ANTIBACTERIAL ACTIVITIES OF THREE COMMONLY USED SPICES; GARLIC (ALLIUM MOLY), GINGER (ZINGIBER OFFICINALE), AND TURMERIC (CURCUMA LONGA) EXTRACTS ON BACTERIAL ISOLATES FROM SPOILT TOMATOES (LYCOPERSICUMESCULATUM)

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ABSTRACT

Spices such as garlic and ginger have been used as antimicrobial agents in their raw form for the treatment of wounds, injuries and joint pains. Garlic, Ginger and Turmeric extracts can also be considered as bio-pesticides in Integrated Crop Disease Management strategies, and these can be a viable, and environmentally friendly alternative to chemical use. This study was carried out to investigate the antibacterial activity of Garlic, Ginger and Turmeric extracts on bacteria isolates associated with spoilt tomatoes. Five samples of spoilt tomatoes were obtained from Wadata market, within Makurdi Metropolis. Standard microbiological and biochemical tests were carried out to identify the test organisms from the tomatoes sample. The organisms identified were, Staphylococcus aureus, Streptococcus spp, Salmonella spp and Escherichia coli. Antibacterial activity of Garlic, Ginger and Turmeric extracts were tested on the organisms using agar well diffusion at different concentration of 500, 250, 125 ,62.5 and 31.25mg/ml. Statistical analysis of ANOVA showed there was significant difference (P< 0.05) in the zones of inhibition at different concentration between ethanolic and aqueous extract of the different spices. Antimicrobial activity was found to be highest in Garlic (8.00mm-25.50mm) followed by Ginger (6.00-25.00mm) and then Turmeric (3.50mm - 24.50mm) against the test organisms. The ethanolic extracts of the different spices demonstrated a higher antibacterial activity than the aqueous extracts. The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) for the test organisms in both extracts (ethanolic and aqueous) of Tumeric, Garlic and Ginger were 31.25 mg/ml and 500mg/ml respectively. The antimicrobial activity of these spices are due to specific phytochemicals constituents and there is possibility of sourcing alternative antibiotic substances in these plants and further development of bio-pesticide for disease management in crops.

Keywords:*Antibacterial;Garlic; Ginger; Turmeric; Phytochemicals; Bio-pesticides*

INTRODUCTION

Herbs and spices are parts of plants from indigenous or exotic origin and are essential part of human diet as they improve taste, color and aroma of foods. In addition they act as preservatives in many foods; they also have antioxidant and antimicrobial properties (Karuppiah and Rajaram, 2012). Herbs have also been utilized in human and veterinary medicine (Alsaid*et al*., 2010). Ginger (*Zingiberofficinale*Roscoe) is one of the most commonly consumed dietary condiments in the world. The main active phytochemicals present in ginger are gingerols, shogoals and paradols, and they have strong antioxidant and chemo-preventive properties (Tchombé*et al.,* 2012).Ginger extracts have been extensively studied for a broad range of biological activities including antibacterial, anticonvulsant and analgesic (Ali *et al.,* 2008). Ginger has been shown to be effective against the growth of both gram-positive and gram-negative bacteria including *Escherichia coli, Proteus vulgaris,Salmonella typhi, Staphylococcus aureus* and *Streptococcus viridans*(Nirmala*et al.,* 2008).

Garlic (*Allium moly*), is a species in the onion genus, *Allium*. *Allium moly*, also known as golden garlic and lily leek. The mostimportant chemical constituents reported from *Alliums* are thesulfur compounds. The important components of garlic are allicin and sulphur containingcompounds like diallylsulphide (DAS) and diallyldisulphide(DADS) possessing antitumor and antioxidant properties (Kaschula*et al.,* 2010).*Allium* has a broad range of antibacterial and antifungal activity.The essential oil, water, and ethanol extracts, and the juice inhibitthe*in vitro* growth of *Bacillus* species, *Staphylococcus aureus*, *Escherichia coli*, *Proteus* species, *Streptococcus faecalis*, *Pseudomonas aeruginosa*, *Candida* species, and *Aspergillusniger*(Anjali and Vinayak, 2013). The antioxidant activity depends on the type and polarity of theextracting solvent, the isolation procedures, purity of activecompounds, as well as the test system (Sagar and Singh, 2010).

Turmeric (*Curcuma longa*) is a dietary spice belonging to the family *zingiberaceae*. It is a colouring and flavouring agent in foods, and has been reported to possess antimicrobial properties both in *in vitro* and animal studies (Varunraj*et al.,* 2011). Aqueous extracts of turmeric showed antioxidant and antimicrobial activity due to the presence of curcumin (5%), a polyphenolic compound. It is known that the phenolic character of curcumin is responsible for its antimicrobial properties (Varunraj*et al.,* 2011).

Spices are normally used either in the process of cooking or after it, to garnish or to mask undesired flavor (Indu*et al*., 2006). It is however not known whether the heat used during the cooking process has any effects on the antimicrobial potency on spices. Food borne pathogens are widely distributed in the environment and may be a significant cause of mortality and morbidity in the population and spice in food can help inhibit food borne pathogens (Indu*et al*., 2006).

In Nigeria, natural herbs and spices are consumed either in food, or used as medicine in order to maintain proper health and to increase longevity of life. In this respect, spices, such as clove (toothache, fever, pain), cinnamon (nervous problems, stomach/intestine infections), mustard, garlic (antiseptic, diuretic), ginger (digestive aid, cold), etc. have been reported to possess very good medicinal and antimicrobial properties (Gul and Bakht, 2015). Apart from being a major part of the Nigeria culinary, spices also contribute to the modern allopathic system of healthcare by providing large number of medicines or parent compounds (Shan *et al.,* 2007).

The use of spice as antimicrobial agents is as a results of their phytochemical constituents. The phenolic present in spices play and important role in antibacterial activity (Gul and Bakht, 2015).Use of spices reduces or inhibits the growth of microorganisms before they produce any toxins (Coccimiglio*et al.,* 2016). An interrelationship between the health-benefiting properties of spices and their use in food needs to be scientifically reestablished (Coccimiglio*et al.,* 2016). In the traditional system of medicine garlic, ginger and turmeric are described to possess medicinal properties, such as being antioxidant, antibacterial, antithrombotic, antiatherosclerotic, hypolipidemic, hypoglycemic, anti-inflammatory antiinflammatory, antiarthritic, etc (Coccimiglio*et al.,* 2016).
Despite the human need of tomato, damage as a result of post-harvest spoilage micro-organisms has been of serious concern. The presence of some microorganisms in *Lycopersiconesculentum*(tomato) is potential food-borne pathogens that could pose some public health challenges, which can lead to potential health hazard to consumers Microbial decay is one of the main factors that determine losses and compromises the quality of the produce. The extent of the losses especially through microbial decay has not been quantified in most areas.

MATERIALS AND METHODS

Study Area

Makurdi Local Government Area has a population of 300,000 persons (NPC, 2006), and lies between latitude 7° 44' 1.50" N of the equator, and longitude 8° 31' 17.00" E of the Greenwich Meridian.

Collection and Authenticity of Plant Samples
Samples of fresh Garlic (*Allium sativum*), Ginger (*Zingiberofficinale*) and Turmeric (*Curcuma longa*) were obtained from Wurukum Market, Makurdi. The plant samples were placed in a separate sterile plastic container and was transported to the Department of Microbiology, Joseph SarwuanTarka University Makurdi, for authentication by renowned taxonomists.

Sterilization and disinfection of materials
Work benches were properly disinfected with an alcohol. All the glass wares used were wrapped with an aluminum foil, fastened with a masking tape and sterilized using a hot air oven at 180ºC for 1 hour.

Plant Sample preparation
The Ginger, Garlic and Turmeric was separately washed and peeled, cut into pieces and sun
dried for one week. The dried ginger, garlic and turmeric wasseparately pulverized with a blender to a fine powder.

Aqueous Extraction
Twenty grams (20g) each of the ground powdered (ginger, ginger and turmeric) material were separately dispensed into 100 ml of hot sterile water and was left for 72 hours. The mixture was stirred thoroughly to obtain a homogenous mixture. The mixture was filtered and further centrifuged at 10, 0000 rpm for 20 minutes. The supernatant was filtered through a 0.2mm pore size Whatman filter paper grade 1 to remove any impurity (Sah*et al.,* 2020).

Ethanolic Extraction
Twenty grams (20g) each of the ground material (ginger, ginger and turmeric) was separately dispensed in 100ml ofethyl alcohol. The mixture was stirred thoroughly to obtain a homogenous mixture. The mixture was filtered and further centrifuged at 10, 000 rpm for 20 minutes. The supernatant was filtered through a 0.2mm pore size Whatman filter paper grade 1 to remove any impurity (Sah *et al.,* 2020).

Preparation of Different Concentrations of the Root Extract.
Double standard dilution method by Joe *et al*. (2009)was used to obtain five different concentrations of the crude aqueous and ethanolic Ginger, Ginger and Turmeric extract, the concentrations will be 500 mg/mL, 250 mg/mL, 125 mg/mL, 62.5 mg/mL and 31.25 mg/mL respectively. This was done by diluting appropriate milligrams of the extracts into corresponding volumes of solvents.

Sample Collection for Test Organism
Tomatoes fruits showing varying degrees of rots werecollected from Wadata Market, Makurdi. The samples was aseptically transferred into sterile plastic container labeled and transported to the Microbiology Laboratory of Joseph SarwuanTarkaUniversity Makurdi for analysis.

Media Preparation
The media used were Nutrient agar, Mannitol Salt Agar and Eosine Methylene Blue Agar. The media were prepared according to manufacturers' instruction. It wassterilized by autoclaving at 121 ^{0}C for 15minutes. This media was allowed to cool for 44 ^{0}C before aseptically pouring into different Petri dishes.

Inoculation of Samples
A streak method of inoculation was used. A sterile swab was used to take sample from the spoilt portion of the tomatoes and was streaked on the Nutrient agar plate. The agar plates was incubated at 27 ^{0}C for 5 days for fungi growth (Cheesbrough, 2006).

Isolation of Bacteria Colonies
Discrete colonies on the plates were identified using method described byCheesebrough (2005). The discrete colonies will be sub-cultured repeatedly by streaking on fresh media. The media will be incubated at 37 ^{0}C for 24 hour for bacteria growth. The pure cultures was then transferred onto slants for biochemical identification.

Identification and Characterization of Bacterial Isolates
Culture Characteristics
The bacterial colonies morphology were identified based on the following: shape (circular, entire, rhizoid, punctiform), Size, elevation (flat, raised, low convex, umbonate), colour (clourless, white, yellow, black, grey, pink), Texture (Dry, Moist, Viscid, Muciod) and Opacity (opaque, translucent, iridescent) (Cheesbrough, 2006).

Gram Staining Technique
Gram staining was carried out on the 24 hour old culture. A thin smear was made by placing a drop of water on a clean glass slide and a loopful of 24 hour old bacteria culture was mixed into the drop of the water to make a thin film. The film was air dried and heat fixed by passing over a flame gently. It was stained with crystal violet solution for 60 seconds and was gently rinsed with distilled water to wash off excess stain. The smear was flooded with Lugols' iodine and was left to stay for 60 seconds and rinsed with water. Acetone was added to the smear for 5 seconds and rinsed with distilled water. The smear was counter stained with safranin and left for 60 seconds and finally rinsed with water. The smear was allowed to air dry at room temperature (27^{o}C). Immersion oil was applied on the smear and the slide was examined microscopically for cell morphology (Coccmighio*et al.,* 2016)

Biochemical Tests
a. Catalase Test
Catalase Test was carried out by pouring 2.0 ml of Hydrogen peroxide solution (3%) into a test tube. Using a sterile wire loop an aliquot of the test bacterial isolates was removed and immersed in the solution of the hydrogen peroxide. A positive result was a rapid evolution of bubbles (within 5-10 sec) (Cheesebrough, 2005).
b. Citrate Utilization Test
Agar slant of Simon's citrate agar was prepared according to manufacturer instruction. A sterile wire loop was used to pick an aliquot of 24 hour old bacteria isolates and streaked on the agar slant. It was incubated at 37^{o}C for 24 hours. The development of a blue color was an indicative of positive citrate test (Cheesebrough, 2005).
c. Urease Test (using Rosco urease Identification Tablet)
A loop full of 24 hour old bacteria isolates were inoculated in 0.5 normal sterile saline in bijou bottle to form a milky suspension. Using a sterile forceps, a urease tablet was collected and added to the bottle and screw cover. It was incubated for 4 hours in a water bath at 37^{o}C. Change from red to pink colouration was an indicative of urease positive (Cheesebrough, 2006).
d. Indole Test
Sterile test tubes containing 4 ml of tryptone broth was inoculated aseptically with an aliquot of 24 hour bacteria isolate. The tube will be incubated at 37°C for 24 hours. Exactly 0.5 ml of Kovac's reagent was added to the broth culture after incubation and was gently shaken and allowed to settle down. A red colour in the alcohol layer was indicative of indole positive (Cheesebrough, 2006).
g. Coagulase Test (Slide Method).
A loopful of 24 hour bacterial culture isolate was emulsified with normal saline solution on a clean glass slide. A drop of anti-coagulated plasma was added to the emulsified isolate and mixed thoroughly and gently for 10 seconds. Formation of clumping within 10 seconds was an indicative of coagulase positive (Cheesebrough, 2006).

Susceptibility Analysis/ Inoculum preparation using McFarland's Standard
The inoculum was prepared by inoculating the isolates into tubes of sterile normal saline and compared with a McFarland standard that was freshly prepared from a solution of Barium chloride and sulphuric acid. The turbidly was then be adjusted to equal that of 0.5 McFarland.

Antibacterial Activity of Garlic (*Allium sativum*), Ginger (*Zingiberofficinale*) and Turmeric extracts on Test Organisms.
Susceptibility testing was carried out using agar well diffusion method, according to the recommendation of the National Committee for Clinical Laboratory Standards (2000). In this method, a sterile cotton swab was dipped into a test tube containing the standard test organism and was rotated properly to allow maximum contact. Excess inoculum was removed by pressing and rotating the swab firmly against the inside wall of the tube above the liquid level. The swab will then be streaked over the surface of the Mueller-Hinton medium three times while rotating the plate at 60° angle after each application. The swab was also passed around the edge of the agar surface. The inoculum was left to dry for a few minutes at room temperature with the lid closed. It was bored on the surface of the agar plates using 4mm cork borer. About 0.2ml of the different concentrations of each extract will be transferred into the well using Pasteur's pipette. The wells wassufficiently spaced to prevent the resulting zone of inhibition from overlapping; Ciprofloxacin 250mg/ml was used as positive control. The plateswasincubated at 37^{o}C for 24hours. The experiment was performed in replicates and the resulting diameters of the zones of inhibitions were measured in millimeter (mm) Joe *et al*. (2009).

Minimum Inhibitory Concentration (MIC)
The MIC of the potent extracts was determined according to the macro broth dilution technique described by Joe *et al*. (2009).

Standardized suspension of the test organisms was inoculated into a series of five sterile test tubes of nutrient broth containing two fold dilutions of the extracts and incubated at 37^{o}C for 24hours. The MIC was recorded as the least concentration that inhibited the growth of the test organism.

Minimum Bactericidal Concentration (MBC)

The MBC of the respective extracts was determined by procedure described by Murray *et al.* (1999). Aliquot was taken from the MIC tubes with no visible growth and sub cultured on freshly prepared nutrient agar plates and later incubated at 37^{0}c for 24hours. The MBC was recorded as the concentration of the extract that did not show any growth on new set agar plates.

Statistical Analysis

Data was analyzed for mean and standard deviation and the analysis was done using statistical package service solution (SPSS) version 21. All significant differences were determined by one way Analysis of variance (ANOVA).

RESULTS

The distributions of the test organisms isolated from spoilt tomatoes are presented in Table 1. *Staphylococcus aureus* had the highest percentage frequency (33.3%) followed by *Escherichia coli* (28.57%)) while Salmonella had the lowest percentage frequency (14.29%)

Table1: Distributions of Test Organisms Isolated from Spoilt Tomatoes

Test Organisms	Frequency
Staphylococcus aureus	5 (33.3%)
Streptococcus spp	3 (21.43%
Salmonella spp	2 (14.29%)
Escherichia coli	4 (28.57%)
Total	**14 (100%)**

Table 2 shows the biochemical test ofbacteria isolates from tomatoes. All the isolates were catalase positive. *Staphylococcus aureus* was coagulase, urease and citrate positive. *Escherichia coli* were indole, urease and citrate positive. *Streptococcus spp* was citrate positive

Table 2: Biochemical Identification of Bacterial Isolates from Tomatoes

S/N	Catalase	Coagulase	Urease	Citrate	Indole	Suspected organism
1.	+	-	-	-	+	*Escherichia coli*
2.	+	-	-	+	-	*Salmonella* spp
3.	+	+	+	+	-	*Staphylococcus aureus*
4.	+	-	+	+	-	*Streptococcus* spp

Table 3 shows the antibacterial activity of different concentrations of ethanolic extract of tumeric on bacterial Isolates from tomatoes. *Staphylococcus aureus* had the highest zone of inhibition (24.50 mm) at 500mg/ml concentration followed by *Streptococcus* spp (23.50mm). *Salmonella* spphad the lowest zones of inhibition at 31.25. 61.25, 125,250 and 500mg/ml concentration respectively.There is a significant difference (P<0.05) in the zones of inhibition at the different concentration of the ethanolic extract on the bacteria isolates.

Table 3: Antibacterial activity of different concentrations of Ethanolic extract of Tumeric on Bacterial Isolates from Tomatoes

Organism	Concentration (mg/ml)/ Zones of inhibition (mm)					Control
	31.25	62.5	125	250	500	Ciprofloxacin
Staphylococcus aureus	15.00 ± 1.41	18.00 ± 1.41	20.00 ± 0.71	23.50 ± 0.71	24.50 ± 6.36	25.20 ± 1.121
***Streptococcus* spp**	11.50 ± 2.12	12.50 ± 2.12	15.00 ± 4.24	21.50 ± 3.54	23.50 ± 3.54	23.50 ± 1.121
Escherichia coli	13.50 ± 0.71	14.00 ± 2.83	15.00 ± 1.41	17.50 ± 0.71	18.50 ± 0.71	24.25 ± 0.71
***Salmonella* spp**	9.00 ± 1.41	10.50 ± 0.71	14.00 ± 2.83	16.50 ± 0.71	17.50 ± 2.12	25.10 ± 1.41

P < 0.05 P= 0.011

Data are expressed as mean plus or minus standard deviation of zones of inhibitions

Table 4 presents the antibacterial activity of different concentrations of aqueous extract of turmeric on bacterial isolates from Tomatoes. At 500mg/ml concentration *Streptococcus* spp had the highest zone of inhibition (17.00mm) while *Escherichia coli*had no zones of inhibition at 31.25mg/ml concentration.There is a significant

difference (P<0.05) in the zones of inhibition at different concentration of the ethanolicextract on the bacteria isolates.

Table 4: Antibacterial Activity of Different Concentrations of Turmeric Aqueous Extract on Bacterial Isolates from Tomatoes.

Organism	Concentration (mg/ml)/ Zones of inhibition (mm)					Control
	31.25	62.5	125	250	500	Ciprofloxacin
Staphylococcus aureus	3.50 ± 0.71	7.50 ± 1.41	9.50 ± 0.71	12.00 ± 0.71	16.50 ± 2.12	22.15 ± 1.41
***Streptococcus* spp**	7.50 ± 0.71	12.50 ± 3.54	12.00 ± 1.41	15.00 ± 1.41	17.00 ± 2.83	20.10 ± 1.121
Escherichia coli	0.00 ± 0.00	10.50 ± 0..71	11.00 ± 4.24	12.00 ± 4.24	15.00 ± 7.07	15.05 ± 0.71
***Salmonella* spp**	4.50 ± 0.71	6.50 ± 0.71	7.50 ± 0.71	8.00 ± 2.83	9.00 ± 0.00	22.15 ± 4.12

P < 0.05 P= 0.014

Data are expressed as mean plus or minus standard deviation of zones of inhibitions

Table 5 displays the antibacterial activity of different concentrations of ethanolic extract of garlic on bacterial isolates from tomatoes. *Streptococcus* spp. had the highest zone of inhibition at 500mg/ml concentration while *Staphylococcus aureus* and *Streptococcus* spp. exhibited same zones of inhibition (20.50mm) each at 250mg/ml concentration. *Salmonella* spp. had the lowest zone of inhibition (8.00mm) at 31.25mg/ml concentration.There was significant difference (P<0.05) in the Zones of inhibition at different concentration of the ethanolicextract on the bacteria isolates.

Table 5: Antibacterial Activity of Different Concentrations of Ethanolic Extract of Garlic on Bacterial Isolates from Tomatoes

Organism	Concentration (mg/ml)/ Zones of inhibition (mm)					Control
	31.25	62.5	125	250	500	Ciprofloxacin
Staphylococcus aureus	10.00 ± 1.41	13.50 ± 2.12	17.00 ± 1.41	20.50 ± 2.12	24.00 ± 1.41	22.50 ± 1.121
***Streptococcus* spp**	14.00 ± 2.83	15.50 ± 1.71	18.00 ± 1.41	20.50 ± 0.71	25.50 ± 2.12	22.40 ± 1.54
Escherichia coli	10.00 ± 0.00	11.50 ± 2.12	13.00 ± 1.41	14.00 ± 1.41	16.00 ± 2.83	20.15 ± 0.71
***Salmonella* spp**	8.00 ± 1.41	13.00 ± 1.41	17.50 ± 2.12	18.50 ± 2.12	21.50 ± 2.12	24.10 ± 8.12

P < 0.05 P= 0.007,

Data are expressed as mean plus or minus standard deviation of zones of inhibitions

The antibacterial activity of different concentrations of aqueous extract of garlic on bacterial isolates from tomatoes are found on Table 6. The result showed that there was significant difference (P<0.05) in the Zones of inhibition at the different concentration of the aqueous extract on the bacteria isolates. *Staphylococcus aureus* and *Streptococcus* spp. exhibited the same zones of inhibition (13.00mm and 15.00mm) each at 500mg/ml and 250mg/ml concentration respectively. *Salmonella* spp. *and Escherichia coli* had no zones of inhibition at 31.25 and 61.25 concentration.

Table 6: Antibacterial Activity of different concentrations of Aqueous Extract of Garlic on Bacterial Isolates from Tomatoes

Organism	Concentration (mg/ml)/ Zones of inhibition (mm)					Control
	31.25	62.5	125	250	500	Ciprofloxacin
Staphylococcus aureus	8.00 ± 1.41	9.00 ± 1.41	12.00 ± 2.83	13.00 ± 2.12	15.00 ± 2.83	21.10 ± 4.12
***Streptococcus* spp**	9.00 ± 1.41	11.00 ± 4.24	11.50 ± 2.12	13.00 ± 2.83	15.50 ± 3.54	24.60 ± 5.21
Escherichia coli	0. .00 ± 0.00	0. .00 ± 0.00	5.50 ± 2.12	7.50 ± 2.121	9.00 ± 1.41	17.25 ± 0.71
Salmonella spp	0. .00 ± 0.00	0. .00 ± 0.00	7.00 ± 1.41	9.50 ± 71	12.00 ± 1.41	23.10 ± 6.12

P < 0.05 P= 0.14

Data are expressed as mean plus or minus standard deviation of zones of inhibitions

The antibacterial activity of different concentrations of ethanolic extract of ginger on bacterial isolates from tomatoes is shown on Table 7.*Staphylococcus aureus* had the highest zone of inhibition (25.00 mm) at 500mg/ml concentration. *Salmonella* spphad the lowest zones of inhibition at 31.25 mg/ml concentration respectively.There was no significant difference (P>0.05) in the Zones of inhibition at the different concentration of the ethanolic extract on the test organisms.

Table 7: Antibacterial activity of different concentrations of Ginger Ethanolic extract on Bacterial Isolates from Tomatoes

Organism	Concentration (mg/ml)/ Zones of inhibition (mm)					Control
	31.25	62.5	125	250	500	Ciprofloxacin
Staphylococcus aureus	11.00 ± 1.41	15.00 ± 1.41	18.00 ± 1.41	22.00 ± 1.41	25.00 ± 1.41	24.15 ± 3.12
***Streptococcus* spp**	12.00 ± 1.41	13.00 ± 1.41	16.00 ± 0.00	19.50 ± .71	22.50 ± 1.71	20.25 ± 1.121
Escherichia coli	11.00 ± 2.83	11.50 ± 0.71	12.50 ± 2.12	15.50 ± 2.12	19.00 ± 1.41	20.10 ± 0.71
Salmonella spp	10.50 ± 1.70	12.50 ± 0.71	12.50 ± 2.12	17.50 ± 2.12	21.00 ± 1.41	25.21 ± 8.12

$P < 0.05$ $P = 0.14$

Data are expressed as mean plus or minus standard deviation of zones of inhibitions

Activity of different concentrations of aqueous extract of garlic on bacterial isolates from Tomatoes (Table 8).*Streptococcus* spp. had the highest zone of inhibition (16.50mm) at 500 mg/ml concentration while*Staphylococcus aureus* and *Streptococcus* spp. exhibited same zones of inhibition (20.50mm) each at 250 mg/ml concentration. *Salmonella* spp. *and Escherichia coli* had no zones of inhibition at 31.25 mg/ml concentration. There was significant difference ($P<0.05$) in the Zones of inhibition at different concentration of the aqueous extract on the bacteria isolates.

The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MFC) of ethanolic and aqueous extract of turmeric are presented on Table 9. From the result 62.5 mg/ml concentration of the aqueous extract was the Minimum Inhibitory Concentration (MIC) for *Escherichia coli* while 31.25 mg/ml of the aqueous Extract was the Minimum Inhibitory Concentration (MIC) for *Staphylococcus aureus, Streptococcus aureus* and *Salmonella* spp. The Minimum Bactericidal Concentration for both the Ethaolic and Aqueous Extracts was 500 mg/ml for all the test organisms.

Table 8: Antibacterial Activity of Different Concentrations of Aqueous Extract of Ginger on Bacterial Isolates from Tomatoes

Organism	Concentration (mg/ml)/ Zones of inhibition (mm)					Control
	31.25	62.5	125	250	500	Ciprofloxacin
Staphylococcus aureus	6.00 ± 1.41	6.50 ± 3.53	9.50 ± 0.71	11.50 ± 3.53	14.50 ± 2.12	20.50 ± 7.32
Streptococcus spp	7.00 ± 1.41	11.00 ± 2.82	13.00 ± 1.41	14.00 ± 0.00	16.50 ± 1.71	23.15 ± 1.121
Escherichia coli	0.00 ± 0.00	6.50 ± 0.71	8.50± 0.71	9.50 ± 2.12	11.00 ± 1.41	21.25 ± 0.71
Salmonella spp	0.00 ± 0.00	5.00 ± 4.24	5.50 ± 0.71	10.00 ± 1.41	10.50 ± 2.12	24.05 ± 9.12

$P < 0.05$ $P = 0.07$

Data are expressed as mean plus or minus standard deviation of zones of inhibitions

Table 9: Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of Ethanolic and Aqueous Extracts of Tumeric.

Organisms	Concentration mg/ml /Zone of inhibition (mm)			
	Aqueous Extract		Ethanolic Extract	
	MIC	MBC	MIC	MBC
Staphylococcus aureus	31.25	500	31.25	500
***Streptococcus* spp**	31.25	500	31.25	500
Escherichia coli	62.5	500	31.25	500
Salmonella spp	31.25	500	31.25	500

Table 10 shows the Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of ethanolic and aqueous extract of garlic the test organism. From the result 125 mg/ml of the aqueous extract was the Minimum Inhibitory Concentration (MIC) for *Escherichia coli* and *Salmonella* spp. 500mg/ml was the Minimum Bactericidal Concentration (MBC) for both ethanolic and aqueous extracts for all the test organisms.

Table 10: Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of Ethanolic and Aqueous Extracts of Garlic

Organisms	Concentration mg/ml /Zone of inhibition (mm)			
	Aqueous Extract		Ethanolic Extract	
	MIC	MBC	MIC	MBC
Staphylococcus aureus	31.25	500	31.25	500
***Streptococcus* spp**	31.25	500	31.25	500
Escherichia coli	125	500	31.25	500
***Salmonella* spp**	125	500	31.25	500

Table 11 displays the Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of ethanolic and aqueous extract of ginger the test organism. From the result 62.5mg/ml of the aqueous extract was the Minimum Inhibitory Concentration (MIC) for *Escherichia coli* and *Salmonella* spp while 500mg/ml was the Minimum Bactericidal Concentration (MBC) for both ethanolic and aqueous extracts for all the test organisms.

Table 11: Minimum Inhibitory Concentration (MIC) and Minimum Fungicidal Concentration (MBC) of Ethanolic and Aqueous Extracts of Ginger

Organisms	Concentration mg/ml /Zone of inhibition (mm)			
	Aqueous Extract		Ethanolic Extract	
	MIC	MBC	MIC	MBC
Staphylococcus aureus	31.25	500	31.25	500
***Streptococcus* spp**	31.25	500	31.25	500
Escherichia coli	62.5	500	31.25	500
***Salmonella* spp**	62.5	500	31.25	500

DISCUSSION

In this study the antibacterial activity of ethanolic and aqueous extracts of ginger, turmeric and Garlic on bacterial isolated from tomatoes was determined. The bacteria isolates were; *Staphylococcus aureus*, *Streptococcus* spp, *Salmonella* spp and *Escherichia coli*. All the extracts showed antibacterial activity against the test organisms. The significant antibacterial activity of ginger, turmeric and garlic could be attributed to the presence of bioactive compounds in the extracts (Grace *et al.,* 2017). This finding is in line with the report of Iram*et al.* (2012) on the Inhibitory effect of *Allium sativum*and*Zingiberofficinale*extracts on clinically important drug resistant pathogenic bacteria. Leucherner and Zamparini (2002) also reported antimicrobial effects of spices on growth and survival of *Escherichia coli* 0157 and *Salmonella enterica*serovarenteridis.

This study evaluated the antimicrobial activity of garlic and found to be highest followed by ginger and turmeric against the test organisms. The antimicrobial activity of garlic is reported to be due to the presence of allicin as the main component of garlic that inhibit bacterial growth by immediate and total inhibition of RNA synthesis, although DNA and protein synthesis are also partially inhibited (Sah*et al.,* 2020). Ginger is widely used as an ingredient in food, pharmaceutical, cosmetic, and other industries. Some volatile compounds which are responsible for antimicrobial activities in ginger are á-pinene, borneol, camphene, and linalool (Venugopal*et al.,* 2009). The presence of essential oil, curcumins, curcuminoids, turmeric oil, turmerol and valeric acid in Tumeric are responsible for its antimicrobial activity (Joe*et al.,* 2009).
The ethanolic extracts were more effective than aqueous extracts. This may be due to the better solubility of the active components in organic solvents as opined by Umeh*et al.* (2005). Different solvents have different polarities, hence different degrees of solubility for the various phytoconstituents. These results agrees with the report of Cowan (2002) that alcoholic solvents like methanol and ethanol are more suitable than other solvents such as water in extracting components of medicinal plants.

It was observed that the overall effectiveness of ethanolic extract of spices is higher in Gram positive bacteria than Gram negative. This finding collaborate the study of Grace *et al.* (2017) who found similar result explaining that ethanolic extract of ginger is best effective against *S. aureus* when compared to other Gram negative. Generally, in Gram negative bacteria, their outer membrane serves as permeability barrier which allows only small hydrophilic molecules to pass through into all, restricting their route of penetration for certain antimicrobial compounds and excluding larger molecules. Besides these, they also possess multidrug resistant pumps which exclude some of antibacterial compounds across barrier (Quadar*et a*l., 2013).

The MIC result showed that increasing concentration has an increasing efficiency in inhibiting the test organisms. The increase of the concentration of the extract implied an increase in the active ingredients of the bioactive compounds which acted upon the bacterial isolates thereby affecting its physiological processes and inhibition of cell wall formation in the cell resulting in a leakage of cytoplasmic constituents by the bioactive components of the extract and consequently lowering the growth of the bacterial isolates. This agrees with the findings of Sah*et al*. (2020)

Conclusion

Staphylococcus aureus, *Streptococcus* spp, *Salmonella* spp and *Escherichia coli* was isolated and identified as organisms associated with tomato spoilage. The antimicrobial effect of ethanolic extract of tumeric, ginger and garlic is higher in Gram positive bacteria than Gram negative. The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) for the test organisms in both extracts (Ethanolic and

Aqueous) of Tumeric, Garlic and Ginger were 31.25 mg/ml and 500mg/ml respectively. The antimicrobial activity of spices is due to specific phytochemicals constituents and there is possibility of sourcing alternative antibiotic substances in these plants and further development of bio-pesticide for disease management in crops.

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