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EVALUATION OF ANTIOXIDANT AND ANTIBACTERIAL ACTIVITIES OF DIFFERENT BANGLADESHI SPICES (TURMERIC, GARLIC AND GINGER)

Trisha Farjana, Md. Mahfujur Rahman, Khadija Akter Eva, Nagma Zerin, Md. Shahidul Kabir*

Department of Microbiology, Stamford University Bangladesh, 51 Siddeswari Road, Dhaka, Post code 1217, Bangladesh.

Corresponding Author: Dr. Md. Shahidul Kabir
Department of Microbiology, Stamford University Bangladesh, 51 Siddeswari Road, Dhaka, Post code 1217, Bangladesh.

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ABSTRACT
Spices are commonly used in preparation of Asian food for fortification of taste, flavor, color and fragrance. They also impart many other properties which are beneficial for human health. Antioxidant and antibacterial properties of turmeric (*Curcuma longa*), garlic (*Allium sativum*) and ginger (*Zingiber officinale*) powders were determined in this study. The spice powders were extracted in ethanol, methanol and distilled water. Antioxidant property was determine by Hydrogen Peroxide (H_2O_2) scavenging assay and antibacterial activity by agar well diffusion assay against twenty four pathogenic bacteria e.g. *Escherichia* coli (n=4), *Staphylococcus* aureus (n=4), *Pseudomonas* spp. (n=4), *Klebsiella* spp. (n=4), *Salmonella* spp. (n=4) and *Vibrio cholera* (n=4). The highest antioxidant activity was observed for methanol extract (60.00 µg/mL) of ginger, % scavenging being 94.09 ± 3.63 %. The ethanol extract (100.00 µg/ml) of turmeric showed the strongest antibacterial activities against *Pseudomonas* spp. and *Vibrio cholerae* with zone of inhibition being 16.00 ± 1.00 mm. While the methanol extract (100.00 µg/ml) of garlic showed maximum zone of inhibition (15.67 ± 1.53 mm) against *Klebsiella* spp., the ethanol extract of ginger (100.00 µg/ml) exhibited the maximum zone of inhibition (18.00 ± 1.00 mm) against *Pseudomonas* spp. This study may contribute to the global efforts towards screening compounds possessing antioxidant and antibacterial properties that may be used as precursor molecules for new drugs to be used for treatment of cancer and emerging drug resistant microorganisms.

KEYWORDS: Turmeric, Garlic, Ginger, Antibacterial activity, Antioxidant activity.

INTRODUCTION
In the last couple of years two health issues, cancer and antimicrobial resistance have raised grave concern due to their rapid and unrestrained increase around the world. Extensive research is being conducted continuously in all spheres of scientific research to develop ways and means for prevention and control of these diseases. One of the major causes of cancer is considered to be oxidative stress, which is essentially an imbalance between the production of free radicals and the ability of the body to counteract their harmful effects (e.g., cell damage) through neutralization by endogenous antioxidants. This imbalance can be created due to many internal genetic and metabolic factors as well as external effects like continuous exposure to environmental pollution, radiation, pesticides, organic solvents, smoking and carcinogenic substances.[1] On the other hand, indiscriminate and excessive use of commercial antibiotics is considered to be one of the major reasons for antimicrobial resistance of drugs. Compounds having both antioxidant and antibacterial properties can play duel role by protecting cells from oxidative stress and fighting against infections caused by drug resistant microorganisms. Thus, it is important to screen and make a library of compounds which possess the combined properties. A prominent research approach is to study various natural compounds which possess antioxidant and antibacterial properties as they can be used to develop alternative cancer therapies as well as novel antibiotics.

Spices are commonly used in food to impart flavor and pungent stimuli.[2] Since the last couple of years different spices (e.g, turmeric, garlic and ginger) have been reported to have high antioxidant and antibacterial properties due to the presence of various bioactive compounds. The major bioactive compounds in turmeric are curcumin (diferuloyl methane), allicin (a compound composed of diallyl thiosulphinate) in garlic and 6-gingerol, 6-shogaol, 8-gingerol and 10- gingerol in ginger.[3-7] On account of having high antioxidant and antibacterial properties, these spices have great medicinal applications. Turmeric has been applied on skin for healing wounds, for treating parasitic skin infections, common cold, urinary tract diseases and liver diseases.[8]

In addition, turmeric has been found to be important in preventing and treating various pro-inflammatory chronic diseases, including neurodegenerative, cardiovascular, pulmonary, metabolic, autoimmune and malignant diseases.[9] Garlic has been claimed to aid in preventing cardiovascular diseases, high cholesterol level, high blood pressure and cancers of stomach and colon.[10] Garlic is also well recognized for treating tuberculosis, malaria, asthma, diabetes and for improving immune system.[11,12] Ginger has been determined to be effective against nausea caused by seasickness, morning sickness and chemotherapy, inflammation, rheumatism, fever, common cold, diabetes, asthma, nervous system disorders and digestive disorders.[13,14]

In this study, antioxidant and antibacterial properties of Turmeric (*Curcuma longa*), Ginger (*Zingiber officinale*) and Garlic (*Allium sativum*) powders were determined to highlight their potential to be used for their medicinal properties.

METHODS

Spice collection

Dry powder of turmeric, garlic and ginger (in commercial packets) were bought from the local grocery stores in Dhaka city, Bangladesh.

Preparation of spice extracts

The spice sample was extracted according to the method used in a previous study with some modifications.[15] For antioxidant activity 5 g of dry spice power was added to 100 ml of ethanol/ methanol /distilled water and was put in a shaker for 1 hour at 120 rpm (room temperature). For antibacterial activity 20 g of dry spice power was added to 100 ml of ethanol/ methanol /distilled water and kept in a shaker for 24 hour at 120 rpm at 37°C. Then they were centrifuged at 3000 rpm for 10 min. The supernatant was filtered using Whatman filter paper and stored in a refrigerator at 4°C. The stock solution was then diluted to various concentrations to determine the antioxidant and antibacterial activities. Each experiment was conducted in triplicate for each concentration, and the results were expressed as the mean value ± standard deviation.

Determination of Antioxidant capacity using Hydrogen Peroxide Scavenging method

The antioxidant capacity of the spices was measured by following the method mentioned elsewhere [16] with some modification. A solution of hydrogen peroxide (40 mM) was prepared in phosphate buffer (50 mM, pH 7.4). The sample extracts of different concentrations were added to hydrogen peroxide solution. Their absorbance values were measured at 230 nm after being kept for 3 hours in a dark place. The subsequent decrease in the absorbance value is the measure of the ability of sample extracts to scavenge H_2O_2. The control solution contained 1 ml solvent (ethanol/methanol/distilled water) and 1 ml hydrogen peroxide solution. The blank solution was phosphate buffer only without any hydrogen peroxide. Hydrogen peroxide solution was freshly prepared before each experiment.

The percentage of hydrogen peroxide scavenging was calculated using the following formula:

% Scavenged (H_2O_2) = {(Ac-As)/Ac}*100

Here Ac is the absorbance of control and As is the absorbance of the sample.

Test Microorganisms

All bacteria used in this study were previously isolated and identified from environmental samples and stored in the laboratory of the Department of Microbiology of Stamford University Bangladesh. The antibacterial activity of the spices was tested against twenty four isolates, comprising of four of each isolates of *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas* spp., *Klebsiella* spp., *Salmonella* spp. and *Vibrio cholerae*.

Determination of Antibacterial activity using Agar Well Diffusion assay

The antimicrobial activity of the spice extracts was determined by agar well diffusion method. The bacteria were grown in Muller Hinton broth (Himedia Laboratories Ltd., India) to match the turbidity of 0.5 McFarland standards to be inoculated on Muller-Hinton Agar.[17] After drying the inoculation plates for 15 minutes, wells were punched using sterile cork borers. Then the wells were filled with 100 µl of spice extracts and the solvents (ethanol, methanol and distilled water) as reagent blanks. In this study, commercially available Gentamycin (10.00 µg) discs were used as a positive control. Plates were incubated for 24 hours at 37°C, which allowed spice extracts to diffuse through the agar media to form zones of inhibition. The diameters of the zone of inhibition for spice extracts against various pathogenic bacteria were measured in millimeter (mm). Antibacterial activity of the extracts was recorded if the diameter of the zone of inhibition was greater than 6 mm. Zone diameters not more than 6 mm were considered as no zone of inhibition.

RESULTS

Antioxidant activities in extracts of Turmeric, Garlic and Ginger

In this study, % scavenging of turmeric extracts in ethanol and methanol ranged from 46.31 ± 16.60 % to 60.42 ± 32.11 % and 65.50 ± 8.79 % to 73.27 ± 14.53 % for the concentrations 100.00 µg/mL and 120.00 µg/mL, respectively (Table 1). For ethanol extract of garlic % Scavenging increased from 48.31± 21.63 % to 62.82 ± 19.73 % as the concentration increased from 40.00 µg/mL to 60.00 µg/mL (Table 2). For Methanol extracts of Garlic, % Scavenging increased from 83.29 ± 19.68 % to 91.95 ± 10.49 % for extract concentrations of 40.00 µg/mL and 60.00 µg/mL respectively (Table 2). For ethanol extract of ginger the % Scavenging increased from 63.94 ± 24.04 % (40 µg/mL) to 79.81 ± 24.43 % (60 µg/mL). For methanol extract of ginger as %

Scavenging increased from 78.48 ± 5.76 % (40.00 µg/mL) to 94.09 ± 3.63 % (60.00 µg/mL) (Table 3).

It was observed that the antioxidant activity (% scavenged) of methanol extracts for all spices were relatively higher than the ethanol extracts. Water extracts (room temperature) for turmeric, garlic and ginger exhibited no absorbance values after 3 hours of experiment. They were therefore, recorded to have no measurable antioxidant activity.

Antibacterial activities in extracts of Turmeric, Garlic and Ginger

Turmeric

The strongest antimicrobial activities of ethanol extract of turmeric were noticed against *Pseudomonas* spp. and *Vibrio cholerae* with zone of inhibition being 16.00 ± 1.00 mm for concentration of 100.00 µg/ml (Table 4). *Salmonella* spp. was noticed to be the most resistant against ethanol extract of turmeric with minimum inhibitory concentration (MIC) being 100.00 µg/ml (Table 4). For methanol extract the highest zones of inhibition were determined to be 16.00 ± 1.00 mm for *Klebsiella* spp. and 15.00 ± 1.00 mm for *Vibrio cholerae* and *Eshcherichia coli* for extract concentration of 100.00 µg/ml (Table 5). Similar to the result of ethanol extract, *Salmonella* spp. was also observed to be the most resistant against methanol extract of turmeric with minimum inhibitory concentration (MIC) being 100.00 µg/ml (Table 5). The water extract of turmeric hardly exhibited inhibition against the tested pathogenic bacteria. The highest zone of inhibition was found to be 15.00 ± 1.00 mm against *Vibrio cholerae* for extract concentration of 100.00 µg/ml (Table 6).

Garlic

For ethanol extract of garlic, the highest zone of inhibition (15.00 ± 1.00 mm) was observed against *Klebsiella* spp. for concentration of 100.00 µg/ml (Table 7). The methanol extract of garlic showed maximum zone of inhibition (15.67 ± 1.53 mm) against *Klebsiella* spp. as well for concentration of 100.00 µg/ml (Table 8). *Pseudomonas* spp. exhibited susceptibility at 100.00 µg/ml of methanol extract of garlic with zone of inhibition being 15.00 ± 0.00 mm (Table 8). The water extract of garlic didn't show any activity against *Staphylococcus aureus*, *Klebsiella* spp., *Salmonella* spp. and *Vibrio cholerae*. The highest zone of inhibition (14.00 ± 1.00 mm) was observed against *Escherichia coli* for concentration of 100.00 µg/ml (Table 9).

Ginger

For ethanol extract of ginger (100.00 µg/ml), the maximum zone of inhibition (18.00 ± 1.00 mm) was recorded against Pseudomonas spp. (Table 10). No inhibition was observed against Salmonella spp. (Table 10). The methanol extract of ginger exhibited highest zone of inhibitions of 15.67 ± 1.53 mm against Vibrio cholerae for concentration of 100.00 µg/ml (Table 11). *Staphylococcus aureus* and *Salmonella* spp. did not show any susceptibility to methanol extract of ginger with Minimum Inhibitory Concentration (MIC) >100.00 µg/ml (Table 11). Water extract of ginger showed the highest zone of inhibition (10.00 ± 1.00 mm) against *Escherichia coli* for concentration of 100.00 µg/ml (Table 12). No antibacterial activity was noticed against *Pseudomonas* spp., *Klebsiella* spp., *Salmonella* spp. and *Vibrio cholerae*.

Table 1: Antioxidant activity of Turmeric in different solvents

Solvent	Concentration (µg/mL)	Absorbance	% H_2O_2 Scavenging
Ethanol	100	0.111±0.024	46.31±16.60
	120	0.082± 0.047	60.42±32.11
Methanol	100	0.148±0.026	65.50±8.79
	120	0.114± 0.044	73.27±14.53
Water	100	-	-
	120	-	-

Table 2: Antioxidant activity of Garlic in different solvents

Solvent	Concentration (µg/mL)	Absorbance	% H_2O_2 Scavenging
Ethanol	40	0.108± 0.032	48.31±21.63
	60	0.077± 0.029	62.82±19.73
Methanol	40	0.072±0.059	83.29±19.68
	60	0.034± 0.032	91.95±10.49
Water	40	-	-
	60	-	-

Table 3: Antioxidant activity of Ginger in different solvents

Solvent	Concentration (µg/mL)	Absorbance	% H_2O_2 Scavenging
Ethanol	40	0.075± 0.035	63.94±24.04
	60	0.042± 0.036	79.81±24.43
Methanol	40	0.092± 0.017	78.48±5.76
	60	0.025± 0.011	94.09±3.63
Water	40	-	-
	60	-	-

Table 4: Antibacterial activity of Turmeric in Ethanol against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	8±2	9±0	14±1	25
Staphylococcus aureus	6±0	7±1	8±1	14±1	25
Pseudomonas spp.	6±0	6±2	10±1	16±1	50
Klebsiella spp.	6±0	8±1	7±0	13±1	50
Salmonella spp.	6±0	6±0	6±2	8±1	100
Vibrio cholerae	6±0	10±1	12±2	16±1	25

Table 5: Antibacterial activity of Turmeric in Methanol against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	8±2	9±1	15±1	25
Staphylococcus aureus	6±0	6±0	9±2	10±1	50
Pseudomonas spp.	6±0	10±1	11±1	13±1	25
Klebsiella spp.	6±0	8±1	11±2	16±1	25
Salmonella spp.	6±0	6±0	6±1	9±1	100
Vibrio cholerae	6±0	8±1	11±1	15±1	25

Table 6: Antibacterial activity of Turmeric in Distilled water against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	6±0	6±0	6±0	>100
Staphylococcus aureus	6±0	6±0	6±0	6±0	>100
Pseudomonas spp.	6±0	6±0	6±0	6±0	>100
Klebsiella spp.	6±0	6±0	7±0	13±1	>100
Salmonella spp.	6±0	6±0	6±0	6±0	>100
Vibrio cholerae	6±0	6±0	6±2	15±1	50

Table 7: Antibacterial activity of Garlic in Ethanol against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	6±0	6.7±1.15	7±0	50
Staphylococcus aureus	6±0	6±0	6±0	6±0	>100
Pseudomonas spp.	6±0	6.33±0.58	8±0	13.33±1.53	25
Klebsiella spp.	6±0	6±0	9±0	15±1	50
Salmonella spp.	6±0	6±0	6±0	6±0	>100
Vibrio cholerae	6±0	6±0	10±0	13±3	50

Table 8: Antibacterial activity of Garlic in Methanol against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	6±0	6±0	7±0	100
Staphylococcus aureus	6±0	6±0	6±0	6±0	>100
Pseudomonas spp.	6±0	7±1	9±1	15±0	25
Klebsiella spp.	6±0	9±2	15±1	15.67±1.53	25
Salmonella spp.	6±0	6±0	7±1	10±1	50
Vibrio cholerae	6±0	6±0	7±1	10.33±2.08	50

Table 9: Antibacterial activity of Garlic in Distilled water against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	7±2	7.67±1.53	14±1	25
Staphylococcus aureus	6±0	6±0	6±0	6±0	>100
Pseudomonas spp.	6±0	6.67±1.15	7±0	7.33±1.53	25
Klebsiella spp.	6±0	6±0	6±0	6±0	>100
Salmonella spp.	6±0	6±0	6±0	6±0	>100
Vibrio cholerae	6±0	6±0	6±0	6±0	>100

Table 10: Antibacterial activity of Ginger in Methanol against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	6±0	7±1	10±1	50
Staphylococcus aureus	6±0	6±0	6±0	6.33±0.58	100
Pseudomonas spp.	6±0	10±0	14±1	18±1	25
Klebsiella spp.	6±0	7±1	8±2	11±1	25
Salmonella spp.	6±0	6±0	6±0	6±0	>100
Vibrio cholerae	6±0	10±0	12±1	15±2	25

Table11: Antibacterial activity of Ginger in Methanol against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	6±0	8±1	13±1	50
Staphylococcus aureus	6±0	6±0	6±0	6±0	>100
Pseudomonas spp.	6±0	8±2.64	10±0	14±1	25
Klebsiella spp.	6±0	6±0	6±0	6.67±1.15	100
Salmonella spp.	6±0	6±0	6±0	6±0	>100
Vibrio cholerae	6±0	9±1	14±1	15.67±1.53	50

Table 12: Antibacterial activity of Ginger in Distilled water against different pathogenic microorganisms

Microorganism	Zone of inhibition (mm)				
	10 (µg/mL)	25 (µg/mL)	50 (µg/mL)	100 (µg/mL)	MIC (µg/mL)
Escherichia coli	6±0	6±0	7±0	10±1	50
Staphylococcus aureus	6±0	6±0	6±0	9±1	100
Pseudomonas spp.	6±0	6±0	6±0	6±0	>100
Klebsiella spp.	6±0	6±0	6±0	6±0	>100
Salmonella spp.	6±0	6±0	6±0	6±0	>100
Vibrio cholerae	6±0	6±0	6±0	6±0	>100

DISCUSSION

Antioxidant activities

According to a previous study, the % inhibition by ethanol extract of turmeric varied from 43.00 % to 91.00 % with concentrations ranging from 100.00-1000.00 µg/ml. In this study, % scavenging of turmeric extraction in ethanol ranged from 46.31 ± 16.60 % to 60.42 ± 32.11 % for the concentrations 100.00 µg/mL and 120.00 µg/mL, respectively. Ethanol extraction of garlic demonstrated % inhibition varied from 41.00 % to 91.00 % with concentrations ranging from 100.00 -1000.00 µg/ml. In this study, % scavenging of garlic extraction in ethanol ranged from 48.31 ± 21.63 % to 62.82 ± 19.73 % for the concentrations 40.00 µg/mL and 60.00 µg/mL. They also reported % inhibition by ethanol extract of ginger between 6.00 to 89.00 % with different concentrations ranging from 10.00-100.00 µg/ml. In this study, % scavenging of ginger extraction in ethanol ranged from 63.94 ± 24.04 % to 79.81 ± 24.43 % for the concentrations 40.00 µg/mL and 60.00 µg/mL, respectively.[18]

Overall, the results obtained from this study are comparable with the other study as in all cases increasing spice extract concentration within a particular range consistently led to higher antioxidant activity. Lack of antioxidant activity of water extracts could be due to the inadequate extraction of spice powders in water. This could be attributed to the fact that the bioactive

compounds responsible for antioxidant activity in turmeric, garlic and ginger are organic and can dissolve more readily in organic solvents like alcohol than in water.

Antibacterial activities

Turmeric

According to a previous study [19] the maximum zone of inhibition for ethanol extract of turmeric was found to be 11.00 ± 0.42 mm against *Escherichia coli* for 100.00 % extract concentration. In this study, the maximum zone of inhibition for ethanol extract of turmeric was found to be higher (14.00 ± 1.00 mm) against *Escherichia coli* (100.00 µg/ml) (Table 4). The methanol extract of turmeric (25.00 % w/v) showed high inhibition against *Escherichia coli* (28.00 ± 0.57 mm) and *Staphylococcus aurues* (20.00 ± 0.57 mm) in a previous study.[20] The methanol extract of turmeric (100.00 µg/ml) exhibited maximum zone of inhibition of 15.00 ± 1.00 mm against *Escherichia coli* and 10.00 ± 1.00 mm against *Staphylococcus aureus* (Table 5) in this study, which were relatively lower than the other report.[20] The water extract of turmeric demonstrated zone of inhibition of 18.00 ± 0.81 mm and 28.00 ± 0.57 mm for *Escherichia coli* and *Staphylococcus aureus*, respectively. However, in this study no zone of inhibition was observed for water extract of turmeric against *Escherichia coli* and *Staphylococcus aureus* (Table 6).

Garlic

The ethanol extract of garlic showed a range of zone of inhibition of 10.50 ± 0.21mm-17 ± 0.58 mm and 10.30 ± 0.42 mm-13.52 ± 0.56 mm against *Escherichia coli* and *Staphylococcus aureus*, respectively for concentrations of 25.00-100.00 µg/ml in a previous study.[21] According to this study, ethanol extract of garlic didn't show any antibacterial activity against *Escherichia coli* at 25.00 µg/ml concentration. However, the zones of inhibition were observed to be 6.70 ± 1.15 mm and 7.00 ± 0.00 mm at 50.00 µg/ml and 100.00 µg/ml concentrations, respectively (Table 7) , which were comparatively lower than the zones of inhibition observed in other study.[21] No zone of inhibition was observed against Staphylococcus aureus for ethanol extract of garlic in this study. Methanol extract (100.00 mg/ml) of garlic showed the zone of inhibition of 12.00 ± 0.00 mm against *Escherichia coli* and 11.00 ± 0.00 mm against *Staphylococcus aureus* as determined by other workers.[22] According to this study, methanol extract of garlic demonstrated maximum zone of inhibition of 7.00 ± 0.00 mm against *Escherichia coli* for 100.00 µg/ml extract concentration and no antibacterial activity was observed against *Staphylococcus aurues* (Table 8).

Water extracts of garlic (100.00 mg/ml) exhibited zone of inhibition against *Escherichia coli* and *Staphylococcus aureus* being 14.3 ± 0.54 mm and 19.3 ± 1.08 mm, respectively by the other researchers.[22] In this study, the zone of inhibition against *Escherichia coli* (14.00 ± 1.00 mm) was similar to the study, but no antibacterial activity was observed against *Staphylococcus aureus* (Table 9).

Ginger

According to a previous report [21] ethanol extract of ginger rhizomes showed a range of zone of inhibition (8.50 ± 0.12 mm - 13.50 ± 0.48 mm and 9.30 ± 0.32 mm - 12.52 ± 0.50 mm) for concentration of 25.00-100.00 µg/ml against *Escherichia coli* and *Staphylococcus aureus*, respectively. However, in this study ethanol extract of ginger demonstrated relatively smaller zone of inhibition against *Escherichia coli* (10.00 ± 1.00 mm) and *Staphylococcus aureus* (6.33 ± 0.58 mm) at concentration of 100.00 µg/ml (Table 10).

In another study methanol extract of ginger showed zone of inhibition of 14.5 ± 0.27 mm against *Escherichia coli* and 14.30 ± 0.27 mm against *Staphylococcus aureus*, respectively (Gull et al., 2012). However, in this study the methanol extract of ginger (100.00 µg/ml) demonstrated the maximum zone of inhibition of 13.00 ± 1.00 mm against *Escherichia coli*, but didn't exhibit any inhibitory activity against *Staphylococcus aureus* (Table 11).

In the other study aqueous extract of ginger exhibited zone of inhibition of 12.30 ± 0.27 mm against *Escherichia coli* and 13.00 ± 0.47 mm against *Staphylococcus aurues*.[22] In contrast, aqueous extract of ginger in this study showed relatively lower antibacterial activity against *Escherichia coli* (10.00 ± 1.00 mm) and *Staphylococcus aureus* (9.00 ± 1.00 mm) (Table 12).

CONCLUSION

After analyzing the results obtained from this study, it was observed that the different extracts of the studied spices (Turmeric, Garlic and Ginger) showed different types of antioxidant and antibacterial activity, depending on the type of solvent used for extraction. The organic solvents (Ethanol/Methanol) were found to be relatively better than distilled water for extraction. Future studies can be conducted to separate bioactive compounds of Turmeric, Garlic and Ginger using phytochemical analysis and to evaluate their potential for developing more efficient therapeutic agents and novel antibiotics.

Conflicts of Interest

There is no conflict of interest in this study.

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