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Screening of antibacterial activity of two tomato varieties against multi-drug resistant human pathogenic bacteria

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Abstract

The present investigation deals with the test of antibacterial activity of fruit extracts of two tomato varieties viz., Raton and Persimmon against five Gram positive bacteria viz., *Staphylococcus aureus, Bacillus cereus, Streptococcus-β-haemolytica, Bacillus subtilis, Sarcina lutea* and five Gram negative bacteria viz., *Klebsiella* sp., *Klebsiella pneumonia, Pseudomonas aeruginosa, Salmonella typhi, Shigella dysenteriae*. Between the two varieties, Raton and Persimmon in two different solvents (methanol and ethanol), ethanol fruit extracts of Raton have showed the highest zone of inhibition (19.50±0.28mm) against Gram negative bacteria *Pseudomonas aeruginosa*. MIC and MBC of the extracts are ranged from 100-300 mg/ml and 150-400 mg/ml respectively. The lowest MIC and MBC values are observed against *Pseudomonas aeruginosa, Klebsiella sp.* and *Staphylococcus aureus*. From the statistical results, it is seen that except replication, bacterial species, solvent and bacterial strain are significantly different with each other. In addition, interaction between bacterial species and solvent has showed that they are significantly different. The result indicates that the ethanol fruit extracts of tomato could be considered as a source of novel antibacterial agents against multi-drug resistant pathogenic bacteria.

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Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetables worldwide because of its high consumption, year round availability and large content of health related components. Tomatoes are now eaten freely throughout the world, and their consumption is believed to benefit the heart, among other organs. They contain the carotene lycopene, one of the most powerful natural antioxidants. In addition to its flavor properties, tomatoes are reported to possess numerous beneficial nutritional and bioactive components that may also benefit human health. These include the nutrients vitamin A, vitamin C, iron, and potassium; nonnutritive digestible and indigestible dietary fiber; the antioxidative compounds lycopene, β-carotene, and lutein (Pellegrini, 2007; Dorais *et al.*, 2008) and the cholesterol lowering (Friedman *et al.*, 2000a; Friedman *et al.*, 2000b) and immune system enhancing glycoalkaloids tomatine and dehydrotomatine (Morrow *et al.*, 2004). Consumption of tomatoes, tomato products, and isolated bioactive tomato ingredients is reported to be associated with lowered risk of cancer (Friedman *et al.*, 2007), heart disease (Willcox *et al.*, 2003), diabetes (Bose and Agrawal, 2007) and hypertension (Engelhard, 2006). These considerations suggest that edible tomato contains antimicrobials which may have multiple benefits.

The use of plants for treating diseases is as old as the human species. Plants have the major advantage of still being the most effective and cheaper alternative sources of drugs (Pretorious and Watt, 2001).

More than 25% of the drugs used during the last 20 years are directly derived from plants (Amin *et al.*, 2009). The local use of natural plants as primary health remedies, due to their pharmacological properties, is quite common in Asia, Latin America and Africa (Bibitha *et al.*, 2002). Plant based antimicrobials represent a vast untapped source for medicines and further exploration of plant antimicrobials needs to occur. Antimicrobials of plant origin have enormous therapeutic potential (Salau and Odeleye, 2007).

Human infections particularly those involving microorganisms i.e. bacteria, fungi, viruses, they cause serious infections in tropical and subtropical countries of the world. Infectious diseases are still a major threat to public health, despite the tremendous progress made in human medicine. Their impact is particularly large in developing countries due to the relative unavailability of medicines and the emergence of widespread drug resistance (Okeke *et al.*, 2005). In recent years, multiple drug resistance in human pathogenic microorganisms has been developed due to indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of such diseases (Mohanasundari *et al.*, 2007). In general, bacteria have the genetic ability to transmit and acquire resistance to drugs, which are utilized as therapeutic agents (Cohen, 1992). The number of infections which are caused by multi drug resistant gram positive and gram negative pathogens and viruses are life threatening for human being. Infections caused by these organisms pose a serious challenge to the scientific community and need for an effective therapy has lead for novel antimicrobial agents. Yet a scientific study of plants to determine their antimicrobial active compounds is a comparatively new field. The antimicrobial properties of plants have been investigated by a number of studies worldwide and many of them have been used as therapeutic alternatives because of their antimicrobial properties (Adriana *et al.*, 2007). Plants generally produce several secondary metabolites like phenols, flavonoids, quinones, tannins, alkaloids, saponins, and sterols which are important sources of biocides and many other pharmaceutical drugs (Akhtar *et al.*, 2008; Naili *et al.*, 2010). From this point of view, the present investigation has been undertaken to find out effective antibacterial properties of two tomato varieties, Raton and Persimmon against ten multidrug resistant human pathogenic bacteria.

Materials and methods

Plant collection and identification

Bangladeshi tomato variety "Raton" was collected from local farmer of Rajshahi-6205, Bangladesh. Seed of American tomato variety "Persimmon" was collected from Dr. Arun K Basak, Professor Emeritus, Department of physics, Rajshahi University, Bangladesh and was grown in home-garden. The identities of both varieties were confirmed by taxonomist Dr. A.H.M. Mahbubur Rahman, Associate Professor, Department of Botany, Rajshahi University, Rajshahi-6205, Bangladesh.

Preparation of extracts

Initially well washed fruits were cut into small pieces and dried in hot air oven. The dried materials were grinded as fine powder. The powdered plant materials were extracted with methanol and ethanol. Fifty gram fine powder was dipped into 150 ml methanol and 150 ml ethanol into different conical flask stoppered with rubber corks and left for full 3 days with constant shaking using orbital shaker. The mixtures were filtered through a thin Teton cloth and Whatman No.1 filter paper. The resulting filtrate was concentrated to dryness (semi-solid) using a water bath (Thermostatic Water Bath, China) at 60 ˚C. Semi-solid residue was kept at 4 ˚C for further use (Akueshi *et al*., 2002).

Bacterial strains

Five Gram positive bacteria namely, *Staphylococcus aureus* **(**BMLRU1002), *Bacillus cereus* (BMLRU1004), *Streptococcus-β-haemolytica* (BMLRU1006), *Bacillus subtilis* (BMLRU1008), *Sarcina lutea* (BMLRU1012) and five Gram negative bacteria namely, *Klebsiella* sp. (BMLRU1003), *Klebsiella pneumonia* (BMLRU1005), *Pseudomonas aeruginosa* (BMLRU1007), *Salmonella typhi* (BMLRU1009), *Shigella dysenteriae* (BMLRU1011) were used for antibacterial study. All of the tested bacterial species were collected from the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B), Mohakhali, Dhaka 1212, Bangladesh.

Determination of Antibacterial Activity

The disc diffusion assay (Kirby-Bauer Method) was used to screen antibacterial activity (Bauer *et al*., 1966; Barry, 1980). Sterilized filter paper discs (6 mm in diameter) were soaked with 10 µl of methanol and ethanol extracts and dried under aseptic condition inside the laminar flow. 30 µl of standard bacterial cultures (approximately 10^8cfu/ml; 0.5 McFarland turbidity standards) were spread on agar plates. Negative controls were prepared using the respective solvents. Ciprofloxacin (30 µgdisc^{-1}) was used as positive control. After drying in air under aseptic condition discs were placed on seeded agar plates and incubated at 37 °C for 24 h. Antibacterial activity was evaluated by measuring the diameter of zones of inhibition (mm) against the tested bacteria. Each assay was carried out in triplicates.

Determination of Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC)

The Minimum Inhibitory Concentration (MIC) and the Minimum Bactericidal Concentration (MBC) of the extracts were determined according to Doughari *et al.* (2007). The Minimum Inhibitory Concentration (MIC) was determined for each of the test organisms in triplicate in test tubes. To 0.5 ml of varying concentrations of the extracts (100, 150, 200, 250, 300, 350, 400, 450, 500, 550 mg/ml) in test tubes, Nutrient broth (2 ml) was added and then a loopful of the test organism, previously diluted to 0.5 McFarland turbidity standards, was introduced. The procedure was repeated on the test organisms using the standard antibiotics (ciprofloxacin). A tube containing Nutrient broth only was seeded with the test organisms, as described above, to serve as controls. The culture tubes were then incubated at 37 ˚C for 24 h. After incubation the tubes were then examined for microbial growth by observing for turbidity. To determine the MBC, for each set of test tubes in the MIC determination, a loopful of broth was collected from those tubes that did not show any growth and inoculated onto sterile Nutrient agar by streaking. Nutrient agar plates only were also streaked with the respective test organisms to serve as

controls. All the plates were then incubated at 37 °C for 24 h. After incubation the concentration at which no visible growth was seen was noted as the Minimum Bactericidal Concentration (MBC).

Statistical analysis

Antibacterial activity of tomato fruit extracts and antibiotic were statistically analyzed using analysis of variance (ANOVA). Least Significant Difference (LSD) test was used to speculate further if there was a significant difference. All the results are represented as means ± SE of three independent replications. Calculated F-values were compared with critical F-value/Table value at 5% significant level.

Results

Antibacterial activity

The antibacterial activity of tomato fruit extracts of Raton and Persimmon against ten human pathogenic bacteria reveal following findings. Both methanol and ethanol extracts of fruits exhibited antibacterial activity towards all the tested bacteria, with more activity observed with ethanol extracts. Negative control exhibits no zone of inhibition against the entire tested organisms. But positive control exhibits zone of inhibition against all the tested organisms and the range of zone was 11.30 mm-20.43 mm.

Table 1. Antibacterial activities of tomato fruit extracts of Raton against ten Human pathogenic bacteria.

	Bacterial species	Zone of inhibition (mm)			
		Methanol extracts (800 mg/ml)	Ethanol extracts (800 mg/ml)	Positive control (30 µg/ml)	Negative control
Gram Positive	*Staphylococcus aureus*	12.63±0.24	18.36±0.43	19.53±0.24	-
	Bacillus cereus	13.66±0.17	16.40±0.30	17.36±0.32	-
	Streptococcus-β-haemolytica	10.46±0.29	11.66±0.33	12.66±0.33	-
	Bacillus subtilis	10.30±0.06	11.40±0.31	12.36±0.32	-
	Sarcina lutea	8.76±0.49	10.53±0.29	11.30±0.30	-
Gram Negative	*Klebsiella* sp.	12.33±0.33	12.66±0.33	19.66±0.33	-
	Klebsiella pneumonia	11.30±0.30	13.30±0.05	13.63±0.18	-
	Pseudomonas aeruginosa	16.36±0.32	19.50±0.28	20.43±0.29	-
	Salmonella typhi	10.33±0.33	13.26±0.08	16.30±0.17	-
	Shigella dysenteriae	9.33±0.33	11.33±0.33	12.66±0.33	-

Note: Data are represented as mean ± SE of triplicate experiments; (-) = No inhibition.

Table 2. Statistical analysis (ANOVA) of antibacterial activity of Raton.

Source of variation	df	SS	MS	F	Comment
Bacterial species	9	641.936	71.326	266.876	*
Solvent	2	247.091	123.545	462.261	*
Bacterial strain	1	22.600	22.600	84.561	*
Replication	2	0.773	0.386	1.446	Ns
Bacterial species X Solvent	18	68.216	3.790	14.180	*
Error	57	15.234	0.267		
Total	89	995.849			

Note: * =significant; Ns = not-significant.

In case of Raton, the ethanol extracts exhibited highest zone of inhibition (19.50±0.28 mm) against *P. aeruginosa*, and the lowest zone (8.76±0.49mm) of Raton was recorded against *S. lutea* for methanol

extracts (Table 1). The results are summarized in the Fig. 1. Statistical result indicated that there were significant differences among bacterial species, solvent, bacterial strain as well as in interaction of bacterial species and solvent, where replication was not significant as expected (Table 2).

Depend on mean separation values, LSD test results showed that bacterial strain and solvent were significantly different at 5% significant level. Moreover, no significant differences were observed among *S. haemolytica, B. subtilis, S. dysenteriae* but *S. aureus, B. cereus, S. lutea, Klebsiella* sp., *K. pneumonia, P. aeruginosa* and *S. typhi* were significantly different from each other (Table 3).

Table 3. Analysis of mean data of antibacterial activity of Raton.

Variables	Mean data
Bacterial species	
S. aureus	16.844[b]
B. cereus	15.811[c]
S. haemolytica	11.6[g]
B. subtilis	11.356[g]
S. lutea	10.2[h]
Klebsiella sp.	14.889[d]
K. pneumonia	12.756[f]
P. aeruginosa	18.767[a]
S. typhi	13.3[e]
S. dysenteriae	11.111[g]
LSD	0.488
Solvent	
Methanol	11.55[c]
Ethanol	13.843[b]
Ciprofloxacin	15.597[a]
LSD	0.267
Bacterial strain	
Gram positive	13.162[b]
Gram negative	14.164[a]
LSD	0.218

Table 4. Antibacterial activities of tomato fruit extracts of Persimmon against ten Human pathogenic bacteria.

	Bacterial species	Zone of inhibition (mm)			
		Methanol extracts (800 mg/ml)	Ethanol extracts (800 mg/ml)	Positive control (30 µg/ml)	Negative control
Gram Positive	*Staphylococcus aureus*	10.33±0.33	11.73±0.37	18.67±0.17	-
	Bacillus cereus	15.33±0.33	16.50±0.29	17.67±0.33	-
	Streptococcus-β-haemolytica	9.00±0.00	9.73±0.37	10.67±0.33	-
	Bacillus subtilis	9.66±0.33	10.33±0.33	11.66±0.33	-
	Sarcina lutea	8.66±0.33	10.33±0.33	11.66±0.33	-
Gram Negative	*Klebsiella* sp.	13.70±0.35	18.50±0.29	19.33±0.33	-
	Klebsiella pneumonia	10.86±0.46	12.66±0.33	13.66±0.33	-
	Pseudomonas aeruginosa	12.50±0.29	13.33±0.33	18.66±0.33	-
	Salmonella typhi	10.00±0.00	11.33±0.33	15.66±0.33	-
	Shigella dysenteriae	9.33±0.33	11.33±0.33	12.66±0.33	-

Note: Data are represented as mean ± SE of triplicate experiments; (-) = No inhibition.

On the other hand, in case of Persimmon, the highest inhibition zone (18.50±0.29mm) was recorded against *Klebsiella* sp. for the ethanol extracts, and methanol extracts showed the lowest inhibition zone (8.66±0.33mm) against *Sarcina lutea* (Table 4). Fig. 2 represents the comparison of antibacterial activity of Persimmon against ten bacteria. From the statistical analysis it is observed that except

replication significant differences were found at 5% significant level among bacterial species, solvent, bacterial strain and in interaction of bacterial species and solvent (Table 5). In addition, Table 6 shows the mean data separation where bacterial strain and solvent were significantly different at 5% significant level. Moreover, bacterial species *S. aureus, B. cereus, Klebsiella* sp., *P. aeruginosa* were significantly different from each other, whereas, the pairs *S. haemolytica* and *S. lutea*; *K. pneumonia* and *S. typhi; B. subtilis* and *S. dysenteriae* were not significant with each other.

Table 5. Statistical analysis (ANOVA) of antibacterial activity of Persimmon.

Source of variation	df	SS	MS	F	Comment
Bacterial species	9	576.536	64.060	206.045	*
Solvent	2	242.729	121.364	390.364	*
Bacterial strain	1	39.867	39.867	128.230	*
Replication	2	0.459	0.229	0.738	Ns
Bacterial species X Solvent	18	62.818	3.490	11.225	*
Error	57	17.721	0.311		
Total	89	940.129			

Note: * = significant; Ns = not-significant

Table 6. Analysis of mean data of antibacterial activity of Persimmon.

Variables	Mean data
Bacterial species	
S. aureus	13.578^{d}
B. cereus	16.5^{b}
S. haemolytica	9.8^{fg}
B. subtilis	10.556^{f}
S. lutea	10.222^{fg}
Klebsiella sp.	17.178^{a}
K. pneumonia	12.4^{e}
P. aeruginosa	14.833^{c}
S. typhi	12.444^{e}
S. dysenteriae	10.455^{f}
LSD	0.526
Solvent	
Methanol	10.94^{c}
Ethanol	12.517^{b}
Ciprofloxacin	14.933^{a}
LSD	0.288
Bacterial strain	
Gram positive	12.131^{b}
Gram negative	13.462^{a}
LSD	0.235

For both variety, methanol extracts provided lower inhibition zone than the ethanol extracts. However, Gram negative bacteria *P. aeruginosa* and *Klebsiella* sp. against ethanol extracts of Raton and Persimmon respectively were the most sensitive strains with highest zones of inhibition. Between two varieties, Raton exhibited higher antibacterial activity than Persimmon (Fig. 1; Fig. 2).

Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC)

MIC and MBC values of methanol extracts of Raton were recorded from 150-300 mg/ml and 200-400 mg/ml, respectively. In contrast, MIC and MBC values of ethanol extracts for the same were observed from 100-250 mg/ml and 150-300 mg/ml, respectively. The least MIC and MBC values were recorded against *Staphylococcus aureus* and *Pseudomonas aeruginosa* in ethanol extracts of Raton (Table 7).

Table 7. Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of tomato fruit extracts of Raton.

	Bacterial strain	Methanol extract		Ethanol extract	
		MIC (mg/ml)	MBC (mg/ml)	MIC (mg/ml)	MBC (mg/ml)
Gram positive	*Staphylococcus aureus*	200	250	100	150
	Bacillus cereus	200	250	150	200
	Streptococcus-β-haemolytica	250	300	250	300
	Bacillus subtilis	250	350	250	300
	Sarcina lutea	300	400	250	350
Gram negative	*Klebsiella* sp.	200	250	200	250
	Klebsiella pneumonia	250	300	200	250
	Pseudomonas aeruginosa	150	200	100	150
	Salmonella typhi	250	300	200	250
	Shigella dysenteriae	300	400	250	300

Table 8. Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of tomato fruit extracts of Persimmon.

	Bacterial strain	Methanol extract		Ethanol extract	
		MIC (mg/ml)	MBC (mg/ml)	MIC (mg/ml)	MBC (mg/ml)
Gram positive	*Staphylococcus aureus*	250	300	250	300
	Bacillus cereus	150	200	150	200
	Streptococcus-β-haemolytica	300	400	300	350
	Bacillus subtilis	300	350	250	300
	Sarcina lutea	300	400	250	350
Gram negative	*Klebsiella* sp.	200	250	100	150
	Klebsiella pneumonia	250	300	200	300
	Pseudomonas aeruginosa	200	250	200	250
	Salmonella typhi	250	350	250	300
	Shigella dysenteriae	300	400	250	350

On the other hand, methanol extracts of Persimmon, the range of MIC and MBC values were 150-300 mg/ml and 200-400 mg/ml, respectively. Whereas the range of MIC and MBC values of ethanol extracts were 100-300 mg/ml and 150-350 mg/ml, respectively. The lowest MIC value and MBC value were recorded against *Klebsiella* sp. in ethanol extracts of Persimmon (Table 8).

On the basis of the entire experimental results like zone of inhibition and corresponding MIC and MBC determination, it can be suggested that Gram (-) bacteria such as *Pseudomonas aeruginosa*, *Klebsiella* sp. and Gram (+) bacteria such as *S. aureus* can aggressively be inhibited by the ethanol fruit extracts. In this study, ethanol tomato fruit extracts of Raton showed the highest antibacterial activity against the tested bacteria with the lowest MIC value of 100 mg/ml.

Discussion

In the present investigation, the crude extracts of two tomato varieties, Raton and Persimmon have been determined for antibacterial activities against the sensitivity of ten pathogenic bacteria (five gram positive bacteria and five gram negative bacteria) and compared with antibiotic Ciprofloxacin. The inhibition zones were varied at different concentrations. The widest inhibition zone of methanol extracts of Raton was 16.36 mm against

Pseudomonas aeruginosa. While the widest zone of methanol extracts of Persimmon was 15.33 mm against *Bacillus cereus*. On the other hand, the widest zone of ethanol extracts of Raton was 19.50 mm against *Pseudomonas aeruginosa*. While the widest zone of ethanol extracts of Persimmon was 18.50 mm against *Klebsiella* sp. The results pointed out that the ethanol extracts showed higher zone of inhibition than methanol. The variation of bacterial growth by different solvents may be due to the better solubility of the active components in the solvents (de Boer *et al.*, 2005).

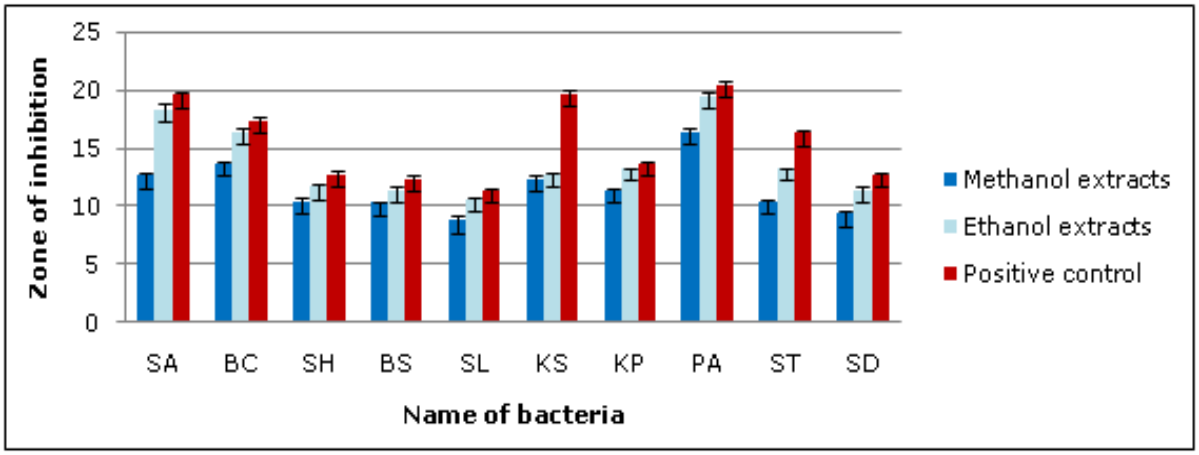

Fig. 1. The comparison of antibacterial activity of tomato fruit extracts of Raton against ten human pathogenic bacteria. SA= *Staphylococcus aureus,* BC= *Bacillus cereus,* SH= *Streptococcus-β-haemolytica,* BS= *Bacillus subtilis,* SL=*Sarcina lutea,* KS=*Klebsiella* sp., KP=*Klebsiella pneumonia,* PA= *Pseudomonas aeruginosa,* ST= *Salmonella typhi,* SD=*Shigella dysenteriae*.

Tomatoes has an antibacterial properties against *Streptococcus pneumonia, Staphylococcus aureus, Escherichia coli, Pretoeus mirabilis, Pseudomonas aeruginosa* when compare with Ciprofloxacin an antibacterial drug base on their minimum inhibitory concentration parameter (Omodamiro and Amechiu, 2013). In this study, Gram negative bacteria are more sensitive than Gram positive bacteria.

This may be attributed to the fact that these two groups differ by its cell wall component and its thickness (Yao and Moellering, 1995). There may be several factors that will predispose bacteria to antibacterial agents such as previous encounters with the agents or the nature of medium used, which may affect the diffusability of the agent. The fact that the extracts were active against both gram-negative and gram-positive bacteria tested may indicate a broad spectrum of activity. This observation is very significant because of the possibility of developing therapeutic substances that will be active against multidrug-resistant organisms.

In this experiment, different extracts showed different degrees of growth inhibition, depending upon the bacterial strains. These variations were found because strains are genetically different from each other, and this is probably due to the differences in chemical composition and structure of the cell wall of both types of microorganisms (Yao and Moellering, 1995). These include differences in microbial growth, exposure of microorganisms to plant extracts, the solubility of extracts or extract components and the use and quantity of an emulsifier (Bansod and Rai, 2008).

Krishna *et al.* (2013) reported on anti-bacterial activity with range of MIC values for *S. aureus* (MIC: 15-39 µg /ml), *E. coli* (MIC: 16-38 µg /ml), *P. aeruginosa* (MIC:15-39 µg /ml) and *B. subtilis* (14-39 µg /ml). Where, in this investigation, the low MIC value (100 mg/ml) observed for *Staphylococcus aureus, Pseudomonas aeruginosa,* and *Klebsiella sp.* which indicates high efficacy of extracts against these bacteria. This outcome is remarkable considering that

the investigated sample can be used as first-line antibiotics against different diseases like pneumonia (caused by *S. aureus, P. aeruginosa, K. pneumonia*), diarrhea (caused by *B. cereus*, *Klebsiella* sp.), meningitis (caused by *P. aeruginosa*, *K. pneumonia*) etc. for its treatment in developing countries. High MIC may be an indication of low efficacy or that the organisms have the potential for developing resistance to the bioactive compounds.

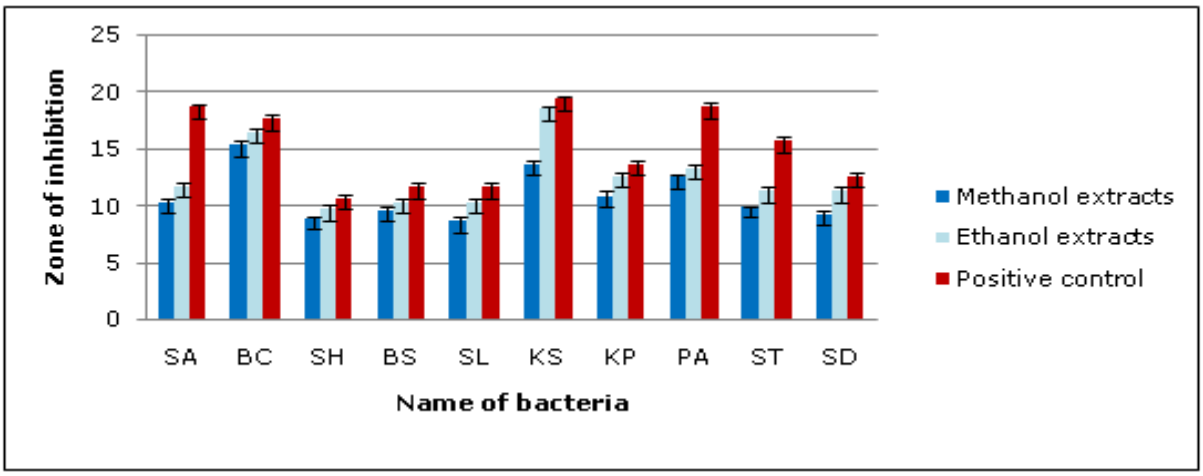

Fig. 2. The comparison of antibacterial activity of tomato fruit extracts of Persimmon against ten human pathogenic bacteria. SA= *Staphylococcus aureus,* BC= *Bacillus cereus,* SH= *Streptococcus-β-haemolytica,* BS= *Bacillus subtilis,* SL=*Sarcina lutea,* KS=*Klebsiella* sp., KP=*Klebsiella pneumonia,* PA= *Pseudomonas aeruginosa,* ST= *Salmonella typhi,* SD=*Shigella dysenteriae*.

However, the difference between the present study and others done by various scientists might be due to differences in the methodology or the difference in the solvent used for extraction of the sample. The results suggest that both Raton and Persimmon contain active ingredients which qualify them for medicinal use. Between these two varieties, ethanol extracts of Raton are more effective. The presence of phytocompounds in the extracts including phenols, tannins, alkaloids, glycosides, terpenoids, saponins and flavonoids as major constituents may be responsible for these antibacterial activities. Therefore, Cushnie (2014), Akiyama *et al.* (2001), Soetan *et al.* (2006), Okwu (2004) reported that alkaloids, tannins, saponins, flavonoids (respectively) have antibacterial properties.

Conclusion

From the above findings, it may be concluded that fruit extracts of Raton and Persimmon presented a significant percentage zone of inhibition against ten pathogenic bacteria. The demonstration of antimicrobial activity against both gram-negative and gram-positive bacteria is an indication that the extracts are a potential source for production of drugs with a broad spectrum of activity. The results of this study also supports the traditional application of the fruits and suggests that the fruit extracts possess compounds with antibacterial properties that can be used as antibacterial agents in novel drugs for the treatment of cancer, artherosclerosis, hypertension, diarrhea, pneumonia, meningitis, wound infections etc. To recapitulate, tomatoes possess pharmacological properties which if properly harness can be used in the management of diseases.

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