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Phenolics, Antioxidant and Radical Scavenging Properties of *Acanthus ilicifolius* L. and *Heliotropium curassavicum* L., of the Palk Bay Region, Tamilnadu

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ABSTRACT: This study was designed to characterize the phytochemical constituents of *Acanthus ilicifolius* and *Heliotropium curassavicum* with antioxidant and nutraceutical activities using different solvents. Analysis of bioactive compounds included the application of common phytochemical screening assays, proximate analysis, FTIR analysis and antioxidant assays. The results showed that the highest extraction yield was observed with methanol. The qualitative phytochemical analysis carried out on the leaves from the methanol extracts of *Acanthus ilicifolius* revealed the presence of medicinally important constituents such as alkaloids, saponins, phenolics, flavonoids, steroids, cardiac glycosides, tannins and terpenoids. Similarly, *H. curassavicum* extracts showed the presence of all the phytochemicals including anthocyanin except cardiac glycosides. As a defensive metabolite, both the halophytes accumulate proline in their leaves, but *A. ilicifolius* has showed relatively high content of proline (37.6 µmol g^{-1}) as of true mangrove than *H. curassavicum* (21.6 µmol g^{-1}). The maximum total phenolic content and highest antioxidant potential were obtained in the methanolic extract of *A. ilicifolius*. The DPPH assay revealed that *A. ilicifolius* has a maximum of 74.5% radical scavenging activity and comparatively *H. curassavicum* has a lesser activity of 68.2%. The antimicrobial assays explored that *S. aureus* and *Bacillus sps* were susceptible to the extracts at the lowest concentration used (<50 mg/ml) whereas none of the fungi was susceptible to the extracts.

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INTRODUCTION

Recent trend in biomedical research entails searching for biomasses that contain extractable active components or phytochemicals, which can be sold as food and cosmetics additives, nutraceuticals, and even pharmaceuticals. Phytochemicals from plant sources such as phenolics and flavonoids have been reported to have positive impact on health and cancer prevention [1]. High content of phenolic and flavonoids in medicinal plants have been associated with their antioxidant activities that play a role in the prevention of the development of age-related disease, particularly cause by oxidative stress. Marine halophytes are the specialized group of plants adopted for high saline conditions which include mangroves, seaweeds, sea grass, and blue green algae. Since these plants thrive in harsh environments, especially hyper saline conditions, halophytes are expected to produce bioactive compounds with high antioxidant capacity and hence could be better candidates for focus [2].

Recently, the medicinal value of mangroves and associated plants persist to provide priceless therapeutic agents, both in modern medicines and in traditional systems. Some recent studies showed the medicinal value of mangroves and associated plants persist to provide invaluable treatment modalities, both in modern and traditional systems of medicine [3]. Numerous reports have documented the traditional uses of saline medicinal plants in rural and tribal

areas all over the world as a successful home remedy against different ailments. Shoots of *Salicornia bigellovi*, *Sesuvium portulacastrum*, *Chenopodium album*, *Portulaca oleracea*, and *Suaeda maritime* are used for vegetables, salads and pickles in various parts of the country [4].

The nutritional usefulness and antioxidant potential of the halophytes from South Eastern coast of India has been rarely studied. Therefore, it is rational to explore the underutilized plants such as halophytes for their application in food and pharmaceutical applications. Hence, the present study is aimed to screen and characterize the phytochemical constituents in a true mangrove *Acanthus ilicifolius* and a halophyte *Heliotropium curassavicum* and also determine their antioxidant potential and antimicrobial properties.

MATERIAL AND METHODS

Healthy plant twigs of *Acanthus illicifolius* L. (Acanthaceae) and *Heliotropium curassavicum* L. (Boraginaceae) were collected during 2017 – 2018 from the coastal villages of Kattumavadi (Lat. 10º12'N; Long. 79º23'E) and Kodiyakarai (Lat. 10º03'N; Long. 79º26'E) in the Palk Bay region of Puthukottai District, Tamilnadu, India. The plant materials were identified and authenticated taxonomically with the help of the local floras [5] and Botanical survey of India, Southern Regional Centre, Coimbatore, Tamil Nadu.

Collected plant material were thoroughly washed, separated into stem and leaves and then dried under shade at 28 ± 2 ºC for about 10 days. The air-dried plant parts were pulverized to a coarse powder in a mechanical grinder, passed through a 40-mesh sieve and extracted in a soxhlet extractor with methanol, water and chloroform [6]. The extract was decanted, filtered with Whatman No. 1 filter paper and concentrated at reduced pressure below 40°C through rota-vapor to obtain dry extract. The obtained extracts were stored then subjected to further analysis.

Phytochemical Screening

The extracts of the plant leaves were subjected to qualitative phytochemical analysis for the presence of tannins, saponin, flavonoids, alkaloids, phenol and other phytochemicals using standard procedures [7, 8].

Proximate analysis

Chlorophyll content (mg g^{-1} fresh weight) was determined through organic solvent (80% acetone) extraction method as described by Arnon, [9]. Sugar [10] and protein, proline [11] were also estimated as per standard procedures. Total ash content was estimated by furnaces incineration gravimetric method described by James [12] and ash value by Dauod *et al.* [13]. The membrane stability index (MSI%) was determined as described by Premchandra *et al.* [14] by measuring the electrical conductivity and the relative water content (RWC) by the method of Barrs and Weatherley [15]. Total phenolic contents (TPC) were determined by the Folin Ciocalteu method proposed by Lin and Tang [16] and the data was expressed as milligram gallic acid equivalents (GAE) 100 g^{-1} fresh weight. The alkaloid contents were determined gravimetrically using the method of Harborne [7], optimized by comparison with the spectrophotometric method of Sreevidya and Mehrotra [17].

FTIR analysis

Fourier Transform Infrared spectra (FTIR) will be studied using a Schimadzu spectrometer (Japan) to quantify the phytochemicals in the halophytic plant samples. For this, 3.0 mg of the sample will be dispersed in 300 mg of spectroscopic grade KBr and subsequently pressed into disks at 10 MPa for 3 min. The spectra were obtained with an average of 25 scans and a resolution of 4 cm-1 in the range of 4000–400 cm^{-1}.

Total antioxidant capacity (TAC)

Protocol devised by Prieto et al. [18] was used to determine the antioxidant activity of crude extracts dissolved in dimethyl sulfoxide solvent (DMSO). 0.3 ml of sample was mixed with 3.0 ml reagent solution (0.6 M sulfuric acid, 28mM sodium phosphate and 4mM ammonium molybdate), and the tubes containing the reaction mixtures were incubated at 95ºC for 90 min. in the water bath. Absorbance at all the mixture was taken at 695 nm. The total antioxidant activity was expressed as mg equivalent of ascorbic acid.

Radical scavenging ability (RSA)

Radical scavenging capability of the plant extracts was determined by slightly modified Mensor [19] technique. 2.5 ml of each of the above extracts were taken in a tube. To the above 1.0 ml from 0.3mM methanol solution of 2, 2-diphenyl-1-picryl hydrazyl radical **(**DPPH) was added. These tubes were stored in dark at room temperature for 30 min. The antiradical activity was determined by taking optical density at 518nm and the antiradical activity (AA) was determined by the formula AA% = 100 – {[(Abs. Sample – Abs. Empty Sample) × 100] / Abs.control}, where, Empty samples = 1 ml ethanol + 2.5 ml of different extract of the plant used here; Control sample = 1 ml 0.3mM DPPH + 2.5 ml methanol. The O.D. of the samples, the control and the empty samples were measured in comparison with methanol.

Antimicrobial activity

The crude extracts of different halophyte species were subjected to antimicrobial assay using the agar disc diffusion method of Kirby *et al.*, [20]. 20 ml of nutrient agar was dispensed into sterile universal bottles, these were then inoculated with 0.2 ml of cultures mixed gently and poured into sterile petridishes. The disc (6mm in diameter) was impregnated with 100 - 1000 µl *A. illicifoilus* and *H. curassavicum* extracts (100mg/ml) and allowed to dry. The discs coated with phytochemicals were placed on seeded agar along with negative and positive controls. Negative controls were prepared with the same solvents employed to dissolve the mangrove extracts. Gentamicin (10µg/disc) was used as positive control for bacteria and fluconazole (10 µg/disc) for fungi. The inoculated plates were incubated at 27 ºC for 72 h. Antimicrobial activity was measured through determining the zone of inhibition against the test organism in contrast to the negative control.

Statistical analysis

Data were analyzed by ANOVA SPSS version 20.0 for windows followed by Duncan Multiple Range Test (DMRT) for comparison at P= 0.05 level of significance.

RESULTS AND DISCUSSION

Preliminary phytochemical screening

The qualitative phytochemical analysis carried out on the leaves from the methanol extracts of *Acanthus ilicifolius* revealed the presence of medicinally important constituents such as alkaloids, saponins, phenolics, flavonoids, steroids, cardiac glycosides, tannins and terpenoids (**Table 1**) than chloroform and aqueous extracts. Similarly, *H. curassavicum* ME extracts showed the presence of all the phytochemicals including anthocyanin and the absence of cardiac glycosides. Similar results were reported earlier which revealed *A. ilicifolius* as the rich source long chain alcohols, terpenes, steroids and triterpinoidal saponins [21, 22]. The aqueous extract showed only the presence of tannin and phenol.

Photosynthetic pigments

The present results on chlorophyll content of both the species agreed with the earlier concept that plants growing in saline soils contained significantly lower chlorophyll a and chlorophyll b as compared to other glycophytes and the *chlorophyll a* being significantly higher than *chlorophyll b* [23]. The *chlorophyll a* content was found maximum (0.357 mg g^{-1}) in *H. curassavicum* while it was lesser in *A. ilicifolius* (0.331 mg g^{-1}), whereas chlorophyll b was found maximum (0.318 mg g^{-1}) in *A. ilicifolius* (**Table 2**). The magnitude of chlorophyll a/b ratio was found higher in *H. curassavicum* while variation in total chlorophyll was found insignificant among *H. curassavicum* and *A. ilicifolius*. But, *A. ilicifolius* has higher carotenoid content (0.076 mg g^{-1}) than *H. curassavicum.* In general, salinity severely impacts photosynthesis by the reduction in chlorophyll content as well as changes in the chlorophyll a/b ratio. The significantly elevated levels of chlorophyll a, chlorophyll b and carotenoids content observed in the present study in both the halophytes, suggesting that the photosynthetic machinery was not disturbed upon imposition of salinity prevailed in the study area [24]. Ramani et al. [25] reported increased chlorophyll a/chlorophyll b ratio and carotenoids in *Sesuvium portulacastrum* grown at sea water salinity. This indicates that different species of halophytes have different mechanisms to adapt under saline condition.

Proximate compounds

Organic metabolites such as total sugar, reducing sugar, and proline were significantly varied among the halophytes *A. ilicifolius* and *H. curassavicum* growing on different salinity regimes which decipher the role of these organic metabolites for osmotic adjustment and salt tolerance in them. The organic constituents of *H. curassavicum* were significantly less compared to *A. ilicifolius* except reducing sugar. The leaf of *H. curassavicum* is rich in carbohydrates and it has showed a maximum content of reducing sugar (23.7 mg g^{-1}) whereas *A. ilicifolius* has showed comparatively lesser content of reducing sugar (19.3 mg g^{-1}) (**Table 3**). As a defensive metabolite, both the halophytes accumulate proline in their leaves. *A. ilicifolius* has showed relatively high content of proline (37.6 µmol g^{-1}) as of true mangrove, where as *H. curassavicum* has showed similar content of proline (21.6 µmol g^{-1}). The salinity-induced accumulation of proline in *A. ilicifolius* might be due to promotion of proline biosynthesis and/or may be due to inhibition of proline catabolism [26]. As a part of osmoregulatory mechanism, increased level of proline in response to salt stress has been reported in *Sesuvium portulacastrum* and many other halophytes [27, 28, 29]. The protein content was comparatively more in *H. curassavicum* (26.4 mg g^{-1}) than *A. ilicifolius*.

Table 1. Preliminary phytochemical analysis of *A. ilicifolius* and *H. curassavicum*

Phytochemical	*Acanthus ilicifolius*			*Heliotropium curassavicum*		
	E1	**E2**	**E3**	**E1**	**E2**	**E3**
Steroids	-	+	-	-	-	-
Alkaloids	-	+	+	-	+	-
Terpenoids	-	+	-	-	+	-
Coumarins	-	-	-	-	-	-
Tannins	+	+	+	-	+	-
Saponins	-	+	-	-	-	-
Anthocyanin	-	+	+	+	+	+
Flavanoids	-	+	-	-	+	-
Phenols	+	+	+	-	+	+
Cardiac glycosides	-	+	+	-	-	-

E1 – Aqueous; E2 – Methanol; E3 – Chloroform extracts

Table 2. Photosynthetic pigments content (mg g^{-1} fresh weight) of *A. ilicifolius* and *H. curassavicum.* Values are Mean ± SE

Pigment	*Acanthus ilicifolius*	*Heliotropium curassavicum*
Total Chlorophyll	0.641 ± 0.12	0.673 ± 0.08
Chlorophyll a	0.331 ± 0.09	0.357 ± 0.12
Chlorophyll b	0.318 ± 0.11	0.309 ± 0.04
Carotenoids	0.076 ± 0.05	0.068 ± 0.02

Phenolic content

Acanthus ilicifolius has showed a maximum total phenol content of 42.3 mg GAE 100 g^{-1} and *Heliotropium curassavicum* has showed a lesser content of total phenol (33.4 mg GAE 100 g^{-1}) (**Table 3**). Both *A. ilicifolius* and *H. curassavicum* had high TPC (≥10 mg g−1) compared to values of some known medicinal plants such as *Diplotaxis harra* and *Diplotaxis simplex* [30]. The present observations are in accordance with the earlier report [31] who reported that dried aqueous and acetone extract of the *A. ilicifolius* has showed a maximum total phenol content of 42.3 mg GAE 100 g^{-1} and *H. curassavicum* has showed a lesser content of total phenol (33.4 mg GAE 100 g^{-1}) (**Table 3**). Both *A. ilicifolius* and *H. curassavicum* had high TPC (≥10 mg g−1) compared to values of some known medicinal plants such as *Diplotaxis harra* and *Diplotaxis simplex* [30]. The present observations are in accordance with the earlier report [31] who reported that dried aqueous and acetone extract of the leaves of *Suaeda maritima* had significant differences in phenolic contents. Sofia and Teresa [32] have observed wide variation in the total phenols in different solvent extracts of three parts (stem, leaf and root) of *A. ilicifolius* L. which ranged from 39.1 to 87.4 mg g^{-1} in terms of extracts and plant parts. Similarly, Reddy and Grace [33] reported lowest and highest content of total phenols in the extracts of *Excoecaria agallocha* (20.56 ± 0.58 µg GAE/100 µg), *Aegiceras corniculatum* (24.06 ± 0.79 µg GAE/100 µg) *Lumnitzera racemosa* (38.80 ± 0.19 µg GAE/ 100 µg). Similarly, *A. ilicifolius* contained higher alkaloid (9.23 mg g^{-1}) content compared to *H. curassavicum*.

Table 3. Proximate analysis of *A. ilicifolius* and *H. curassavicum*

Content	*A. ilicifolius*	*H. curassavicum*
Reducing sugar (mg g^{-1})	19.3 ± 0.07	23.7 ± 0.03
Proline (µmol g^{-1})	37.6 ± 0.11	21.6 ± 0.03
Protein (mg g^{-1})	21.9 ± 0.11	26.4 ± 0.18
Total Phenol (mg GAE 100 g^{-1} FW)	42.3 ± 0.08	33.4 ± 0.05
Alkaloids (mg g^{-1})	9.23 ± 0.09	6.37 ± 0.12

Values are Mean ± SE; GAE – Gallic Acid Equivalent

Ash value

The physicochemical parameters including relative water content, membrane stability index, total ash content, acid insoluble ash, and water soluble ash were carried out (**Table 4**). Total ash value was noted as 9.54%, followed by water soluble ash value 5.84% and the acid insoluble ash value is 0.64% in *A. ilicifolius*. The acid insoluble ash content of *H. curassavicum* was 0.43%. As ash value is useful in determining authenticity and purity of drugs and also these values are important quantitative standards. The ash content varied with the species and ranged from below 10% in the salt excluders (*H. curassavicum*), to over 40% in the shoots of the includers (*A.ilicifolius*) which accumulated high mineral levels. Similar results of high total ash content were also reported earlier in other mangroves such as *Rhizophora mucronata* [34] and *Aegiceras corniculatum* [35] which ranged from 7 – 13%.

Relative water content (RWC) and Membrane stability Index (MSI)

Both the halophytes have similar MSI in the range of 41 – 46% and the RWC was higher in *H. curassavicum* (42%) and lower in *A. ilicifolius* (33%) (**Table 4**). The capacity of *H. curassavicum*, to maintain high RWC in their leaves, despite of high external salinity might have a protective role from the deleterious effects of salinity. Tissue tolerance of salinity requires compartmentalization of toxic sodium ion at the cellular and intracellular levels to avoid toxic concentrations in the cytoplasm, especially in mesophyll cells of leaves [36, 37]. This hypothesis is further reinforced by the fact that both leaf succulence (water content per unit area) and leaf thickness were considerably higher in the leaves of plants growing at high soil salinity [38].

Table 4. Ash value (%), Relative water content (%) and Membrane stability index (%) **of *A. ilicifolius* and *H. curassavicum***

Content	*A. ilicifolius*	*H. curassavicum*
Total ash	9.54 ± 0.08	7.93 ± 0.03
Water soluble ash	5.84 ± 0.03	4.67 ± 0.07
Acid insoluble ash	0.64 ± 0.11	0.43 ± 0.11
Relative water content	33.5 ± 0.04	42.3 ± 0.13
Membrane Stability Index	41.6 ± 0.04	46.8 ± 0.09

Values are Mean ± SE

FTIR characterization

The FTIR analysis of methanol and chloroform extracts of both the halophytes revealed the functional group components of amino acids, amides, amines, carboxylic acid, carbonyl compounds, organic hydrocarbons, halogens, phenolic compounds, flavonoids, saponins, tannins and carbohydrate as major functional groups. The FTIR spectrum of leaf extracts of *A. ilicifolius* is given in **Fig 1**. The methanolic extract of *A. ilicifolius* showed characteristic absorption bands at 3439 cm -1 for a hydroxyl (-OH) group, 2854 cm^{-1}, 2102 cm^{-1} (for aldehyde), 1382 cm^{-1} (for CH_3 bending), and at 1622 cm^{-1} for alkane group. The characteristic absorption band in chloroform extracts were exhibited at 2921 cm^{-1} (for C-H stretching), 1492 cm^{-1} (for C-H bending) for C-H group and at 1631 cm^{-1} , 1405 cm^{-1} for carbonyl groups (C=O). Major peaks were observed at 2921 cm^{-1} that could be assigned to the C-H stretching vibrations of methyl, methylene and methoxy groups in *A. officinalis* [39]. Additional peaks observed at 3350.08 cm^{-1} and 2855.40 cm^{-1} that are indicating the presence of O-H Alcohol and =C-H Aldehyde groups. Similarly, the methanol extracts (ME) of *H. curassavicum* **(Fig. 2**) showed characteristic bands at 3395.1 exhibiting O-H stretch of poly hydroxy compounds, 2144.7 of nitrile compounds, 1411.2 (O-H bend) of phenol or tertiary alcohol and 1081.5 (C-O stretch) of cyclic ethers. The FTIR analysis of chloroform extracts (CF) of *H. curassavicum* showed different functional groups like amides, alkanes, bending water, lipids, alkenes, aromatic ring and chlorides compounds, which shows peaks at range of 3305- 3325, 2920-2937, 2050-2154, 1739-1769, 1617-1639, 1440-1505 and 533 - 615. Both spectra clearly indicated the presence of alkaloids, flavonoids and polyphenols. Similar results were reported in other halophytes such as *Sesuvium portulacastrum*, *Ichnocarpus frutescens* [40] and *Solanum torvum* [41].

Total antioxidant activity

In general, methanolic extracts showed better antioxidant activity than the aqueous extracts of both the halophytes (**Table 5**). *A. ilicifolius* has showed a maximum TAC of 85.3 mg g^{-1} ascorbic acid Eq., and comparatively *H. curassavicum* has showed a lesser content of 66.7 mg g^{-1}. The phytochemical analysis in the present study that confirms the presence of flavonoids, tannins and saponins in methanol extract could be the reason behind antioxidant properties of these plants [42]. Several studies showed that maximum yield of phenolic antioxidants has been found in aqueous-methanolic extracts rather than pure water extracts [43, 44, 45] where in most cases higher TPC have been linked with higher AC [46, 47]. Similar to our results, a highest antioxidant activity was reported in dichloromethane extract of *Avicennia marina* (112.95 mg/g DW ascorbic acid eq.) than ethyl acetate extract (83.56 mg/g DW ascorbic acid eq.) [48]. Edison [49] reported that the methanol and ethyl acetate extracts of *Salicornia brachiata*, an edible halophyte has showed significant radical scavenging activity. The total antioxidant activity comparable to higher plants (245– 376 mg/g DW ascorbic acid eq.) has revealed the medicinal significance of these halophytes [50].

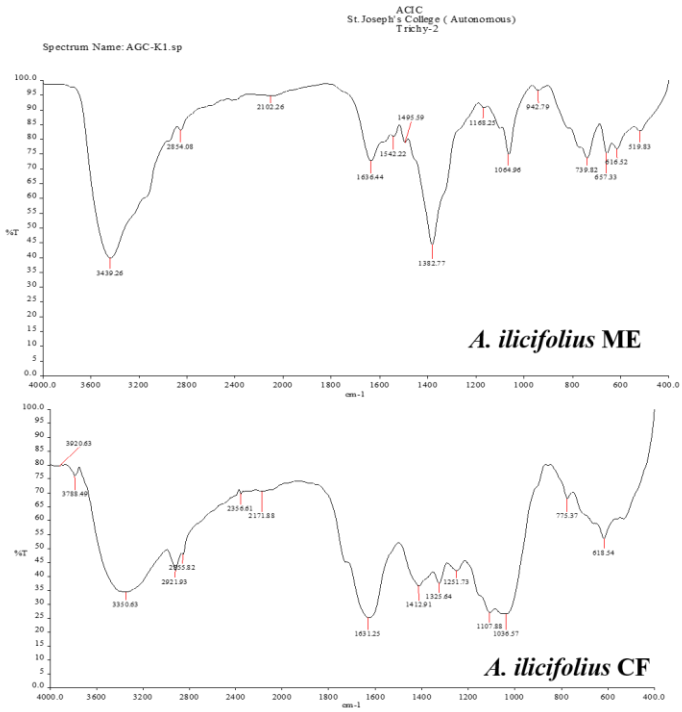

Fig 1. FTIR spectrum of leaf extracts (ME – methanol; CF – Chloroform) of *A. ilicifolius*

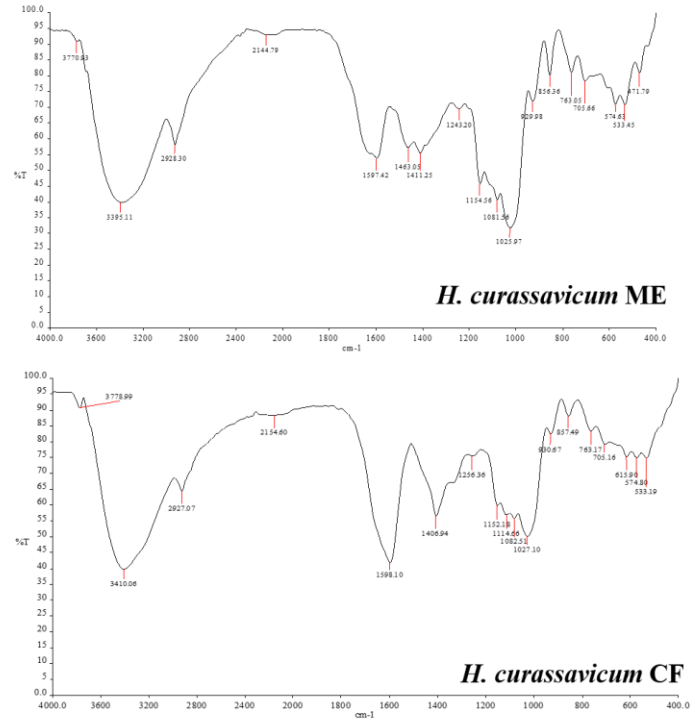

Fig 2. FTIR spectrum of leaf extracts (ME – methanol; CF – Chloroform) of *H. curassavicum.*

Radical Scavenging Activity

Both the halophytes exhibited significant RSA and in general methanolic extracts showed better RSA than the aqueous extracts (**Table 5**). *A. ilicifolius* has showed a maximum of 74.5 % and comparatively *H. curassavicum* has showed a lesser activity of 68.2%. Firdaus *et al.* [51] have scrutinized the antioxidant properties of *A. ilicifolius* by the DPPH scavenging assay on five extracts (acetone, methanol, acetone 70%, methanol 80% and water) of flowers and found that methanol extract showed highest antiradical efficiency (141.30%), while water extract of showed lowest (0.0037%) among the extracts. confirmed the antioxidant effects of the methanol extract of the plant. From the data, it is clear that extracts having high TPC had high DPPH free radical scavenging capability. This may suggest that polyphenolics are responsible for this activity among the extracts of halophyte. This may be correlated that different solvents having different polarity may often the specific group of the antioxidant compounds that influenced the scavenging capability of the extracts in different solvents taken from the same plants. It is conformed in the present findings as maximum scavenging capability was 74% in methanol extract followed by chloroform and weak scavenging ability was noted in the aqueous extracts. The scavenging capability of a solution having polyphenolics with DPPH radicals have also been reported by other workers in *Lumnitzera racemosa*, *Excocaria agallocha* [33] and in the barks of *Ceriops decandra* [52].

Antimicrobial Activity

According to preliminary study and studies of other people [53], it has been recorded that, a number of mangrove plant extracts of methanol, ethanol and water showed antibacterial activity against pathogenic isolates as well as antibiotic resistant bacteria. In the present study, chloroform and methanol extract exhibited different degree of growth inhibition against tested bacterial and fungal strains (**Fig 3**). Results of the present study showed that methanol extract of *A.ilicifolius* reduced the growth of *Bacillus sps*, and *S. aeurus.* However inhibition of growth was minimum in water extract. But all methanol, chloroform, water extracts of *H. curassavicum* showed the inhibitory effect on pathogenic bacteria and also against *Aspergillus flavus.* The zone of inhibition (ZOI) is concentration dependent and the ZOI diameter increased with the increase in the concentration of phytochemical extract of both the selected halophytes. A maximum of 16.7 mm zone of inhibition was observed in the methanol extract of *A. ilicifolius* followed by *H. curassavicum.* Based on the results, minimum inhibitory concentration (MIC) of methanol extract of *A. ilicifolius* for *Bacillus sps* was 40 mg/ml, while it was 50 mg/ml for *H. curassavicum*. In this study, the maximum size of inhibition zone for *H. curassavicum* CF extract was 8.54 mm for *S. aeurus*. Only *S. aureus* and *Bacillus sps* were susceptible to the extracts at the lowest concentration used (<50 mg/ml), all the other bacteria were susceptible at 100, 200 and 300 mg/ml. This is similar to the findings of Omodamiduro and Ekelemo [54] who reported that the leaf extract of polar solvent show a significant dose dependent inhibition of *Staphylococcus aureus*, *Streptococcus pneumoniae*, *E. coli*, *Proteus mirabilis* and *Pseudomonas aeruginosa*. This research work is in consonance with the findings of Abeysinghe and Pathirana [55] who reported that the activity might also be due to the differences in the concentration of the phytocompounds of various secondary metabolites present in the extracts as well as the extracting ability of the solvents. Further studies are needed to isolate and characterize the bioactive principle compounds to develop new antibacterial drug [56].

Table 5. Total antioxidant activity (mg g^{-1} ascorbic acid Eq) and Radical scavenging activity (%) of *A. ilicifolius* and *H. curassavicum*

Sample	Extracts	TAC	RSA
A. ilicifolius	E1	11.2 ± 0.13	30.2 ± 0.09
	E2	85.3 ± 0.07	74.5 ± 0.11
	E3	58.5 ± 0.11	54.6 ± 0.06
H. curassavicum	E1	9.20 ± 0.08	21.3 ± 0.02
	E2	66.7 ± 0.13	68.2 ± 0.09
	E3	43.4 ± 0.06	53.3 ± 0.11

Values are Mean ± SE (E1 – Water; E2 – Methanol; E3 – Chloroform)

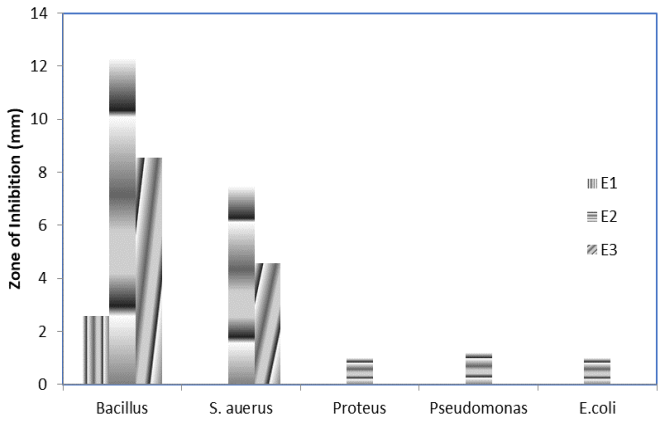

Fig 3. Antibacterial activity of *A. ilicifolius* and *H. curassavicum*

CONCLUSION

This study brought out the medicinal properties of native halophytes like *Acanthus ilicifolius* and *Heliotropium curassavicum* with significant antioxidant and nutraceutical activities. Preliminary screening of phytochemical constitutes revealed the presence of tannins, flavonoids and several aromatic compounds or secondary metabolites of plants in saline environment that may be useful in the detection of the bioactive principles and subsequently may lead to the drug discovery. Development of value-added products from these underutilized species will also promote their farming in coastal habitats, which has not been seriously explored earlier

due to the lack of knowledge about their commercial importance.

CONFLICT OF INTEREST

The authors have no conflict of interest.

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DATA AVAILABILITY

Not declared.

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