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Research Article

Investigation For Phytochemical And Antibacterial Properties Of Arial Part Extracts From *Portulaca Oleracea Linn*. (Purslane) Against

Indranil Chatterjee*[1,4], Nibadita Garain[2], Arnab Maji[3], Suchetan Sarkar[3]

[1]*Associate Professor, Department Of Pharmaceutical Biotechnology, Birbhum Pharmacy School,West Bengal,India*
[2]*Assistant Professor, Department Of Pharmacology, Birbhum Pharmacy School,West Bengal,India*
[3]*B.Pharm, Department Of Pharmacy, Birbhum Pharmacy School,West Bengal,India*
[4]*Ph.D. Research Scholar, Department Of Pharmaceutical Technology,Jis University,West Bengal,India*

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ABSTRACT

Bacteria as etiological agents have been reported to cause many diseases and have increased the rate of mortality globally. Their resistance to conventional medicine has made medicinal plants a credible alternative in the management of diseases caused by bacterial infection. This work was designed to identify secondary metabolites present in arial part extracts of ethno-medicinally utilised Portulaca oleracea L. and evaluate their antibacterial activities. The arial parts of P. oleracea L. were obtained and phytochemical screening was carried out using standard qualitative tests and the antibacterial activity of extracts was evaluated using agar well diffusion method whilst the minimum inhibitory concentration (MIC) was evaluated by micro-dilution method. The screening was assessed against Bacillus subtilis, Candida albicans, Enterobacter cloacae, Escherichia coli, Klebsiella pneumoniae, Micrococcus luteus, Pseudomonas aeruginosa, Salmonella typhi, Shigella dysenteriae, Staphylococcus aureus and Streptococcus agalactiae, which are responsible for the transmission of common diseases. Phytochemical screening of P. oleracea L. showed the presence of carbohydrates, steroids, triterpenes, cardiac glycosides, and saponins. All extracts showed a high level of minimum inhibition concentration against the pathogens except K. pneumoniae, M. luteus and P. aeruginosa. Generally, the antibacterial activity of extracts increased with decrease in polarity as compared with ciprofloxacin. The mean (± s.d.) values were significantly different by Duncan's multiple range tests with $p < 0.05$. Portulaca oleracea L. has been identified for the first time as a good antibacterial

***Corresponding Author:** Indranil Chatterjee
Address: *Associate Professor, Department Of Pharmaceutical Biotechnology, Birbhum Pharmacy School,West Bengal,India*
Email : indrani1.chax@outlook.com
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agent, which corroborates the ethno-medicinal uses of the plant.

INTRODUCTION

The utilize of plants as pharmaceutical originates before composed human history. It is evaluated that around 80% of individuals living in immature and creating nations depend on plant as a source of essential healthcare (Ajala, Olusola & Odeku 2020; Ojah, Moronkola & Osamudiamen 2020; Ojah & Kachi 2020; Rafiu, Sonibare & Adesanya 2019). Roughly half of medications in the world are determined from common items and more than a quarter of the medicines apportioned every year in the Joined together States were at first inferred from plants. It was moreover detailed that 80% of the world's populace specifically or by implication use home grown pharmaceutical for the treatment or anticipation of infections (Newman, Cragg & Snader 2000). A wide assortment of phyto-constituents perform fundamental organic, pharmacological, and physiological capacities. Inquire about has appeared that at slightest 12 000 bioactive compounds have been confined in later times (Dosumu et al. 2019; Motaleb 2010). Phytochemicals intervene their impact on the human body through forms comparable to those caught on in routine drugs, hence plant medications are not as it were as successful as standard drugs but too posture side impacts. Plants parts such as roots, takes off, stem bark and seeds have a few dynamic components that are of helpful esteem and consequently valuable in the treatment of infections such as cancer, coronary heart illness, diabetes and irresistible malady. Numerous of the home grown drugs that demonstrated to be viable have been consolidated into present day medication (Motaleb 2010). Restorative plants give a riches of antimicrobial specialists, which can be utilized as an interchange source of anti-microbials (Malik et al. 2011; Walter et al. 2011; Prasannabalaji et al. 2012). Auxiliary metabolites in plants act as antibacterial operator that is used as treatment or prophylactics against a few diseases caused by microscopic organisms (Nasrullah et al. 2012). In the final few decades, most pathogenic microbes created resistance to numerous anti-microbials and this is a major risk to human wellbeing. Restorative plants are sources of different atoms, numerous of which show antimicrobial properties, which secure human body from pathogenic diseases. Hence, it is vital to characterise diverse restorative plants for their antibacterial potential (Bajpai et al. 2005; Wojdylo, Oszmianski & Czemerys 2007). A huge number of antibacterial specialists inferred from conventional restorative plants are accessible for treating different maladies caused by microorganisms (Jain 1994). Plants for the most part, create phytochemicals that have antibacterial action. In the final few a long time, numerous bacterial living beings have proceeded to appear expanding multidrug resistance to a few antibacterial specialists (Njenga & Mugo 2020). In spite of the fact that hundreds of plant species have been tried for antibacterial properties, the endless larger part have not been enough assessed (Balandrin et al. 1985; Muthusamy et al. 2013).

Portulaca oleracea L. commonly known as purslane is a warm-climate herbaceous juicy yearly plant with a catholic dispersion having a place to Portulacaceae family. It is commonly known as purslane (Joined together States and Australia), rigla (Egypt), pigweed (Britain), pourpier (France) and Ma-Chi-Xian (China) (Elkhayat, Ibrahim & Aziz 2008). It is disseminated broadly in the tropical and subtropical ranges of the world, counting numerous parts of the Joined together States and is eaten broadly as a potherb and is included to soups and servings of mixed greens around the Mediterranean and tropical Asian nations (Palaniswamy, Book of scriptures & McAvoy 2002). This plant might have begun in Asia and is presently omnipresent in Africa and the

Mediterranean locale (Masoodi et al. 2011). Portulaca oleracea too gives a source of wholesome benefits owing to its wealthy omega-3 greasy acids and antioxidant properties (Palaniswamy, McAvoy & Book of scriptures 2001). The plant contains numerous naturally dynamic compounds, which are dependable for the wide application of the plant in medication. The plant has been detailed as a wealthy source of phytoconstituents, such as oxalic acids, alkaloids, omega-3 greasy acids, coumarins, flavonoids, cardiac glycosides and anthraquinone glycosides (Ezekwe et al. 1999). Unrefined extricates of P. oleracea have been found to have strong wound-healing properties (Rashed, Afifi & Disi 2003). The plant has culinary property used in the planning of servings of mixed greens, soups and pickles. It has been utilized in people medication in numerous nations as febrifuge, sterile and vermifuge (Lee et al. 2012.). It shows a wide run of pharmacological impacts such as antiulcerogenic (Karimi, Hosseinzadeh & Ettehad 2004), anti-inflammatory (Chan, Islam & Kamil 2000), antioxidant (Rashed et al. 2003), and wound- mending (Xu, Yu & Chen 2006) properties. It is recorded by the World Wellbeing Organization as one of the most utilized restorative plants, and it has been given the term 'Global Panacea' (Chen, Wang & Wang 2009). The Chinese fables depicted it as 'vegetable for long life' and it has been utilized for thousands of a long time in conventional Chinese medication (Jin et al. 2013; Li, Wu & Chen 2013). It is cold in nature and acrid in taste and is utilized to cool the blood, stanch dying, clear warm and resolve poisons. The dried ethereal portion of this plant is utilized for the treatment of fever, loose bowels, the runs, carbuncle, dermatitis, and hematochezia (Li et al. 2013; Zhao et al. 2014). In spite of the fact that conventional pharmaceutical has been acknowledged by a few populaces of the world, however more noteworthy rate still depend on normal cures to illnesses caused by microbes. Portulaca oleracea is of impressive significance to the nourishment industry and moreover has a wide range of pharmacological properties such as neuroprotective, antimicrobial, antidiabetic, antioxidant, anti-inflammatory, antiulcerogenic, and anticancer exercises, which are related with its different chemical constituents, counting flavonoids, alkaloids, polysaccharides, greasy acids, terpenoids, sterols, proteins, vitamins, and minerals.

Scientific classification:

Kingdom: Plantae
Clade: Tracheophytes
Clade: Angiosperms
Clade: Eudicots
Order: Caryophyllales
Family: Portulacaceae
Genus: Portulaca Species: P. oleracea
Binomial name: Portulaca oleracea L.

Figure 1: P. oleracea.

P. oleracea Plant Profile:

The plant may reach 40 centimetres (16 inches) in tallness. It has smooth, ruddy, generally prostrate stems, and the clears out, which may be substitute or inverse, are clustered at stem joints and closes. The yellow blossoms have five normal parts and are up to 6 millimeters (1Ú4 inch) wide. Depending upon precipitation, the blossoms show up at any time amid the year. The blossoms open

independently at the center of the leaf cluster for as it were a few hours on sunny mornings. The modest seeds are shaped in a unit that opens when the seeds develop. Purslane has a taproot with stringy auxiliary roots and can endure destitute soil and dry season. The natural products are numerous- seeded capsules. The seed set is impressive; one plant can create up to 193,000 seeds. The seeds sprout ideally at a temperature over 25 °C; they are light germinators, with indeed a soil cover of 5 mm having a negative impact on germination.

Table 1: Nutritional value per 100 g (3.5 oz) of Purslane, raw

Nutritional value per 100 g (3.5 oz)		
Energy	84 kJ (20 kcal)	
Carbohydrates	3.39 g	
Fat	0.36 g	
Protein	2.03 g	
Vitamins	**Quantity**	**%DV†**
Vitamin A	1320 IU	
Thiamine (B_1)	0.047 mg	4%
Riboflavin (B_2)	0.112 mg	9%
Niacin (B_3)	0.48 mg	3%
Vitamin B_6	0.073 mg	4%
Folate (B_9)	12 µg	3%
Vitamin C	21 mg	23%
Vitamin E	12.2 mg	81%
Minerals	**Quantity**	**%DV†**
Calcium	65 mg	5%
Iron	1.99 mg	11%
Magnesium	68 mg	16%
Manganese	0.303 mg	13%
Phosphorus	44 mg	4%
Potassium	494 mg	16%
Zinc	0.17 mg	2%
Other constituents	**Quantity**	
Water	92.86 g	

Raw purslane is 93% water, 3% carbohydrates, 2% protein, and contains negligible fat (table). In a 100-gram reference amount, purslane supplies 20 calories, and rich amounts (20% or more of the Daily Value, DV) of vitamin E (81% DV) and vitamin C (25% DV), with moderate content (11–19% DV) of several dietary minerals (table). Purslane is a rich source of alpha-linolenic acid, an essential omega-3 fatty acid (A P Simopoulos 2013). Hence, this study was designed to evaluate the antibacterial activity of phytoconstituents present in arial part extracts of P. oleracea. L.

MATERIALS & METHODS:

Collection of Plant Materials and Authentication.

Plant of P. oleracea L. were collected from Rampurhat, Birbhum India. P. oleracea herbarium specimen was authenticated by Dr. Vijay Kumar Mastakar, Scientist in- charge, Acharya Jagdish Chandra Bose Indian Botanic Garden Botanical Survey of India, P.O. Botanic Garden, Howrah: 711103.

Plant preparation and extraction.

The arial parts of the plant were air-dried at a temperature below 40°C and pulverised using a laboratory milling machine into fine powder after which a total of 500 g each of the ground powder were extracted successively in n-hexane, ethyl acetate, chloroform, and methanol by maceration using 5 L each of respective solvents (volume per volume [v/v]). The extract was concentrated using a water bath and dried in a vacuum desiccator. The dried extract was reduced to powder using a laboratory mill and then sieved with a 250-µm mesh sieve.

Pytochemical screening.

Phytochemical examinations were carried out for all the extracts using standard qualitative tests.

Quantitative Estimation of Phytochemicals.

a. Test for steroid

i. Liebermann- Burchard testAbout 0.2 g of extract was dissolved in chloroform and few drops of acetic anhydride and concentrated sulphuric acid were added to the chloroform solution. Violet blue and finally green colour was formed indicating the presence of steroids (Harborne 1998; Talukdar et al. 2010).

ii. Salkowski test- About 0.2 g of extract was dissolved in chloroform and a few drops of concentrated sulphuric acid were added to the solution. A reddish colour in the upper chloroform layer was observed indicating the presence of steroids (Kumar et al. 2007).

b. Test for alkaloids

i. Dragendroff's test- About 0.2 g of the extract was warmed with 2% H2SO4 for 2 min. It was filtered and few drops of Dragendroff's reagent were added. Orange red precipitate indicates the presence of alkaloids (Egwaikhide & Gimba 2007).

ii. Mayer's test- To a few milliliters of filtrate, a few drops of Mayer's reagent were added by the side of the tube. A creamy white precipitate confirms the presence of alkaloids (Narasimhan et al. 2012).

c. Test for flavonoid

i. Shinoda test- To 3 mL of 5 mg of methanolic extract, a piece of magnesium ribbon was added and 1 mL of concentrated hydrochloric acid. Pink-red or red colouration of the solution indicates the presence of flavonoids (Ajala et al. 2020).

ii. NaOH test- About 0.5 g of extract was treated with 10% NaOH solution; formation of intense yellow colour indicates the presence of flavonoid (Sawant & Godghate et al. 2013).

d. Test for phenolic compounds

The extract (500 mg) was dissolved in 5 mL of distilled water. To this, a few drops of neutral 5% ferric chloride solution were added. A dark green colour indicated the presence of phenolic compounds (Mir, Sawheny & Jassal 2013).

e. Test for glycoside

i. Kellar–Kiliani test- A total of 2 mL of filtrate was added to 1 mL of glacial acetic acid, 1 mL ferric chloride and 1 mL concentrated sulphuric acid. Green-blue colouration of solution confirms the presence of glycosides (Chhetri et al. 2008; Parekh & Chanda 2007).

f. Test for tannins

To 0.5 mL of extract solution 1 mL of water and 1–2 drops of ferric chloride solution were added. Blue colour was observed for gallic tannins and green-black for catecholic tannins (Talukdar et al. 2010).

g. Test for saponins

i. Frothing test or foam test- A total of 0.5 mL of filtrate was added to 5 mL of distilled water and shaken properly. Persistence of frothing on the solution confirmed the presence of saponins (Victor & Chidi 2009).

h. Test for carbohydrates

i. Molisch's test- Few drops of Molisch's reagent were added to each of the portion dissolved in distilled water, this was then followed by addition of 1 mL of concentrated H2SO4 by the side of the test tube. The mixture was then allowed to stand for 2 min and then diluted with 5 mL of distilled water. Formation of a red or dull violet colour at the interphase of the two layers was a positive test (Sofowora 1993).
ii. Fehling's test- About 0.5 g each of the extract was dissolved in distilled water and filtered. The filtrate was heated with 5 mL of equal volumes of Fehling's solution A and B. Formation of a red precipitate of cuprous oxide was an indication of the presence of reducing sugars (Sofowora 1993).

Test organisms

The antibacterial activities of the extract were determined using the agar well diffusion method of Balouiri, Sadiki and Ibnsouda (2016). The bacteria isolates used include Staphylococcus aureus (ATCC 6538), Bacillus subtilis (ATCC 6633), Salmonella typhi (ATCC 167), Shigella dysenteriae (ATCC 13313), Escherichia coli (ATCC 8739), Enterobacter cloacae (ATCC 13047), Streptococcus agalactiae (ATCC 13813), Micrococcus luteus (ATCC 10240), Pseudomonas aeruginosa (ATCC 10145) and Klebsiella pneumonia (ATCC 13883), which are responsible for the transmission of common diseases. They were obtained from the Department of Microbiology, CDL, Kolkata, India. All the isolates were checked for purity and maintained in nutrient agar.

Antibacterial screening procedure

The antibacterial activities of the extracts were tested against the selected strains using agar well diffusion method as described by Mbata, Debiao and Saikia (2008). An amount of 20 mL of sterilized nutrient agar medium was poured into each sterile Petri dish and allowed to solidify. The test bacteria cultures were standardised to 0.5% McFarland standard (NCCLS 1993) and evenly spread over the appropriate media with the aid of a swab stick. Then wells of 6 mm were made in the medium using a sterile cork borer (Bhargav et al. 2016). Concentrations of sample solutions were prepared followed by appropriate dilutions to the required concentration (10 mg/mL). These concentrations (at 0.1 mL) were transferred into separate wells, followed by the incubation of the plates at 35 °C for 24 h. After the incubation period, the zones of growth inhibition (ZI) were observed and measured using transparent ruler (Mbata, Debiao, & Saikia, 2008). Each test was repeated three times to ensure reproducibility. The mean of the triplicate tests ± their standard error of mean (SEM) was calculated and recorded as the diameter of zone of inhibition. Standard sensitivity discs of selected antibiotics ciprofloxacin, was used as positive control. Active plant extracts showing visible zones of inhibition were further tested at lower concentrations to determine their minimum inhibitory concentration (MIC), using the broth microdilution method in 96-well microtitre plate (Essawi & Srour 2000; Janet & John 2007). The minimum bactericidal concentration (MBC) was determined by subculture of the preparations that have shown no evidence of growth in the MIC determination assay. These subcultures were made in nutrient agar plates (Grierson & Afolayan 1999; Muthusamy et al. 2013).

Statistical analysis

The experiments were conducted three times and all determinations were performed in triplicates (n = 3) and results were expressed as mean ± s.d. Statistical analysis was performed by one-way analysis of variance (ANOVA) with GraphPad Prism statistical software package, version 8. Duncan's new multiple range test were applied to the result at 0.05 level of significance ($p < 0.05$).

RESULTS:

Table 2: Phytochemical constituents of the roots of Portulaca oleracea.

Phytochemical	Test	Hexane	Ethyl acetate	Chloroform	Methanol
Alkaloids	Dragendorff	–	–	–	-
	Mayer	–	–	–	-
Carbohydrates	Molisch	+	+	+	+
	Fehling	+	+	+	+
Anthraquinones	Bontrager	–	–	–	–
Steroids	Liebermann–Burchard	+	+	+	+
Triterpenes	Liebermann–Burchard	+	+	+	+
Cardiac Glycosides	Killer–Killiani	+	+	+	+
Saponins	Frothing	+	+	+	+
Tannins	Ferric chloride	–	-	-	-
Flavonoids	NaOH	–	-	-	-
	Shinoda	-	-	-	-

Note: All the results are mean ± standard deviation (n = 3). The mean (± s.d.) values are significantly different by Duncan's multiple range test ($p < 0.05$). NA, not applicable.

Table 3: Antibacterial activity (mg/mL) of arial part extracts of Portulaca oleracea based on zones of inhibition.

Test organisms	Zone of inhibition (mm)				Ciprofloxacin 10 mg/mL
	Methanol	Ethyl acetate	Chloroform	Hexane extract	
Staphylococcus aureus	22 ± 0.2	25 ± 0.4	27 ± 0.3	25 ± 0.2	35 ± 0.2
Bacillus subtilis	23 ± 0.6	29 ± 0.5	28 ± 0.2	27 ± 0.7	37 ± 0.2
Klebsiella Pneumoniae	0	0	0	0	30 ± 0.2
Streptococcus agalactiae	21 ± 0.4	30 ± 0.6	25 ± 0.2	28 ± 0.5	32 ± 0.3
Salmonella typhi	20 ± 0.8	29 ± 0.4	28 ± 0.2	25 ± 0.3	41 ± 0.2
Shigella dysenteriae	20 ± 0.6	22 ± 0.4	25 ± 0.3	23 ± 0.2	40 ± 0.5
Micrococcus luteus	0	0	0	0	NA
Escherichia coli	22 ± 0.4	30 ± 0.5	26 ± 0.8	28 ± 0.2	39 ± 0.4
Enterobacter cloacae	24 ± 0.3	31 ± 0.4	27 ± 0.5	25 ± 0.1	35 ± 0.2
Pseudomonas aeruginosa	0	0	0	0	NA

Note: All the results are mean ± standard deviation (n = 3). The mean (± s.d.) values are significantly different by Duncan's multiple range test ($p < 0.05$). NA, not applicable.

Table 4: Minimum inhibitory concentration in mg/mL of arial part extracts from P. oleracea

Test organisms	Extracts (mg/mL)				Ciprofloxacin
	Methanol	Ethyl acetate	Chloroform	*n*-Hexane	
Staphylococcus aureus	1.00 ± 0.4*	0.250 ± 0.6**	0.250 ± 0.3**	0.250 ± 0.5**	0.100 ± 0.1
Bacillus subtilis	1.00 ± 0.2*	0.125 ± 0.7***	0.125 ± 0.4***	0.125 ± 0.5***	0.080 ± 0.2
Klebsiella pneumoniae	-	-	-	-	0.140 ± 0.1
Streptococcus agalactiae	1.00 ± 0.2*	0.125 ± 0.3***	0.125 ± 0.6***	0.125 ± 0.4***	0.120 ± 0.3
Salmonella typhi	1.00 ± 0.3*	0.125 ± 0.5***	0.250 ± 0.6**	0.250 ± 0.4**	0.050 ± 0.1
Shigella dysenteriae	1.00 ± 0.7*	0.125 ± 0.5***	0.250 ± 0.2**	0.250 ± 0.6**	0.052 ± 0.2
Micrococcus luteus	-	-	-	-	-
Escherichia coli	1.00 ± 0.3*	0.125 ± 0.7***	0.125 ± 0.5***	0.125 ± 0.5***	0.054 ± 0.1
Enterobacter cloacae	1.00 ± 0.5*	0.125 ± 0.3***	0.250 ± 0.1**	0.250 ± 0.6**	0.065 ± 0.2
Pseudomonas aeruginosa	-	-	-	-	-

Note: All results are mean ±s.d. (n = 3). The mean (±s.d.) values are significantly different by Duncan's multiple range test. *, $p < 0.01$; **, $p < 0.001$; ***, $p < 0.02$..

Table 5: Minimum bactericidal concentration in mg/mL of root extracts from P. oleracea

Test organisms	Extracts (mg/mL)				Ciprofloxacin
	Methanol	Ethyl acetate	Chloroform	*n*-Hexane	
Staphylococcus aureus	4.00 ± 0.5*	0.500 ± 0.4***	0.500 ± 0.3***	0.500 ± 0.6***	0.050 ± 0.3
Bacillus subtilis	2.00 ± 0.4**	0.250 ± 0.7***	0.500 ± 0.8**	0.500 ± 0.7**	0.050 ± 0.2
Klebsiella pneumoniae	-	-	-	-	-
Streptococcus agalactiae	4.00 ± 0.2*	0.250 ± 0.3***	0.250 ± 0.4***	0.250 ± 0.7***	0.100 ± 0.2
Salmonella typhi	4.00 ± 0.6*	0.250 ± 0.5***	0.500 ± 0.4**	0.500 ± 0.7**	0.010 ± 0.4
Shigella dysenteriae	2.00 ± 0.4**	0.250 ± 0.7***	0.250 ± 0.5***	0.250 ± 0.1***	0.010 ± 0.2
Micrococcus luteus	-	-	-	-	-
Escherichia coli	4.00 ± 0.5*	0.250 ± 0.4***	0.250 ± 0.3***	0.250 ± 0.7***	0.010 ± 0.2
Enterobacter cloacae	2.00 ± 0.4**	0.250 ± 0.6***	0.500 ± 0.7**	0.500 ± 0.3**	0.050 ± 0.1
Pseudomonas Aeruginosa	-	-	-	-	-

Note: All results are mean ±s.d. (n = 3). The mean (±s.d.) values are significantly different by Duncan's multiple range test. *, p < 0.01; **, p < 0.001; ***, p < 0.02.

DISCUSSION:

The present study identified secondary metabolites present in root hexane, ethyl acetate, chloroform and methanol extracts of P. oleracea using standard methods (Trease & Evans 2002). Phytochemical screening on root extracts showed the presence of carbohydrates, steroids, triterpenes, cardiac glycosides and saponins (Table 2). The presence of these useful phytochemicals could be responsible for the observed antibacterial activities and can be seen as a potential source of antibiotic drugs. In general, the accumulation and concentration of secondary metabolites are responsible for the antibacterial activity of a plant (Tim-Cushnie & Andrew 2005). Flavonoids possess antibacterial, antifungal and antiviral activity (Cowan 1999). Tannins are known for their astringent property and antimicrobial activity. Alkaloids are good antibacterial drugs whilst saponins possess antibacterial and anticandidal activity as reported in literature (Maatalah et al. 2012; Ramanathan et al. 2013; Tim-Cushnie, Benjamart & Andrew 2014). Antibacterial screening on root hexane, ethyl acetate, chloroform and methanol extracts of P. oleracea exhibited good activity against the tested organisms from the zones of inhibition obtained (Table 3). The inhibitory effect was compared with standard antibiotic drugs ciprofloxacin at 10 mg/mL. The significant activity of methanol extract was maximum against E. cloacae (24 ± 0.3 mm) followed by B. subtilis (23 ± 0.6 mm). Staphylococcus aureus, E. coli had 22 ± 0.4 mm as zone of inhibition. Streptococcus agalactiae had zone of inhibition of 21 ± 0.4 mm when exposed to the extracts. Salmonella typhi and S. dysenteriae had the least zones of inhibition (20 ± 0.7 mm). Enterobacter cloacae had the highest zone of inhibition in the ethyl acetate extract (31 ± 0.4 mm) whilst the least activity was observed in S. dysenteriae (22 ± 0.4 mm). Enterobacter cloacae had the highest zone of inhibition in the chloroform extract (31 ± 0.4 mm) whilst the least activity was observed in S. dysenteriae (22 ± 0.4 mm). Streptococcus agalactiae had the highest inhibition in the hexane extract (28 ± 0.5 mm) whilst S. dysenteriae had the least activity (23 ± 0.2 mm). Klebsiella pneumoniae, M. luteus and P. aeruginosa had zero activity in all extracts tested. Ciprofloxacin and fluconazole, standard antibiotic drugs had the highest zones of inhibition (mm) against all organisms tested; [(S. aureus, 35 ± 0.2 mm), (B. subtilis, 37 ± 0.2 mm), (K. pneumoniae, 30 ± 0.2 mm), (S. agalactiae, 32 ± 0.3 mm), (S.

typhi, 41 ± 0.2 mm), (S. dysenteriae, 40 ± 0.5 mm), (E. coli, 39 ± 0.4 mm) and (E. cloacae, 35 ± 0.2 mm)]. The MIC and MBC of extracts were determined in mg/mL as presented in Tables 4 and 5, respectively. The MIC (mg/mL) revealed that the standard antibacterial drug ciprofloxacin had the highest activity with MIC values; [(S. aureus, 0.100 ± 0.1), (B. subtilis, 0.080 ± 0.2), (K. pneumoniae, 0.140 ± 0.1), (S. agalactiae, 0.120 ± 0.3), (S. typhi, 0.050 ± 0.1), (S. dysenteriae, 0.052 ± 0.2), (E. coli, 0.054 ± 0.1), and (E. cloacae, 0.065 ± 0.2)]. Also, MBC in mg/mL revealed that the standard antibiotic drug ciprofloxacin had the highest activity with MBC values; [(S. aureus, 0.050 ± 0.3), (B. subtilis, 0.050 ± 0.2), (K. Pneumoniae, 0.100 ± 0.1), (S. agalactiae, 0.100 ± 0.2), (S. typhi, 0.010 ± 0.4), (S. dysenteriae, 0.010 ± 0.2), (E. coli, 0.010 ± 0.2), and (E. cloacae, 0.050 ± 0.1)]. The MIC and MBC revealed that hexane and chloroform extracts from P. oleracea had the highest antibacterial activity compared with ethyl acetate and methanol fractions. Generally, the antibacterial activity of extracts increased with decrease in polarity in the order hexane < chloroform < ethyl acetate < methanol. The mean (±s.d.) values were significantly different by Duncan's multiple range tests with $p < 0.05$. The extracts showed significant activities against E. cloacae, the bacteria responsible for bacteremia, lower urinary and respiratory tract infections. Extracts also showed substantial activities against E. coli, the bacteria responsible for diarrhoea and stomach pain. The sensitivity of S. typhi, S. aureus, B. subtilis, S. agalactiae to all the extracts implies that chemical compounds in the extracts could be used to develop drugs in treatment of ailments caused by these microorganisms. Extracts also showed good activities against S. dysenteriae, the bacteria responsible for bacillary dysentery. The results reported in this study corroborate earlier literature data on antibacterial assessments of plant extracts (Ajala et al. 2020; Archana & Abraham 2011; Ćetković et al. 2007; Chew, Jessica & Sasidharan 2012; Kumar et al. 2010; Mahesh & Satish 2008; Rafiu et al. 2019; Shihabudeen, Priscilla & Thirumurugan 2010; Silva et al. 2016). The inhibitory activities of all extracts confirmed the potential use of the plant in the treatments of bacterial induced ailments.

CONCLUSION:

The root of P. oleracea L. was collected to investigate its phytoconstituents and antibacterial potentials, with the goal of establishing the presence of bioactive constituents responsible for the medicinal applications of the plant. The study revealed antibacterial phytochemicals present in root extracts of P. oleracea L. , which support its vast utilisation in ethno-medicine. Our study suggests that P. oleracea L. could be a potential source for antibacterial drug discovery.

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