Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Special Issue [1]2022 : 603-610

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD

ORIGINAL ARTICLE **OPEN ACCESS**

Comparative study on phytochemical screening and antimicrobial activities of different extracts of cladodes of *Opuntia dillenii*(Ker Gawl.) Haw., *Cereus pterogonus* Lem.and *Acanthocereus tetragonus*(L.) Hummelinck

A.Mohamed Niyaz*, S. Ravikumar
Department of Plant Biology and Plant Biotechnology, Presidency College (Autonomous), Chennai – 600005, Tamilnadu, India
Email: niyasbobby@gmail.com

ABSTRACT
Succulents are water-retainers, survive as indigenous plants in many parts of the world at 40-80oF. This study focused on the phytochemical screening and antimicrobial activity of aqueous, ethanolic and chloroform extracts of three succulents namely Opuntia dillenii (Ker Gawl.) Haw., Cereus pterogonus Lem. and Acanthocereus tetragonus(L.) Hummelinck .The phytochemical analysis revealed that the ethanolic extracts of the succulents contain the large amount of phytochemicals particularly alkaloids, phenols, flavonoids and glycosides. The antibacterial activity of all the extracts was tested by agar well diffusion method, which showed a potent activity against all the tested organisms. Maximum zone of inhibition was measured against Staphylococcus aureusand minimum inhibition was measured against Klebsiella pneumonia by the ethanolic extracts of all the three samples. They also exhibited effective antifungal activity against the selected fungal strains. Maximum inhibition was found against Fusarium oxysporum and minimum inhibition was found against Candida albicans by the ethanolic extracts of all the three samples.Hence, this study proposed a comparative antimicrobial efficacy of these three plants.
Keywords: *Opuntia dillenii*(Ker Gawl.) Haw., *Cereus pterogonus*Lem., *Acanthocereus tetragonus*(L.) Hummelinck, phytochemical, antimicrobial

Received 11.03.2022 Revised 21.03.2022 Accepted 04.04.2022

INTRODUCTION

One of the biggest threats to the planet has been the infectious diseases for many decades. Infectious diseases hold a predominant position among the top deadly diseases listed in the world. The rate of evolution of new infectious diseases is on the rise, while hygiene, cleanliness and other preventive measures were pursued. This evolution of novel diseases restricted the therapeutic options against many microorganisms as they got adapted to it [1]. Antibiotics were produced in two means-bactericidal, those that kill the bacteria and bacteriostatic, those that inhibit the growth of the bacteria.

Macrolides, tetracyclines, quinolones, sulphonamides, glycopeptides, aminoglycosides, oxazolidinones, beta lactams, Carbapenems are the different classes of antibiotics discovered so far [2].Synthetically produced antibiotics impose a major issue of resistance toantibiotics and a number of after effects. The secondary metabolites of the plants often remain as the potential source of antibacterial, antifungal, antioxidant, antipyretic, anti-inflammatory and even many other diseases [3]. One among them is the succulents, the water-retaining plants.

Succulents are thick, sap-containing plants found commonly in arid environmental conditions. They belong to different families and each of them has unique features that make a difference in them. Around 3-5% of all the flowering plants are known to be succulents. The unique role of these plants is to conserve water for future remobilization. For this purpose, they have tailored a wide range of adaptations such as thick, flat and smooth cuticles, low density of stomata, high sensitivity of stomata to environmental stimuli and low hydraulic conductance. Aizoceae, Cactaceae, Amaranthaceae, Crassulaceae are some of the families [4]. One of the most beneficial groups of plants is identified under the family Cactaceae. Hence, the plants *Opuntia, Cereus* and *Acanthocereus* are chosen for this research.

Opuntia species are most predominant and widespread group of plants in Cactaceae family. These plants are distinguished by the presence of shallow root system that allows for rapid absorption of water, a thick waxy cuticle that prevents excessive loss of water and an alternative photosynthetic metabolism of

crassulacean acid (CAM) pathway, which helps plants to absorb atmospheric CO_2 during night due to which the loss of water is minimized. Hence, these groups of plants are considered as great option to grow in dry regions, as they tend to conserve large amount of water. *Opuntia* exist as variety of species namely *O. streptacantha, O. hyptiacantha, O. megacantha, O. albicarpa, O. dillenii, O. ficus-indica, O. humifusa* and so on[5].

Opuntia sp. are rich in nutrients including proteins, fibres, calcium, carbohydrates and other phytochemical constituents. Nutritional values vary between various parts of the plant-stem, fruit, fruit peel, cladodes, root and flower. Notably, the calcium was found to be exceptionally high in *Opuntia* sp. than other plant species which helped in improving bone mineral density and calciuria in adult women [6]. The presence of various nutritive constituents makes this plant a biologically prospective medicinal plant. It has been documented that various extracts from parts of this plant are used to treat atherosclerosis and other cardio vascular diseases, type-2 diabetes mellitus, obesity, cancer, skin wound etc.,[7].

Cereus pterogonus and *Acanthocereus tetragonus* are also the members of Cactaceae family. Fewer investigations are made on their medicinal utilities. Isolation of various enzymes such as xylose isomerase[8], thermophilic xylanase [9] and thermophilic laccase[10] from *Cereus pterogonus* have been documented. *Acanthocereus tetragonus* has been used as an natural coagulant for decolourization of synthetic dye waste water[11].

Most of the beneficial properties of the plants owes to the presence of its chemical constituents named as 'phytochemicals'. These are the secondary metabolites of the plants that are biologically active naturally occurring compounds. They contribute to the colour, flavor and aroma of the plants and also in protecting the plants from diseases and damages caused by drought, pollution, UV radiations, stress etc., More than 4000 phytochemicals have been identified so far. Type and concentration of these phytochemicals varies with plants and also with different parts of a single plant [12].

Every phytochemical constituent has been identified to play a beneficial role. Phenols, alkaloids, terpenoids are the large group of phytochemicals present in plants. They serve as the efficient inhibitors of microbes. Alkaloids and terpenoids also act as effective antioxidants and neuropharmacological agents. Flavonoids, Carotenoids, tocopherols, polyphenolic compounds and ascorbic acid are known to quench the free radicals, inhibit lipid peroxidation, tumor inhibition and exhibit anti-metastatic activity. Tocopherols, retinoids, phytosterols, indoles, coumarines, flavones act as detoxifying agents and inhibitors of procarcinogen activation and tumourogenesis [13].Considering these properties of *Opuntia* sp., the present comparative study was performed with the aim;

i. To extract the phytochemicals of the cladodes of three selected plants - *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* with 3 different solvents (water, ethanol, chloroform)
ii. To screen the presence of phytochemical constituents in all the extracts of the three selected plants
iii. To assess the antibacterial activity of all the plant extracts against 3 selected gram positive and 3 gram negative bacterial strains
iv. To assess the antifungal activity of all the plant extracts against 6 selected fungal strains.

MATERIAL AND METHODS

Collection of plant samples:

Cladodes of the plants were collected from various localities in and around Chennai city. The plants were randomly selected and their healthy cladodes were collected in sterile plastic bags. The taxonomic identification of the plants has beendone using standard floras at Presidency College, Chennai- 05, Tamilnadu,India.

Extraction with different solvents:

The collected plant materials were sun dried before processing. They were then chopped into pieces using a sterile knife and were allowed to dry in sunlight. They were completely dried in vacuum desiccators. The dried materials were then crushed using mortar and pestle into powder. 20g of this powder were extracted with 500 ml of distilled water, ethanol and chloroform (37%) separately using Soxhlet apparatus. The obtained extracts were filtered using 0.2µm syringe filters and the filtrate were concentrated by evaporating the solvents by drying in vacuum desiccators[14].

Preliminary screening for Phytochemical constituents:

All the test for phytochemical screening were done by adopting standard protocols [15,16].

Test for Alkaloids:

a. Dragendorff's test:

To 2ml of the extract, 2ml of hydrochloric acid (HCl) followed by 1 ml of Dragendroff's reagent were added. Formation of an orange/red coloured precipitate immediately after the addition of Dragendroff's reagent indicates the presence of alkaloids.

b. Wagner's test:
To 2ml of the extract, 2ml of hydrochloric acid (HCl) followed by few drops of Wagner's reagent were added. Formation of a yellow/brown coloured precipitate indicates the presence of alkaloids
c. Hager's test:
To 2ml of the extract, few drops of Hager's reagent were added. Presence of alkaloids was confirmed by the formation of yellow coloured precipitate.
Test for phenols:
a. Ferric chloride test:
To 2ml of the extract, 0.5ml of ferric chloride ($FeCl_3$) was added drop wise. Formation of intense violet-purple colour indicates the presence of phenols.
b. Ellagic acid test:
To 2ml of the extract, few drops of glacial acetic acid (5%) and $NaNo_2$ (5%) were added. Formation of brown coloured precipitate indicates the presence of phenols.
Test for flavonoids:
a. Alkaline reagent test:
To 2ml of the extract, few drops of dilute sodium hydroxide solution was added. The presence of flavonoids was confirmed when the yellow coloured solution formed becomes colourless on the addition of dilute acid.
b. Shinoda's test:
To 0.5ml of the extract, few drops of dilute hydrochloric acid was added followed by a piece of magnesium. Presence of flavonoids was confirmed when a pink/red/brown colour is formed
c. Ferric Chloride test:
To 2ml of the extract, few drops of ferric chloride was added. Formation of intense green colour indicates the presence of flavonoids.
Test for triterpenoids:
a. Salkowaski test:
To 2ml of the extract, 1ml of chloroform was added for dissolving. Then 1ml of acetic anhydride followed by 2ml of concentrated sulphuric acid was added. Presence of terpenoids was indicated by the formation of reddish violet colour.
b. Liebermann-Burchards'test:
To 2ml of the extract, add few drops of acetic anhydride boil it and cool down. To this solution add 1ml of concentrated sulphuric acid slowly along the sides of the tube. Presence of triterpenoids was confirmed by the formation of violet-colour ring.
Test for Saponins:
a. Foam test:
To 5ml of the extract, small amount of sodium bicarbonate was added. The tube was then shaken vigorously and left undisturbed. Presence of Saponins was indicated by the formation of froth having honeycomb-like appearance after 3 minutes of shaking.
Test for Steroids:
a. Liebermann-Burchards'test:
To 2ml of the extract, add few drops of acetic anhydride boil it and cool down. To this solution add 1ml of concentrated sulphuric acid slowly along the sides of the tube. Presence of steroids was confirmed by the formation of green colour.
b. Salkowaskitest:
To 1ml of the extract, add 10ml of chloroform and shake the tube to dissolve the extract thoroughly. To this slowly add concentrated sulphuric acid. Presence of steroids was confirmed by the formation of red colour.
Test for tannins:
a. Gelatin test:
To 2ml of the extract, add few drops of 1% gelatin containing sodium chloride. Formation of white precipitate indicates the presence of tannins.
b. Lead acetate test:
To 2ml of the extract, add few drops of 1% lead acetate solution. Presence of tannins was indicated by the formation of yellow colour precipitate.
Test for glycosides:
a. Legal's test:
To 2ml of the extract, add few drops of hydrochloric acid and keep it in water bath for few hours for hydrolysis. To this hydrolysate, add 1ml of pyridine, few drops of sodium nitroprusside followed by sodium hydroxide solution. Presence of glycosides was indicated by the appearance of pink to red colour.

b. Keller-killiani test:

To 2ml of the extract, add few drops of ferric chloride and mix it. When concentrated sulphuric acid was added two layers would be formed-an upper bluish green layer and a lower reddish brown layer. This indicates the presence of glycosides.

Test for resins:

To 1 ml of the extract, add few drops of acetone to dissolve it. Pour this solution in distilled water. Presence of resins was indicated by turbid formation.

Assessment of antibacterial activity of the extracts:

Agar well diffusion method was carried out to assess the antibacterial activity of aqueous, ethanolic and chloroform extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus*. 25ml of Muller Hinton Agar (MHA) was prepared and poured into sterile petri dishes. Plates were swabbed with gram-positive strains-*Bacillus subtilis* (ATCC6051), *Staphylococcus aureus* (ATCC9144), *Micrococcus luteus* (ATCC14452) andgram-negative strains-*Escherichia coli* (ATCC15223), *Klebsiella pneumoniae* (ATCC15380), *Salmonella typhi* (ATCC10749). 200µl of solvent extracted samples were added to wells punched in the plates in the concentration of 500µg/ml. Tetracycline (500µg/ml) was used as the standard antibiotic. The plates were incubated at 37oC for 24 hours [17].

Assessment of antifungal activity of the extracts:

Agar well diffusion method was carried out to assess the antifungal activity of aqueous, ethanolic and chloroform extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus*. 25ml of Saubouraud dextrose agar medium (SDA) was prepared and poured into sterile petri dishes with the fungus *Candida albicans*(ATCC2091), *Fusarium oxysporum*(ATCC52429), *Aspergillus niger*(ATCC9029), *Penicillium chrysogenum*(ATCC10106), *Trichoderma harzianum*(ATCC60850)and *Monilinia fruticola*(ATCC62880).200µl of the extracts were added into the wells. Amphotericin (500µg/ml) was used as the standard antifungal drug. The plates were incubated at 28oC for 36 to 48 hours[17].

Statistical analysis:

All the experiments were performed as triplicates and the values were calculated as mean±SEM. The differences between the samples were determined by Dunnett's multiple comparison tests using GraphPad Prism version 8.0.2.

RESULTS AND DISCUSSION

Collection and extraction of samples:

Three plants of the family Cactaceae were selected for the study and they were taxonomically identified as - *Opuntia dillenii*(Figure 1), *Cereus pterogonus*(Figure 2), and *Acanthocereus tetragonus*(Figure 3),. *Opuntia* sp. was one of the most recognized plants in the family Cactaceae. With many reported benefits against many chronic diseases, *Opuntia* was a well-characterized succulent of this family [7].Less study has been conducted on the positive effects of *Cereus pterogonus*. Many of the studies have only focused on the enzymes in it and their respective functions8,9,10. *Acanthocereus tetragonus* has been widely studied for understanding the Crassulacean Acid Metabolism (CAM) [18] and its anticoagulant properties [11].These plants were therefore chosen for an in-depth study of their potential roles played against the microbes. The dried and powdered cladodes of the selected plant samples weighed about 300g. The weight of the concentrated yield was determined and stored in air tight container until further use to prevent the loss of biological activity.



Figure: 1 Figure: 2 Figure: 3

Opuntia dillenii (Figure 1); *Cereus pterogonus* (Figure 2)*; Acanthocereus tetragonus* (Figure 3)

Preliminary screening for phytochemical constituents:

The phytochemical analysis revealed the presence of steroids, alkaloids, phenols, flavonoids and glycosides in large amount whereas terpenoids, saponins and tannins are present in lower amount. Resins were absent in all the extracts (Table 2). Comparatively, ethanol extracts have high level of phytochemicals followed by chloroform and aqueous extracts respectively in all the three plant samples. The presence of alkaloids, flavonoids , phenols and saponins in cladodes was also shown by phytochemical examination of cladodes and leaves of *Opuntia dillenii* Haw, while terpenoids and steroids were also found in fruits [15].Extracted phytochemicals found to vary with the solvents. Polar extracts of *Opuntia dillenii* revealed the presence of flavonoids and phenols, while the non-polar extracts revealed the presence of terpenoids and fatty acid derivatives [19]. Phytochemical constituents of *Opuntia dillenii* was found to be similar to the phytochemicals reported in cladodes of *Opuntia ficus-indica*[20]. Aqueous and ethanolic extracts of fruit skin of *Opuntia streptacantha* revealed the presence of trans ferrilic acid, quinic acid and hyperoside. The presence of high concentration of the phytochemicals in the ethanol extracts of the plant was also reported in this study [21].The presence of these phytochemicals tends to many beneficial biological activities of these plants.

Table 2. Preliminary phytochemical screening in various extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* cladodes; + indicates 'presence' and - indicates 'absence'.

Constituent	*Opuntia dillenii*(Ker Gawl.) Haw.			*Cereus pterogonus*Lem.			*Acanthocereus tetragonus*(L.) Hummelinck		
	Aqueous	Ethanol	Chloroform	Aqueous	Ethanol	Chloroform	Aqueous	Ethanol	Chloroform
Alkaloids	+	+	+	-	+	-	-	-	+
Phenols	-	+	+	-	+	-	-	+	+
Flavonoids	+	+	-	+	+	-	+	+	-
Terpenoids	-	-	-	-	-	+	-	-	+
Saponins	-	-	-	-	-	-	-	+	-
Steroids	+	+	+	-	+	+	-	+	+
Tannins	-	-	-	-	+	-	-	-	-
Glycosides	+	+	+	+	+	+	+	+	-
Resins	-	-	-	-	-	-	-	-	-

Assessment of antibacterial activity of the extracts:

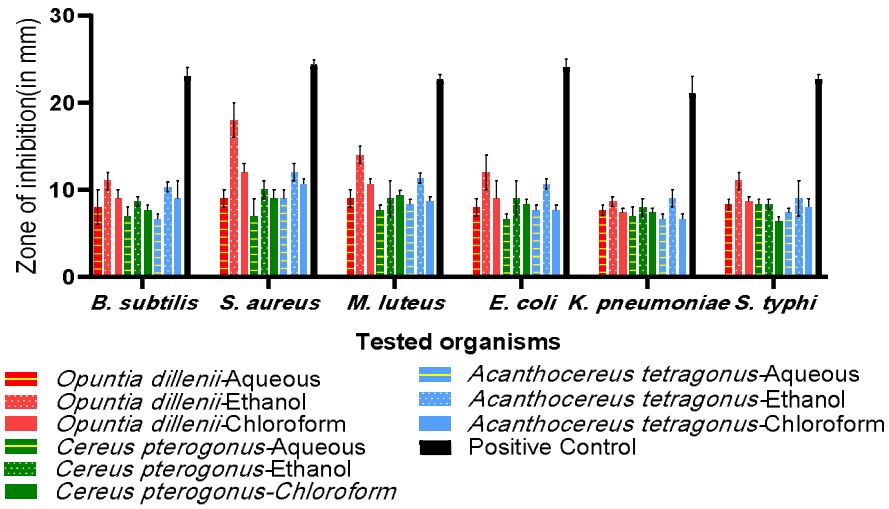
Antibacterial activity was tested by agar well diffusion method in Mueller Hinton Agar (MHA) medium. All the three extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* exhibited antibacterial activity against all the tested organisms. Ethanolic extract of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* exerted high activity when compared to chloroform and aqueous extracts (Table 3). Tetracycline was used as the positive control. Maximum inhibition was found against *Staphylococcus aureus* with the zone of inhibition measured as 18$\pm$1.15 for *Opuntia dillenii,*12$\pm$0.58 for *Acanthocereus tetragonus* and 10$\pm$0.57 for *Cereus pterogonus.* Minimum inhibition was found against *Klebsiella pneumoniae* with the zone of inhibition measured as 9$\pm$0.57 for *Acanthocereus tetragonus,* 8$\pm$0.57 for *Cereus pterogonus* and 8$\pm$0.33 for *Opuntia dillenii.* Overall, *Opuntia dillenii* exerted higher antibacterial activity followed by *Acanthocereus tetragonus* and *Cereus pterogonus* respectively (Fig. 4).

Antibacterial activity of polar and non-polar solvent extracts of *Opuntia dillenii* were reported against *Bacillus subtilis, Klebsiella pneumoniae, E.coli* and *Micrococcus* sp. with *B. subtilis* exerting higher MIC values [19]. The polar solvents of dried stem of *Opuntia dillenii* exhibited effective inhibiting activity against *B. subtilis* and *S. aureus*14 that was similar to the current findings. A new peptide named opuntisine A was isolated from the fruit extracts of *Opuntiastricta* var. *dillenii.* This exerted antibacterial efficacy against *E.coli,* a gram-negative bacteria but not against other strains [22]. This may give future insight into the discovery of novel peptides in the currently studied plants.

Table 3. Antibacterial activity of three different extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* cladodes against selected gram-positive and gram-negative strains measured as zone of inhibition (mean±SEM); positive control-Tetracycline (500µg/ml)

Test Organism	*Opuntia dillenii*(Ker Gawl.) Haw.			*Cereus pterogonus*Lem.			*Acanthocereus tetragonus*(L.) Hummelinck			Positive Control
	Aqueous	Ethanol	Chloroform	Aqueous	Ethanol	Chloroform	Aqueous	Ethanol	Chloroform	
Bacillus subtilis	8±1.15	11±0.57	9±0.57	7±0.57	9±0.33	8±0.33	7±0.33	10±0.33	9±1.15	23±0.57
Staphylococcus aureus	9±0.58	18±1.15	12±0.57	7±1.15	10±0.57	9±0.57	9±0.57	12±0.58	11±0.33	24±0.33
Micrococcus luteus	9±0.57	14±0.57	11±0.33	8±0.33	9±1.15	9±0.33	8±0.33	11±0.33	9±0.33	23±0.33
Escherichia coli	8±0.57	12±1.15	9±1.15	7±0.33	9±1.16	8±0.33	8±0.34	11±0.33	8±0.33	24±0.58
Klebsiella pneumonia	8±0.33	8±0.33	7±0.33	7±0.57	8±0.57	7±0.33	7±0.33	9±0.57	7±0.33	21±1.15
Salmonella typhi	8±0.33	11±0.57	9±0.33	8±0.33	8±0.33	6±0.33	7±0.33	9±1.15	8±0.57	23±0.33

Fig. 4. Comparison of antibacterial activity of three different extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* cladodes against selected gram-positive and gram-negative bacterial strains; positive control-Tetracycline (500µg/ml).



Assessment of antifungal activity of the extracts:

Antifungal activity was assessed through agar well diffusion method in Saubouraud Dextrose Agar (SDA) medium against six selected fungal strains. Amphotericin was used as the positive control. All the extracts exhibited activity against all the tested organisms. Similar to antibacterial activity, ethanol extracts of all the three samples exhibited the highest antifungal activity (Table 4). Maximum inhibition was observed against *Fusarium oxysporum* with zone of inhibition of 21±0.57 for *Opuntia dillenii,* 20±0.33 for *Acanthocereus tetragonus* and 19±1.15 for *Cereus pterogonus.* Minimum inhibition was observed against *Candida albicans* with the zone of inhibition of 17±0.57 for *Opuntia dillenii,* 11±0.33 for *Cereus pterogonus* and 16±0.33 for *Acanthocereus tetragonus.* Hence, *Opuntia* was found to be highly efficient as an antifungal agent followed by *Acanthocereus tetragonus* and *Cereus pterogonus* (Fig. 5).

The methanolic fruit extract of *Opuntia dillenii* exhibited notable activity against six tested fungal strains of which *Aspergillus niger, Candida albicans, Monilinia fruticola* showed the zone of inhibition of 10mm, 14mm, 12mm respectively at a concentration of 500µg/ml17. This was comparatively lower than the efficacy of ethanolic cladode extracts of *Opuntia dillenii* observed in the present study. Another study was conducted on the fungal black spot disease in *Opuntia* spp. caused by the fungus *Pseudocercospora opuntiae*through mass selection, one of the *Opuntia ficus-indica* (L.) Mill. cultivars were found to be immune to *P. opuntiae* colonization. Analysis of the ethanolic cladode extracts of the resistant plants revealed the high levels of phytochemicals and the enzyme β-1,3-glucanase that has the ability to inhibit

the respective fungal growth [23]. Apart from the phytochemical compounds found in the plants, some actinobacteria were also found to be responsible for the antifungal activity. Such a strain *Streptomyces* sp. SCA3-4 of rhizosphere origin of *Opuntia stricta* exhibited a broad-spectrum antifungal activity against phytopathogenic fungi including *Fusarium oxysporum* [24]. These establish the finding that ethanolic extracts of cladodes of *O. dillenii* were highly efficient in inhibiting the growth of fungi.

Table 4. Antifungal activity of three different extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* cladodes against selected fungal strains measured as zone of inhibition (mean±SEM); positive control-Amphotericin (500µg/ml)

Test Organism	*Opuntia dillenii*(Ker Gawl.) Haw.			*Cereus pterogonus*Lem.			*Acanthocereus tetragonus*(L.) Hummelinck			Positive control
	Aqueous	Ethanol	Chloroform	Aqueous	Ethanol	Chloroform	Aqueous	Ethanol	Chloroform	
Candida albicans	15±0.57	17±0.57	16±0.58	10±0.33	11±0.33	9±0.33	14±1.15	16±0.33	15±0.57	20±1.15
Fusarium oxysporum	16±0.33	21±0.57	20±0.33	15±1.15	19±1.15	17±0.57	16±0.57	20±0.33	19±0.33	21±0.57
Aspergillus niger	16±0.33	21±0.34	17±1.16	12±0.57	14±0.33	10±0.33	15±0.34	20±0.34	19±0.58	21±0.33
Penicillium chrysogenum	18±0.57	20±0.33	18±1.16	13±0.33	18±2.31	12±0.58	16±0.57	19±1.15	17±0.33	23±0.58
Trichoderma harzianum	19±1.15	20±0.57	20±0.34	16±0.33	14±0.33	16±0.34	18±0.58	18±0.58	17±0.57	24±0.33
Monilinia fruticola	16±1.73	19±0.57	19±0.33	15±0.34	17±0.33	16±1.15	16±1.15	17±0.33	15±0.58	22±1.15

Fig. 5. Comparison of antifungal activity of three different extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* cladodes against selected fungal strains; positive control-Amphotericin (500µg/ml).

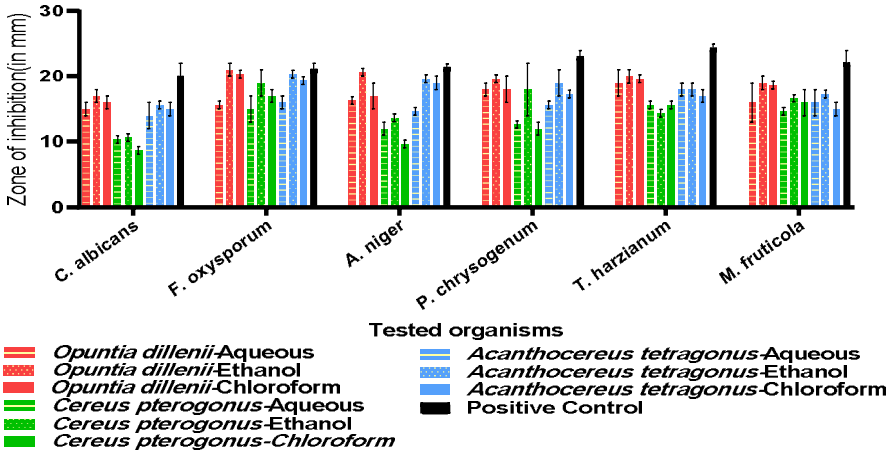


Fig. 5. Comparison of antifungal activity of three different extracts of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* cladodes against selected fungal strains; positive control-Amphotericin (500µg/ml).

CONCLUSION

Photochemical screening and *in vitro* antibacterial and antifungal potential of aqueous, ethanol and chloroform extracts of cladodes of *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus* were investigated. The study shows the presence of diverse phytochemicals such as phenol, flavonoids, alkaloids, glycosides, terpenoids, steroids, saponins, tannins and glycosides. The study also confessed the efficacy of the plants to act as a good antibacterial and antifungal agent. To highlight, the ethanolic extracts of all the three selected plants were distinctly potential than the other solvent extracts and *Opuntia dillenii* was on the top-notch. On the whole, the findings of the present study proposed a potential antimicrobial agent from the extracts of the *Opuntia dillenii, Cereus pterogonus* and *Acanthocereus tetragonus.* These finding pave the way for the discovery of the antimicrobial compounds and the mechanism of inhibition of microbial growth in the potential plants.

REFERENCES

1. Powers JH. (2004). Antimicrobial drug development – the past, the present, and the future. *Clin Microbiol Infect*. 10:23-31. doi:10.1111/j.1465-0691.2004.1007.x
2. Etebu E, Arikekpar I. (2016). Antibiotics: Classification and mechanisms of action with emphasis on molecular perspectives. *Ijambr*. 4(January 2016):90-101.
3. Bereksi MS, Hassaïne H, Bekhechi C, Abdelouahid DE. (2018). Evaluation of antibacterial activity of some medicinal plants extracts commonly used in algerian traditional medicine against some pathogenic bacteria. *Pharmacogn J*. 10(3):507-512. doi:10.5530/pj.2018.3.83
4. Griffiths H, Males J. (2017). Succulent plants. *Curr Biol*. 27(17):R890-R896. doi:10.1016/j.cub.2017.03.021
5. Reyes-Agüero JA, Aguirre Rivera JR. (2011). Agrobiodiversity of Cactus Pear (Opuntia, Cactaceae) in the Meridional Highlands Plateau of Mexico. *J Nat Resour Dev*. 1-9. doi:10.5027/jnrd.v1i0.01
6. Aguilera-Barreiro M de los A, Rivera-Márquez JA, Trujillo-Arriaga HM, Tamayo y Orozco JA, Barreira-Mercado E, Rodríguez-García ME. (2013). Intake of dehydrated nopal (Opuntia ficus indica) improves bone mineral density and calciuria in adult Mexican women . *Food Nutr Res*. 57(1):19106. doi:10.3402/fnr.v57i0.19106
7. Del Socorro Santos DIáz M, Barba De La Rosa AP, Héliès-Toussaint C, Guéraud F, Nègre-Salvayre A. (2017). Opuntia spp.: Characterization and Benefits in Chronic Diseases. *Oxid Med Cell Longev*.:1-17. doi:10. 1155/2017/8634249
8. Ravikumar S, Srikumar K. (2008). Xerophytic Cereus pterogonus xylose isomerase is a thermostable enzyme. *Chem Nat Compd*. 44(2):213-215. doi:10.1007/s10600-008-9017-z
9. Vikramathithan J, Nirmal Kumar G, Muthuraman P, Srikumar K. (2010). Purification and characterization of thermophilic xylanase isolated from the xerophytic-cereus pterogonus SP. *Protein J*. 29(7):481-486. doi:10. 1007/ s10930-010-9276-y
10. Gali NK, Kotteazeth S. (2012). Isolation, purification, and characterization of thermophilic laccase from the xerophyte cereus pterogonus. *Chem Nat Compd*. 48(3):451-456. doi:10.1007/s10600-012-0271-8
11. Vijayaraghavan G, Vignesh Kumar P, Chandrakanthan K, Selvakumar S. (2017). Acanthocereus tetragonus an effective natural coagulant for Decolorization of synthetic dye wastewater. *J Mater Environ Sci*. 8(9):3028-3033.
12. Narasinga Rao BS. (2003). Bioactive phytochemicals in Indian foods and their potential in health promotion and disease prevention. *Asia Pac J Clin Nutr*. 12(1):9-22.
13. Kurmukov AG. (2013). Phytochemistry of medicinal plants. *Med Plants Cent Asia Uzb Kyrg*.1(6):13-14. doi:10.1007/978-1-4614-3912-7_4
14. Umar MI, Javeed A, Ashraf M, et al. (2013). Polarity-based solvents extraction of opuntia dillenii and zingiber officinale for in vitro antimicrobial activities. *Int J Food Prop*. 16(1):114-124. doi:10.1080/ 10942912. 2010.517886
15. Pooja S, Gm V. (2016). Phytochemical screening for secondary metabolites of Opuntia dillenii Haw. *J Med Plants Stud JMPS*.;39(45):39-43. http://www.plantsjournal.com/archives/2016/vol4issue5/PartA/4-4-38-365.pdf.
16. Kumar S, Nair P, Ganesan K, Sinaga M, Letha N, Gani SB. (2016). Preliminary phytochemical screening of different solvent extracts of leaves of Echeveria elegans Rose, an Endangered Mexican Succulent Herb. *J Glob Biosci*. ;5(1):3429-3432. www.mutagens.co.in.
17. Shravana Kumaar AP, Vanitha J, Venkateshwaran K, Srikanth Reddy K, Karthikeyan D. (2013). Antibacterial and Antifungal Activity of Opuntia Dillenii (Cactaceae) Fruit Extract. *J Environ Nanotechnol*.;2(1):05-12. doi:10.13074/jent.2013.02.121021
18. Izaguirre-Mayoral M, Marys E. (1996). Interactions between irradiance levels and cactus X virus infection on the crussalacean acid metabolism in Nopalea cochenillifera and Acanthocereus tetragonus plants. *J Plant Physiol*. 149:35-42. doi:https://doi.org/10.1016/s0176-1617(96)80170-2
19. Katanic J, Yousfi F, Caruso MC, et al. (2019). Characterization of bioactivity and phytochemical composition with toxicity studies of different Opuntia dillenii extracts from Morocco. *Food Biosci*. 30(April):100410. doi:10.1016/j.fbio.2019.04.011
20. Hfaiedh M, Brahmi D, Zourgui MN, Zourgui L. (2018).Phytochemical analysis and nephroprotective effect of cactus (Opuntia ficus-indica) cladodes on sodium dichromate-induced kidney injury in rats. *Appl Physiol Nutr Metab*. 2019;44(3):239-247. doi:10.1139/apnm-2018-0184
21. Zourgui MN, Hfaiedh M, Brahmi D, et al. (2020).Phytochemical screening, antioxidant and antimicrobial activities of Opuntia streptacantha fruit skin. *J Food Meas Charact*. ;14(5):2721-2733. doi:10.1007/s11694-020-00518-w
22. Surup F, Minh Thi Tran T, Pfütze S, et al. (2020).Opuntisines, 14-membered cyclopeptide alkaloids from fruits of Opuntia stricta var. dillenii isolated by high-performance countercurrent chromatography. *Food Chem*.334:127552. doi:10.1016/j.foodchem.2020.127552
23. Ochoa MJ, González-Flores LM, Cruz-Rubio JM, et al.(2019). Resistance of cactus pear (Opuntia ficus-indica) against Pseudocercospora opuntiae through β-1,3-glucanase activity and polyphenolic compounds in cladodes. *Acta Hortic*. 247(4200):183-190. doi:10.17660/ActaHortic.2019.1247.25
24. Qi D, Zou L, Zhou D, et al. (2019). Taxonomy and broad-spectrum antifungal activity of streptomycessp. SCA3-4 isolated from rhizosphere soil of opuntia stricta. *Front Microbiol*;10(JUN):1-15. doi:10.3389/fmicb.2019.01390

CITATION OF THIS ARTICLE

A.Mohamed Niyaz, S. Ravikumar. Comparative study on phytochemical screening and antimicrobial activities of different extracts of cladodes of *Opuntia dillenii*(Ker Gawl.) Haw., *Cereus pterogonus*Lem.and *Acanthocereus tetragonus*(L.) Hummelinck. Bull. Env.Pharmacol. Life Sci., Spl Issue [1] 2022 : 603-610