extracts.The growth inhibitory effects of the crude extracts were compared with some third generation antibiotics: Ampicillin and Griseofulvin. The conventional antibiotics exhibited greater zones of inhibition compared to the crude extracts. Generally, garlic exhibited a higher growth inhibition when compared to other extracts.

Keywords: *Extracts, Inhibition, Crude, Isolates, Antimicrobial, Diffusion, Agar*

1. Introduction

1.1. Background of Study

The Geneva based International Standards Organization (ISO) defines spices and condiments as vegetable products or mixtures thereof, free from extraneous matter, used for flavouring, seasoning, and imparting aroma in foods. Spices come from various woody shrubs and vines, trees, aromatic lichens, roots, flowers, seeds, and fruits of herbaceous plants. Each spice has a unique aroma and flavor, which derives from compounds known as phytochemicals or "secondary compounds" (because they are secondary to the plant's basic metabolism). The use of spices and herbs for their flavouring, preservative and health promoting properties has been known since ancient times. Early records indicate that they were used as medicines in ancient Egypt and Assyria and as food preservatives in ancient Rome and Greece (Kaefer, Milner, 2008). In fact, development of bacterial resistance to the available antibiotics and

increasing popularity of traditional medicine has led researchers to investigate the antibacterial compounds in plants. Natural antioxidants can protect the human body from free radicals and retard the progress of many chronic diseases as well as retard lipid oxidative rancidity in foods (Miller, Murray 1998).

The growing concern about safety of food has recently led to the development of natural antimicrobials to control bacteria and fungi. Spices are some of the commonly used natural antimicrobial agents in foods. The addition of spices in foods not only imparts flavor and pungent stimuli, but also provides antimicrobial property. (Adejumo, 1989). A wide variety of local spices are in use by conventional and traditional medicine in Nigeria to improve and sustain health and to treat minor illnesses. (Rees, Minney, *et al.,*1993). These local spices are also used as flavours and spices in several refreshing foods, drinks and daily meals such as Pepper soup, Zobo, Kunnu, Barbecue spice, Chili powder, etc. (Arnault, Auger, *et al.,* 2006).

A component of garlic called diallyl disulfide has been shown to kill leukemia cells. These local spices include *Allium sativum* (Garlic), *Zingiber officinale*(Ginger), *Piper guineense*(West Africa pepper), and *Allium cepa*(Onion). Only a limited number of studies have been conducted to assess the microbiological quality of local spices. Black Pepper is able to modify supplement and drug metabolism. A process in the liver called glucuronidation, (Bordia, Mohammed, *et al.,* 1996) which attaches a molecule (glucuronide) to drugs to signal for their urinary excretion, is inhibited with piperine. This process prevents excessive levels of drugs and supplements in the body, but sometimes inhibits all uptakes and renders some supplements useless.

Garlic is also a triple threat against infections, offering antibacterial, antiviral *and* antifungal properties. (Elinima, Ahmed, *et al.,*1983). It's thought that much of garlic's therapeutic effect comes from its sulfur-containing compounds, such as allicin, (Sheela, Kumud, *et al.,* 1985) which are also what give it its characteristic smell. Research has revealed that as allicin digested in the body, produces sulfenic acid, a compound that reacts with dangerous free radicals faster than any other known compound. (Ying, Chang, 1998). Pepper is a spice commonly used in many areas of the world for flavor. *Allium sativum*has traditional dietary and medicinal applications as an anti-infective agent. In vitro evidence of the antimicrobial activity of fresh and freeze-dried garlic extracts against many bacteria, fungi and viruses supports these applications. Allicin, the active ingredient of *Allium sativum*, acts by partially inhibiting DNA and protein synthesis and also totally inhibiting RNA synthesis as a primary target. (Onyeagba, Ugbogu, Okeke, *et al.,*2004).

Like *Allium sativum*, *Allium cepa*is another medicinally important anti-infective agent. Raw *Allium cepa*can completely sterilize mouth and throat. (Bianchini, Vainio, 2001). *Zingiber officinale*has been used widely as herbal medicine. In particular, its gingerol-related components have been reported to possess antimicrobial and anti-fungal properties, as well as several pharmaceutical properties. (Onyeagba, Ugbogu, Okeke, *et al.,* 2004). *Zingiber officinale*is used to treat asthma, chronic indigestion, colon toxins, obesity, sinus, congestion, fever, intermittent fever, cold extremities, colic, gastric ailments and diarrhoea. It has shown to have antimicrobial activity. (Park, Bae, *et al.,* 2008). The antimicrobial potency of plants is believed to be due to tannins, saponins, phenolic compounds, essential oils and flavonoids. It is interesting to note that even crude extracts of these plants showed good activity against multidrug resistant strains where modern antibiotic therapy has limited effect. (Dorman, Deans, 2000). This work therefore seeks to evaluate the antimicrobial effects of local spices (onions, pepper, ginger, and garlic) on selected pathogenic bacteria and fungi

2. Materials and Method

2.1. Test Organisms

The organisms used for the study were clinical isolates obtained from the microbiology department of the Federal Medical Centre Owerri, Imo State. They comprised of strains of *Staphylococcus aureus, Salmonella typhi, Escherichia coli, Bacillus species, and Candida albicans*.

2.2. Test Solvents

The solvents used in this study for the extraction of the active principles of garlic, ginger, onions, and pepper was hot water, ethanol (99%), and methanol (99%).

→ Control Used: the control used in the study was Ampicillin.

2.2.1. Sterilization of Materials

The materials used for this study were sterilized by standard methods according to Chesbrough (2000). Test tubes and other glasswares were sterilized in hot air oven at 160^{o}c for 1 hour. Test media was also sterilized by autoclaving at 121^{o}c, for 15psi for 15 minutes, except stated otherwise by the manufactures example salmonella agar medium. Wire loops were sterilized by flaming to red hot over a Bunsen flame. Glass rod spreader was sterilized by dipping in absolute alcohol, and burning off over a Bunsen flame.

2.3. Extraction of Active Principles from Samples

2.3.1. Soxhlet Extraction Using Ethanol as Solvent

To obtain the soxhlet extract, the spices were first washed thoroughly in running water. Using a sterile surgical blade, the barksof ginger, onion, and garlic were removed, sliced and dried using the oven at 60^{o}c for 24 hours. The spices were then grinded into fine powder.10 grams of each spice were weighted, and each spice one after another was put into a tumble, and placed into the soxhlet apparatus containing cotton wool. Attach a dried pre- weighed 500ml round bottle flask containing few crystals of anti-bumping chips to the base of the extractor, and clamp to the retort stand. 90 mill of ethanol was added into the barrel containing tumble, and placed

(the assembled unit) on an electro thermal heater, with the top of the extractor connected to the reflux condenser. The source of water supply was turned on connected to the reflux condenser. The source of heat enables the solvent in the flask to boil for about 3-6 hours, thereby extracting the lipids present in each sample. Each spice is continuously extracted, until the solvent lost its colour.
On completion, the tumble was removed and solvent (ethanol) reclaimed by distillation. The flask and extracted lipid were placed in an oven at 70^{o}c for a few minutes to complete removal of all the ethanol then cooled in a desecrator. The extracts were then transferred into different sterile conical flasks, and kept at room temperature. Residues of the extracts were collected and stored in the refrigerator.

2.3.2. Using Cold Methanol as Solvent
10grams of the spices were weighed, and put into four different conical flasks. 90mills of methanol was poured into the four conical flasks containing each spice (onion, pepper, ginger, and garlic). The conical flasks were corked and allowed to stand for 24hours. Each solution was filtered using a sterile filter paper.

2.3.3. Aqueous Extracts
To obtain the aqueous extract, 10grams of dried and finely powdered spices were weighed and put into 4 conical flasks. The spices were homogenized using 90mills of boiled water (100^{o}c), and then allowed to stand for 24 hours. After 24 hours, the solutions were filtered using a sterile filter paper.

2.4. Isolation of Test Organisms
The organisms used for this study were isolated from the microbiology department of Federal Medical Centre Owerri. Prepared agar slants were sent to the licensed laboratory scientist. Pure cultures were sub cultured on different agar slants, and incubated at 37^{o}c for 24 hours. After incubation, the agar slants containing the different isolates were collected and transported back to the laboratory. They isolate were stored in the refrigerator until required for use.

2.5. Identification of Test Isolates
The test isolates obtained from Federal Medical Centre Owerri were confirmed before use. They were sub cultured on nutrient agar, mackonkey agar, blood agar, blood agar, and SDA, and incubated at 37^{o}c for 24 hours. Their morphological characteristics on the different agar on the different media were recorded. The 24 hour pure cultures of the different isolates were gram stained and examined microscopically. Motility test using stab culture method was carried out on the isolates. Further biochemical identification test was also carried out on the test isolates as described by (Chessbrough, 2000).

2.6. Antimicrobial Susceptibility Test
The modified Collins, Barnes, *et al.,*1995 agar well diffusion method was employed to determine the antimicrobial activities for ethanol, methanol, and hot water extracts of onion, pepper, ginger, garlic. Different graded concentrations of the extracts 100%, 50%, and 33.3% of onions, garlic, ginger, and pepper was prepared. About 0.1 mills(ml) of the standardized 24-hour culture of the tested organisms *(Staphylococcus aureus, Salmonella typhi, Bacillus subtilis, Escherichia coli*) in nutrient broth was spread unto sterile prepared Nutrient agar plates, which was then allowed to set. Also about 0.1 mills of the standardized 24-hour culture of the tested organism *(Candida albicans*) in a nutrient broth was spread unto a sterile prepared Sabouraud's dextrose agar plate (SDA). With the aid of a sterile cork borer, wells of about 5milimeter (mm) in diameter were bored on the plates. About 0.05mills of each concentration of the extracts were dispersed into the wells and then allowed to stand for about 15 minutes for per diffusion of the extracts to occur. These were then incubated at 37^{o}c for 24 hours. At the end of the period (24hours), zones of inhibition formed on the agar were evaluated in millimeters. The diameters of the zones of inhibition in the plates were measured using a meter rule by calculating the difference between the cork borer (5mm) and the diameter of the inhibition.

3. Result

3.1. Data Presentation

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION (mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	16	14	7	33	11
Escherichia coli	11	8	4	29	9.67
Staphylococcus aureus	17	11	8	14	4.67
Bacillus	12	7	6	23	7.67
Candida	7	6	5	21	7

Table 1: Inhibition Zones (mm) of Onion Extract with Hot Water Solvent

From the table, hot water extracts of onion exhibited the highest inhibition zone on strains of *Salmonella typhi* with a mean of 11, and the least inhibition zone on strains of *Candida albicans* with a mean of 7.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION (mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	13	12	8	33	11
Escherichia coli	15	8	6	29	9.67
Staphylococcus aureus	11	2	1	14	4.67
Bacillus	11	7	5	23	7.67
Candida albicans	10	6	5	21	7

Table 2: Inhibition Zones (mm) of Onion Extract with Ethanol Solvent

From the table, ethanol extracts of onion exhibited the highest growth inhibition on strains of *Salmonella typhi*, with a mean of 11mm, while it exhibited the least inhibition zones on strains of *Staphylococcus aureus* with a mean of 4.67mm.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION (mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	7	5	4	16	5.33
Escherichia coli	7	6	4	17	5.67
Staphylococcus aureus	11	7	5	23	7.67
Bacillus	17	16	14	47	15.67
Candida albicans	25	18	14	57	19

Table 3: Inhibition Zones (mm) of Onion Extract with Methanol Solvent

From the table, methanol extracts of onion exhibited the highest growth inhibition on strains of *Candida albicans*, with a mean of 19mm, while it exhibited the least inhibition on strains of *salmonella typhi* with a mean of 5.33mm.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION (mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	8	7	5	20	6.67
Escherichia coli	12	11	9	32	10.67
Staphylococcus aureus	14	8	3	25	8.33
Bacillus	13	11	9	33	11
Candida albicans	12	7	4	23	7.67

Table 4: Inhibition Zones (mm) of Pepper Extract with Hot Water Solvent

From the table, hot water extracts of pepper exhibited the greatest inhibition zones on strains of *Bacillus* with a mean of 11mm, and exhibited the least inhibition zone on strains of *Salmonella typhi* with a mean of 6.6mm.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION (mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	17	11	9	37	12.33
Escherichia coli	12	9	7	28	9.33
Staphylococcus aureus	17	14	11	42	14
Bacillus	11	8	5	24	8
Candida albicans	12	6	2	20	6.67

Table 5: Inhibition Zones (mm) of Pepper Extract with Ethanol Solvent

From the table, methanol extracts of pepper exhibited the greatest inhibition zones on strains of *Staphylococcus aureus* with a mean of 14mm, and exhibited the least inhibition zone on strains of *Bacillus* with a mean of 8mm.

Isolates	ZONE DIAMETER OF GROWTH INHIBITION (mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	16	14	6	36	12
Escherichia coli	24	11	9	44	14.67
Staphylococcus aureus	12	7	3	22	7.33
Bacillus	14	12	10	36	12
Candida albicans	10	6	5	22	7.33

Table 6: Inhibition Zones (mm) of Pepper Extract with Methanol Solvent

From the table, methanol extracts of pepper exhibited the greatest growth inhibition on strains of *Escherichia coli* with a mean of 14.63mm, and exhibited the least inhibition zones on strains of *Candida albicans* with a mean of 7.32mm.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION (mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	10	9	5	24	8
Escherichia coli	10	8	4	22	7.33
Staphylococcus aureus	12	11	8	31	10.33
Bacillus	9	3	-	12	4
Candida albicans	7	4	3	11	3.67

Table 7: Inhibition Zones (mm) of Ginger Extract with Hot Water Solvent

Hot water extracts of ginger exhibited the greatest inhibition zones on strains of *Staphylococcus aureus* with a mean of 10.33mm, and showed the least inhibition zones on strains of *Bacillus*, with a mean of 4

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION (mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	15	13	11	39	13
Escherichia coli	17	11	4	32	10.67
Staphylococcus aureus	16	13	9	38	12.67
Bacillus	11	9	7	27	9
Candida albicans	12	6	2	26	8.67

Table 8: Inhibition Zones (mm) of Ginger Extract with Ethanol Solvent

From the table, ethanol extracts of ginger exhibited the greatest growth inhibition on strains of *Salmonella typhi* with a mean of 13mm, and showed the least inhibition zones on strains of *Candida albicans* with a mean of 9mm.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	10	6	4	20	6.67
Escherichia coli	16	13	10	39	13
Staphylococcus aureus	10	8	5	23	7.67
Bacillus	24	6	4	34	11.33
Candida albicans	20	16	14	50	16.67

Table 9: Inhibition Zones (mm) of Ginger Extract with Methanol Solvent

From the table, methanol extracts of ginger exhibited the greatest inhibition zones on strains of *Candida albicans* with a mean of 16.33mm, and exhibited the least inhibition zones on strains of *Salmonella typhi* with a mean of 6.67mm.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	21	15	13	49	16.33
Escherichia coli	12	9	8	32	10.33
Staphylococcus aureus	13	10	8	25	8.33
Bacillus	12	11	4	33	11
Candida	8	7	5	23	7.67

Table 10: Inhibition Zones (mm) of Garlic Extract with Hot Water Solvent

From the table, hot water extracts of garlic exhibited the greatest inhibition zones on strains of *Salmonella typhi* with a mean of 16.33mm, and exhibited the least inhibition zones on strains of *Candida albicans* with a mean of 7.67mm.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	15	9	4	28	9.33
Escherichia coli	10	7	4	21	7
Staphylococcus aureus	12	10	7	29	9.67
Bacillus	11	7	5	27	9
Candida albicans	10	6	5	34	11.33

Table 11: Inhibition Zones (mm) of Garlic Extract with Ethanol Solvent

From the table, ethanol extracts of garlic exhibited the greatest growth inhibition on strains of *Candida albicans* with a mean of 11.33mm, and exhibited the least growth inhibition on strains of *Escherichia coli* with a mean of 7mm.

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)				
	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	20	15	10	45	15
Escherichia coli	18	15	11	44	14.67
Staphylococcus aureus	14	9	4	27	9
Bacillus	17	14	10	41	13.67
Candida albicans	17	10	6	33	11

Table 12: Inhibition Zones (mm) of Garlic Extract with Methanol Solvent

From the table, methanol extracts of garlic exhibited the greatest inhibition zones on strains of *Salmonella typhi* with a mean of 15mm, and exhibited the least inhibition zones on strains of *Staphylococcus aureus* with a mean of 9mm.

Comparative Analysis of Growth Inhibitory Effects of Extracts and Antibiotics (Amphicillin and Griseofulvin)

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)					
	CONTROL	100%	50 %	33.3 %	TOTAL	MEAN
Salmonella typhi	20	15	13	11	59	14.75
Escherichia coli	21	17	11	4	53	13.25
Staphylococcus aureus	24	16	13	9	62	15.5
Bacillus substilus	19	11	9	7	46	11.5
Candida albicans	4	12	8	6	30	7.5

Table 13: Comparism of Ethanol Ginger Extract with Antibiotics(ampicillin)

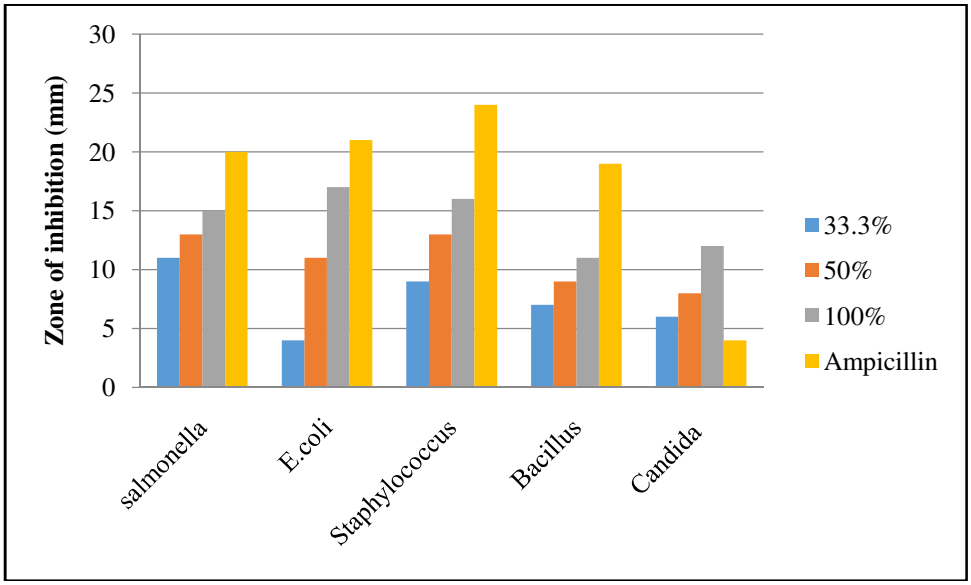

Figure 1: Ethanol extract of ginger on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	19	10	6	4	39	9.75
Escherichia coli	18	16	13	10	57	14.25
Staphylococcus aureus	26	10	8	5	49	12.25
Bacillus substilus	18	24	6	4	52	13
Candida albicans	22	20	16	14	72	18

Table 14: Comparism of Methanol Ginger Extract with Antibiotics (ampicillin)

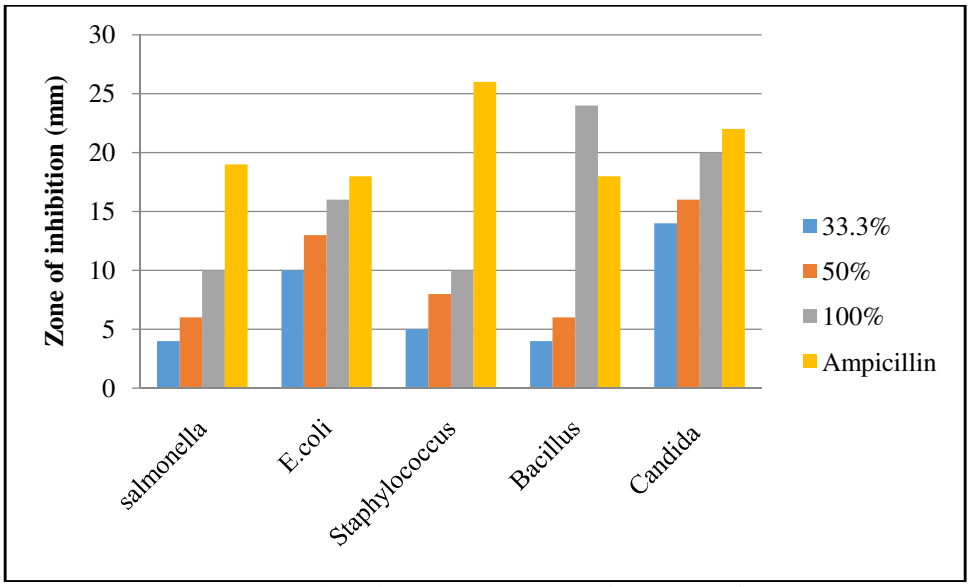

Figure 2: Methanol extract of ginger on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	21	10	9	5	45	11.25
Escherichia coli	19	10	8	4	41	10.25
Staphylococcus aureus	22	12	11	8	63	15.75
Bacillus substilus	19	9	3	-	42	10.5
Candida albicans	6	7	4	-	26	6.5

Table 15: Comparism of Hot Water Ginger Extract with Antibiotics (ampicillin)

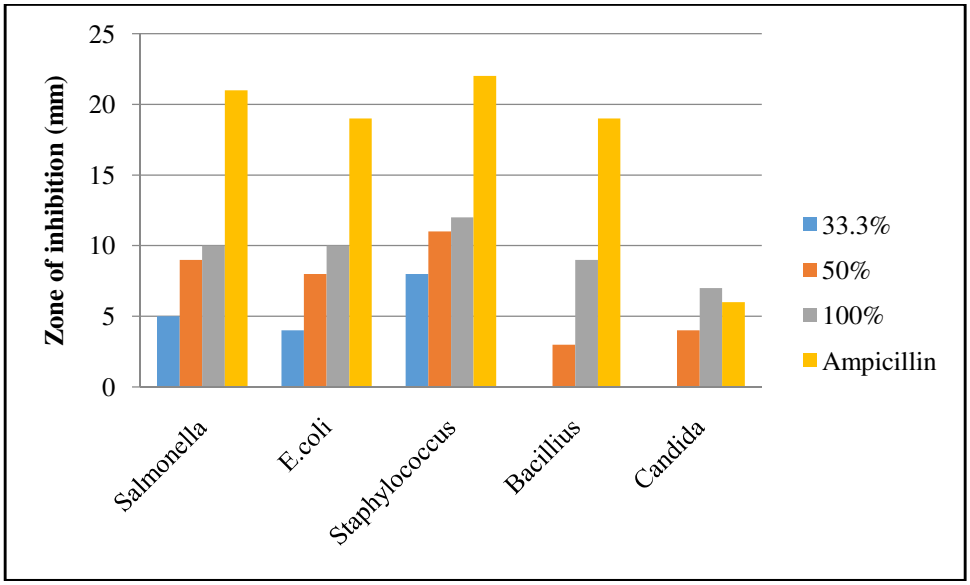

Figure 3: Hot water ginger extract on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	21	15	9	4	49	12.25
Escherichia coli	19	10	7	4	40	10
Staphylococcus aureus	22	12	10	7	51	12.75
Bacillus substilus	17	13	9	5	44	11
Candida albicans	10	16	12	6	44	11

Table 16: Comparism of Ethanol Garlic Extract with Antibiotics(ampicillin)

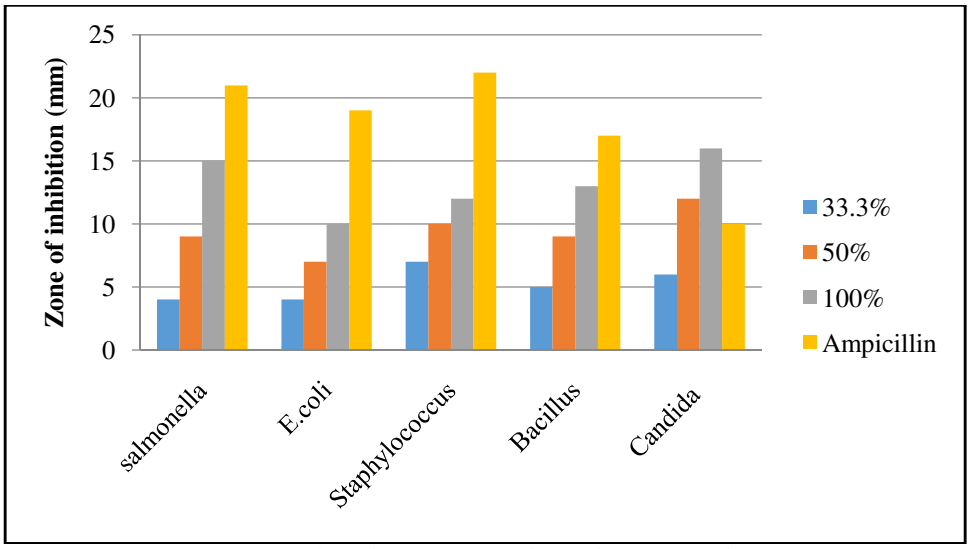

Figure 4: Ethanol extract of garlic on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	22	20	15	10	67	16.75
Escherichia coli	18	18	15	11	62	15.5
Staphylococcus aureus	24	14	9	4	51	12.75
Bacillus substilus	22	17	14	10	63	15.75
Candida albicans	21	17	10	6	54	13.5

Table 17: Comparism of Methanol Garlic Extract with Antibiotics (ampicillin)

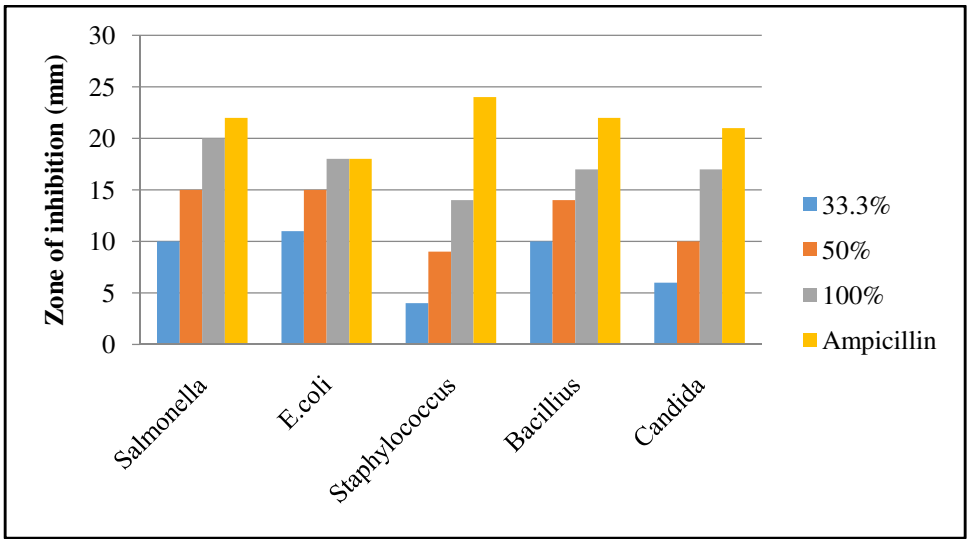

Figure 5: Methanol extract of garlic on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	25	21	15	13	74	18.5
Escherichia coli	21	12	9	8	50	12.5
Staphylococcus aureus	23	13	10	8	54	13.5
Bacillus substilus	20	12	11	4	47	11.75
Candida albicans	8	8	7	5	28	7

Table 18: Comparism of Hot Water Garlic Extract with Antibiotics(ampicillin)

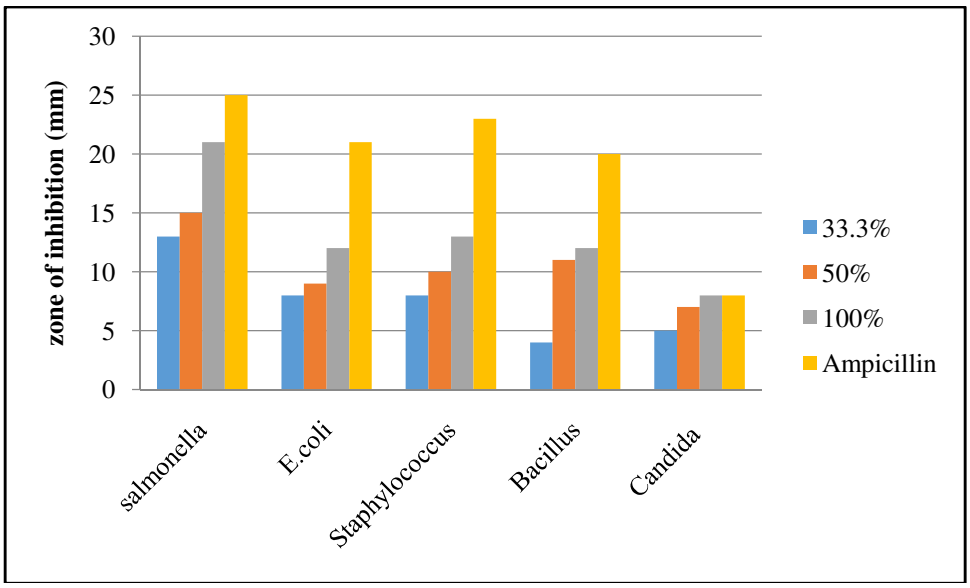

Figure 6: Hot water garlic extract on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	22	13	12	8	55	13.75
Escherichia coli	22	15	8	6	51	12.75
Staphylococcus aureus	22	11	2	1	36	9
Bacillus substilus	20	11	7	5	43	10.75
Candida albicans	10	10	6	5	31	7.75

Table 19: Comparism of Ethanol Onion Extract with Antibiotics(ampicillin)

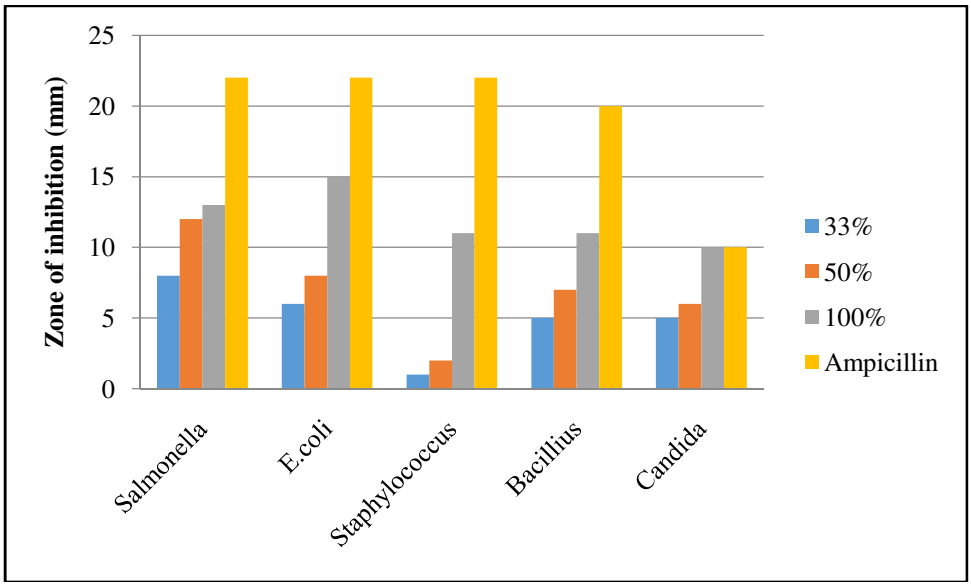

Figure 7: Ethanol Extracts of Onions on Bacteria and Fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION(mm)					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	18	7	5	4	34	8.5
Escherichia coli	16	7	6	4	33	8.25
Staphylococcus aureus	25	11	7	5	48	12
Bacillus substilus	20	17	16	14	67	16.75
Candida albican	21	25	18	14	78	19.5

Table 20: Comparism of Methanol Onion Extract with Antibiotics

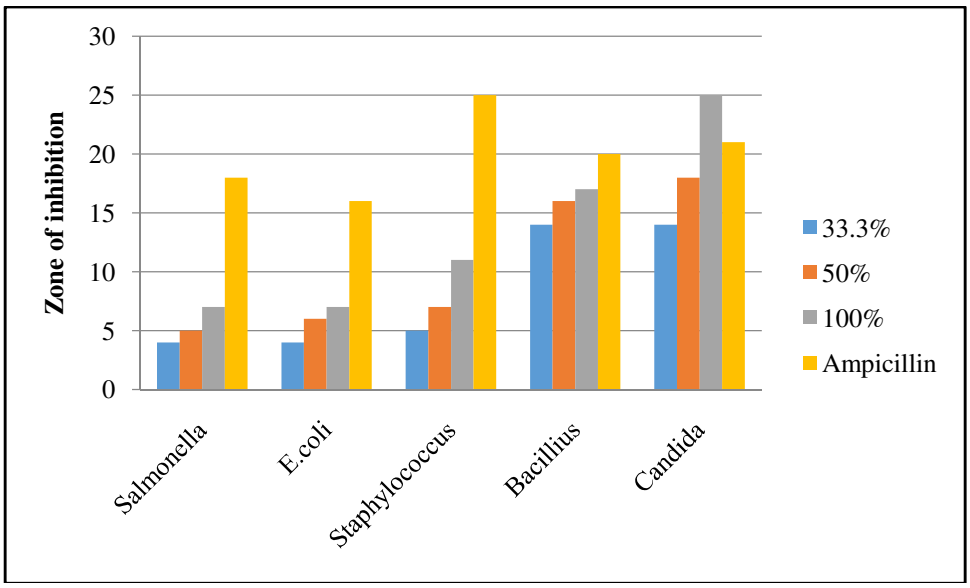

Figure 8: Methanol extract of onions on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	21	16	14	7	58	14.5
Escherichia coli	18	11	8	4	41	10.25
Staphylococcus aureus	24	17	11	8	60	15
Bacillus substilus	17	12	7	6	42	10.5
Candida albicans	7	7	6	5	25	6.25

Table 21: Comparism of Hot Water Onion Extract with Antibiotics

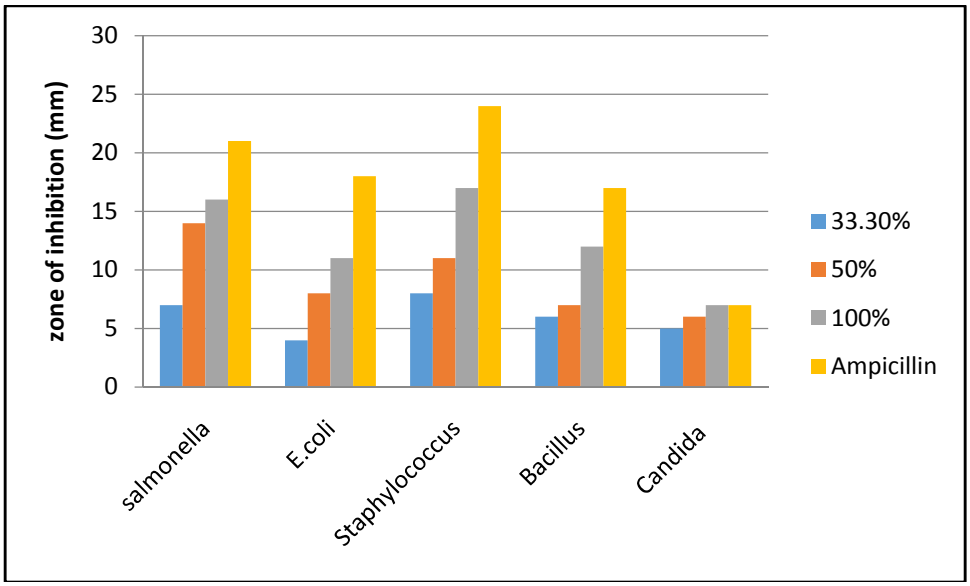

Figure 9: Hot water onion extract on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	21	17	11	9	56	14.5
Escherichia coli	21	12	9	7	49	12.25
Staphylococcus aureus	21	17	14	11	63	15.75
Bacillus substilus	18	11	8	5	42	10.5
Candida albicans	6	12	6	2	26	6.5

Table 22: Comparism of Ethanol Pepper Extract with Antibiotics

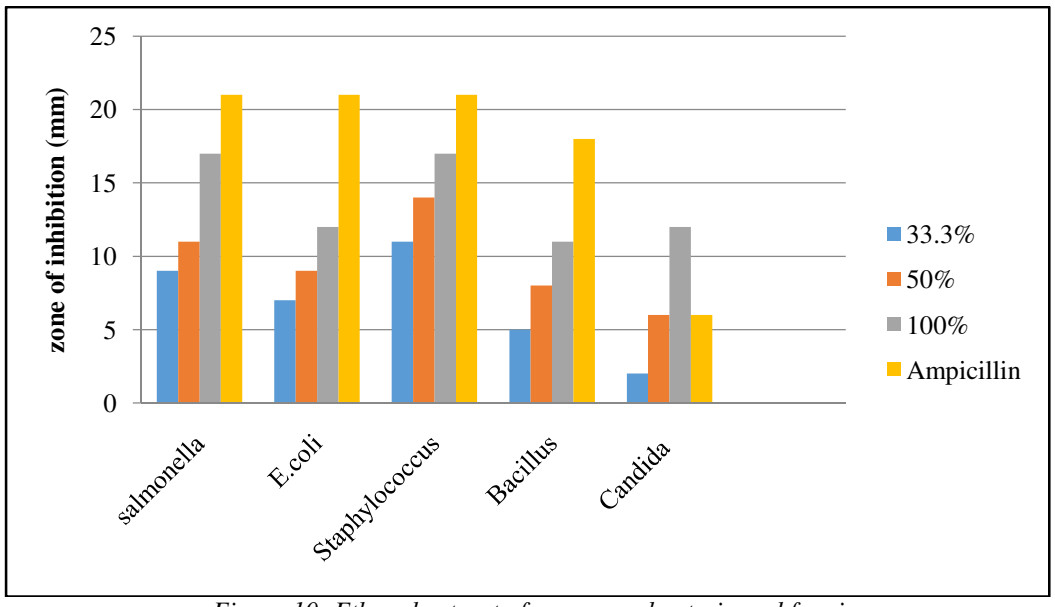

Figure 10: Ethanol extract of pepper on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	22	16	14	6	58	14.5
Escherichia coli	20	24	11	9	64	16
Staphylococcus aureus	20	12	7	3	42	10.5
Bacillus substilus	20	14	12	10	56	14
Candida albicans	12	9	7	6	34	8.5

Table 23: Comparism of Methanol Pepper Extract with Antibiotics

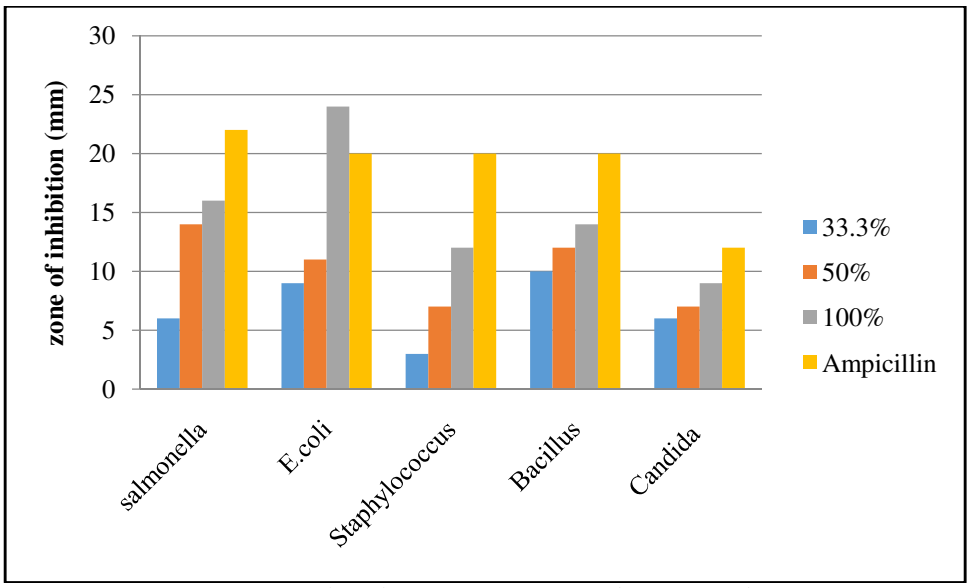

Figure 11: Methanol extract of pepper on bacteria and fungi

ISOLATES	ZONE DIAMETER OF GROWTH INHIBITION					
	CONTROL	100%	50%	33.3%	TOTAL	MEAN
Salmonella typhi	20	8	7	5	40	10
Escherichia coli	21	12	11	9	53	13.25
Staphylococcus aureus	20	14	8	3	45	11.25
Bacillus substilus	17	13	11	9	50	12.5
Candida albicans	7	12	7	4	30	7.5

Table 24: Comparism of Hot Water Pepper Extract with Antibiotics

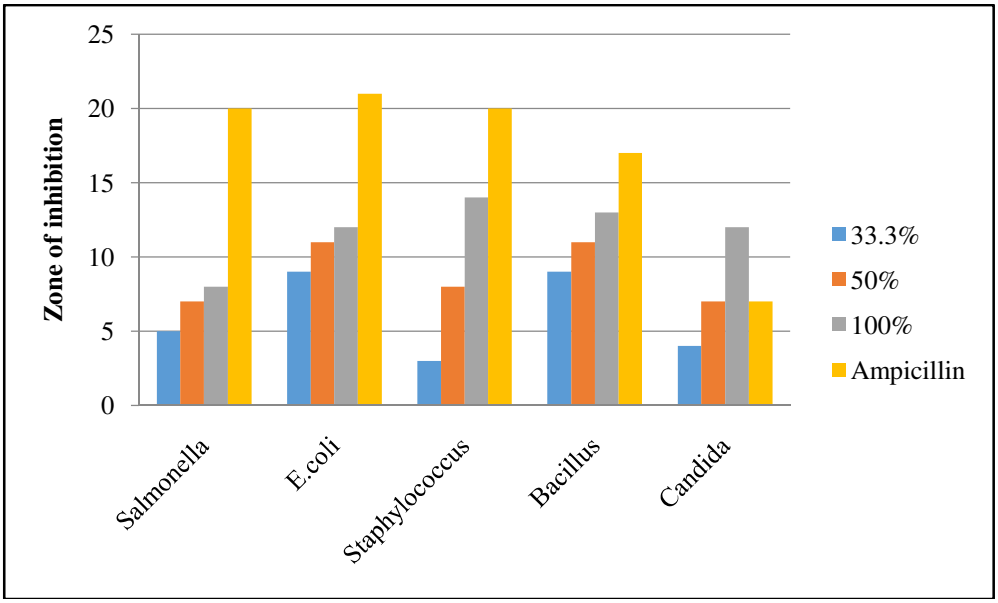

Figure 12: Hot water pepper extract on bacteri and fungi

4. Discussion

100% concentration of extracts exhibited greater zones of inhibition compared to 50% and 33.3% concentration of extracts. Some extracts exhibited lesser inhibition or antibiotic effects on strains of *Candida albicans* (Fungus). Alcoholic and aqueous extracts of pepper, ginger, onion, and garlic exhibited different degrees of growth inhibition on the different strains of isolates. The addition of spices in foods not only imparts flavor and pungent stimuli, but also provides antimicrobial property (Adejumo, 1989). A wide variety of local spices are in use by conventional and traditional medicine in Nigeria to improve and sustain health and to treat minor illnesses (Rees, Minney, *et al.,* 1993). From the results, it was observed that among the twelve (12) extracts, organic extracts using methanol as solvent exhibited the greatest zones of inhibition on the isolates, next to soxhlet ethanol extracts, while the aqueous extract (hot water extracts) exhibited the least inhibition zones. These illustrated that 99% methanol is a better solvent in extracting active principles of the spices, compared to soxhlet extraction using ethanol, and hot water. The study also illustrated that heating inhibited the active principles found in the extracts. This can be explained by saying that the antimicrobial substances found in these spices (onion, pepper, garlic, and ginger) are phenolic compounds, and can be denatured, or destroyed by heat (as seen in the soxhlet ethanol extraction, and hot water extraction). Heating denatures or inactivates a percentage of the active ingredients. Amongst the different extracts, garlic exhibited the greatest growth inhibition zones on the isolates, followed by pepper, next to ginger, and lastly onions. Lastly, the antimicrobial effects of alcoholic extracts, and aqueous extracts of the spices were compared to conventional antibiotics (Ampicillin). The convectional antibiotics used exhibited greater zones of inhibition compared to the alcoholic and aqueous extracts of the spices. The antimicrobial effects of these spices depend on the concentration of the extracts used. The antimicrobial effects of these spices can be enhanced by biotechnological means which will reduce the immergence of these multiple antibiotics resistant bacteria and fungi.

5. Conclusion

The results obtained from the study showed that onion, pepper, garlic, and ginger exhibits antimicrobial effects on *Staphylococcus aureus, Salmonella typhi, Escherichia coli, Bacillus*, and little effects on strains of *Candida albicans*. Their antimicrobial effects can be attributed to the different solvents used, their methods of preparation, and the degrees of the concentration of the extracts. These spices exhibited minimal growth inhibition effects on the isolates compared to the conventional antibiotics used. The antifungal ability of these extracts can be improved biotechnologically. The research has brought to the notice of the public, and society at large on the therapeutic and antibiotic effects of these commonly used spices.

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