Bioactive compounds and antifungal activity of three different seaweed species \textit{Ulva lactuca}, \textit{Sargassum tenerrimum} and \textit{Laurencia obtusa} collected from Okha coast, Western India

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ABSTRACT

Objective: To evaluate bioactive compounds responsible for antifungal activity from seaweeds of Okha coast, Western India.

Methods: Each species were extracted with different solvents with increasing polarity: hexane, ethyl acetate, chloroform and methanol using Soxhlet apparatus. The antifungal activity was determined by agar diffusion plate method by using fluconazole, ketoconazole and amphotericin B as standards. Gas chromatography-mass spectrometer analysis was done for identification of bioactive compounds present in crude extract.

Results: The gas chromatography-mass spectrometer analysis of all the extracts revealed the presence of steroids, fatty acids and esters compounds. Among the three species, the maximum crude extract yield (53.46%) and the largest inhibition zone (36 mm) were recorded in methanol extract of \textit{Ulva lactuca}, whereas the minimum crude extract yield and inhibition zone were recorded in chloroform extract of the same species as 0.5% and 10 mm, respectively. Methanol and ethyl acetate extract showed the maximum antifungal activity and the major important compounds like steroids, fatty acids and esters were detected with higher amount in all the extracts.

Conclusions: The present study revealed that the different seaweed extracts showed moderate to significant antifungal activity against the strains tested as compared with the standard fungicides, and polar solvents methanol and ethyl acetate were comparatively efficient for extraction of different metabolites that are responsible for antifungal activity.

1. Introduction

Seaweeds are considered as a source of bioactive compounds as they are able to produce a great variety of secondary metabolites characterized by a broad spectrum of biological activities. Compounds with antioxidant, antiviral, antifungal and antimicrobial activities have been detected in brown, red and green algae\cite{1-3}. Numerous substances were identified as antimicrobial agents from algae: chlorellin derivatives, acrylic acid, halogenated aliphatic compounds, terpenes, sulphur containing heterocyclic compounds, phenolic inhibitors, etc. \cite{4}. Many researchers suggested that the crude extracts of Indian seaweeds are active against Gram-positive bacteria\cite{5}. Decreased efficiency and resistance of pathogen to antibiotics has demanded the development of new alternatives\cite{6}. Steroids and fatty acid esters of \textit{Acanthophora spicifera} were reported to exhibit potent antitumor and antibacterial activity against human cancer cell lines and microorganisms\cite{7}. Algae and their extracts are the source of biologically active compounds. Their beneficial properties for humans, animals and plants were recognized in the past and are appreciated nowadays, in the development of new biotechnological products\cite{8} due to the finding of antibacterial and antifungal activities in many species of marine algae from different parts of the world and the isolation of some active compounds from them\cite{9,10}. Compounds with cytostatic,
antiviral, antihelmintic, antifungal and antibacterial activities have been detected in green, brown and red algae[11,12]. The seaweed species Chaetomorpha spp., Cladophora fascicularis, Ulva lactuca Linnaeus (U. lactuca), Caulerpa racemosa, Caulerpa sertularioides, Valoniopsis pachynema, Sargassum ilicifolium, Sargassum polycystum and Porphyra vietnamensis of Bet Dwarka, Okha coast are rich in minerals, metabolites and pigments[13,14]. Therefore the present study aims to investigate the bioactive compounds possibly responsible for antifungal activity of three different seaweed species U. lactuca, Sargassum tenerimum J.G. Agardh (S. tenerimum) and Laurencia obtusa Lamouroux (L. obtusa) collected from Okha coast, Western India.

2. Materials and methods

2.1. Sample collection and processing

The seaweed species U. lactuca, S. tenerimum and L. obtusa were collected during November 2014 from Okha situated at 22°28’ N and 69°5’ E at the mouth of Gulf of Kutch on the north-western part of Saurashtra, Gujarat, Western India. The species were picked with hand and immediately washed with seawater to remove the foreign particles, sand particles and epiphytes. Then they were kept in an ice-box and immediately transported to the species were kept in airtight plastic bottles at reduced pressure using rotary evaporator (40–50 °C). All air-dried samples were placed in an oven at 50 °C, pulverized in the grinder and sieved through a screen with mesh size of 0.5 mm. Then, the powdered material was kept in airtight plastic bottles at room temperature.

2.2. Preparation of extract

The three seaweed species were evaluated for the important biochemical composition as well as their bioactive properties. The seaweed sample (3.0 g) was extracted in solvents with increasing polarity: hexane, ethyl acetate, chloroform and methanol (1:10; w/v) for 24–48 h, using Soxhlet apparatus as described by Zakaria et al.[16]. The resulting extracts were concentrated to dryness under reduced pressure using rotary evaporator (40–50 °C). All concentrated extracts were then air-dried in fume hood and stored at 4 °C. Analytical grade solvents (Sigma, USA) were used in the present study.

2.3. Antifungal assay

The seaweed extracts were further tested for antifungal activity using the agar diffusion plate method[17]. Each seaweed extract was tested against two fungal species Aspergillus niger (A. niger) (NCBI accession No. KC545848) and Penicillium janthinellum (P. janthinellum) (NCBI accession No. KC545842) which have petroleum oil-degrading capacity and isolated from petrol spill site used for antifungal assay[18]. In this assay, 0.1 mL of fungal spore suspension grown for 3 days on 10 mL of nutrient dextrose agar was thoroughly mixed with 25 mL of melted potato dextrose agar (Himedia, India) and was poured into sterilized Petri plates. When the agar solidified, 4 wells of 6 mm diameter were made on each of the seeded plates. These wells were filled with 50, 100 and 200 μL of the test samples and solvent alone in the fourth cup was kept as control. The standard fluconazole (10 μg), ketoconazol (10 μg) and amphotericin B (20 μg) commercial antifungal discs were used for comparison. The Petri plates were incubated at 28 °C for 2–4 days and all the culture plates were examined from 24 h onwards.

2.4. Bioactive compound analysis by gas chromatography-mass spectrometer (GC-MS) method

The crude extracts of seaweed samples were subjected to GC-MS (AutoSystem XL GC, PerkinElmer, USA) at Sophisticated Instrumentation Centre for Applied Research and Testing, Vallabh Vidhyanagar, Gujarat. GC-MS analysis was performed using GC apparatus attached to a PE-5MS fused silica capillary 5% phenyl/95% methyl polysiloxane column (30 mm × 50 mm, 0.25 μm film thickness, PerkinElmer, USA). The column temperature was initially 80 °C, held for 5 min, then increased at 10 °C/min from 80 °C to 290 °C and detector temperature was set at 250 °C. Helium at 1 mL/min was used as the carrier gas. Samples (1 μL) were injected in the split mode (1:40). Mass spectral condition was run in electron impact mode through a PerkinElmer turbo MS as follows: ionization energy 70 eV; scan rate 1.6 scans/s; interscan delayed 0.01 s; source temperature 250 °C; mass unit ranged from 30 to 650 m/z; solvent delayed 3 min. Mass spectra of the chromatographic peaks were compared by spectra in the Wiley NIST/EPA/NIH Mass Spectral Library 2005[19].

3. Results

The yields of 2.7% followed by 2.5% and 1.9% of hexane extract were recorded in L. obtusa, U. lactuca and S. tenerimum, respectively. Besides, yields of 0.8%, 3.6% and 4.2% of ethyl acetate extract were found in S. tenerimum, L. obtusa and U. lactuca. Moreover, the yields of chloroform extracts of U. lactuca, S. tenerimum and L. obtusa were 0.5%, 2.0% and 2.5%, whereas yields of methanol extract of S. tenerimum, L. obtusa and U. lactuca were 2.70%, 36.06% and 53.46%, respectively. Among all the extracts, the maximum yield was recorded in methanol extract of U. lactuca as 53.46% and the minimum yield was noticed in the same species as 0.5% in chloroform extract. Methanol extract showed the maximum yield for all the three species compared to
other solvent extracts. The yield of extract indicated the efficiency of solvent for extraction of different biochemical compounds.

### 3.1. Antifungal activity

For methanol extract, the maximum antifungal activity was showed by *U. lactuca* (36 mm), followed by *S. tenerrimum* (35 mm) against *A. niger* at 200 µL, but at the same concentration, the minimum zone of inhibition was observed in *P. janthinellum* by *L. obtusa* (17 mm) followed by *U. lactuca* (21 mm) (Table 1). The ethyl acetate extract of *S. tenerrimum* at 200 µL exhibited highest activity (20 mm) against *P. janthinellum* followed by *L. obtusa* (17 mm), while at 200 µL, the minimum zones of inhibition 11 mm and 14 mm were measured in *U. lactuca* and *L. obtusa* against *A. niger* (Table 2). Moreover, the chloroform extract of *S. tenerrimum* showed the highest activity (30 mm) against *P. janthinellum* at 200 µL, and the lowest activity at the same concentration was observed in *U. lactuca* (10 mm) against *A. niger* (Table 3). On the other hand, the hexane extract of *U. lactuca* showed the maximum activity (15 mm) against *A. niger* at 200 µL, while at the same concentration, the minimum activity (12 mm) against *P. janthinellum* was showed by *L. obtusa* (Table 4). The inhibition zone was increased with increase in amount of extract. All the extract showed the maximum activity at 200 µL. Chloroform and hexane extracts did not show much more significant antifungal activity.

#### Table 1

| Zone of inhibition by methanol extract of three tested seaweeds. mm. |
|-----------------|---------------------------------|-----------------|-----------------|
|                  | *A. niger*                      | *P. janthinellum* |
|                  | 50 µL  100 µL  200 µL           | 50 µL  100 µL  200 µL |
| U. lactuca       | 15   20   36                   | 13   19   21     |
| S. tenerrimum    | 19   23   35                   | 13   15   25     |
| L. obtusa        | 18   20   25                   | 13   14   17     |
| NA: Not appeared.|

#### Table 2

| Zone of inhibition by ethyl acetate extract of three tested seaweeds. mm. |
|-----------------|---------------------------------|-----------------|-----------------|
|                  | *A. niger*                      | *P. janthinellum* |
|                  | 50 µL  100 µL  200 µL           | 50 µL  100 µL  200 µL |
| U. lactuca       | NA    10   11                   | 11   13   15     |
| S. tenerrimum    | 11    12   15                   | 10   17   20     |
| L. obtusa        | 11    13   14                   | 11   13   17     |
| NA: Not appeared.|

#### Table 3

| Zone of inhibition by chloroform extract of three tested seaweeds. mm. |
|-----------------|---------------------------------|-----------------|-----------------|
|                  | *A. niger*                      | *P. janthinellum* |
|                  | 50 µL  100 µL  200 µL           | 50 µL  100 µL  200 µL |
| U. lactuca       | 9     9    10                   | 11   NA   NA     |
| S. tenerrimum    | 11    NA   12                   | 15   17   30     |
| L. obtusa        | 10    12   18                   | 10   12   13     |
| NA: Not appeared.|

#### Table 4

| Zone of inhibition by hexane extract of three tested seaweeds. mm. |
|-----------------|---------------------------------|-----------------|-----------------|
|                  | *A. niger*                      | *P. janthinellum* |
|                  | 50 µL  100 µL  200 µL           | 50 µL  100 µL  200 µL |
| U. lactuca       | 8     13   15                   | NA   NA   NA     |
| S. tenerrimum    | 9     10   13                   | NA   10   13     |
| L. obtusa        | NA    NA   NA                   | NA   9    12     |
| NA: Not appeared.|

The standard fungicides fluconazole, ketoconazole and amphotericin B showed inhibition zone of 10, 17 and 18 mm against *A. niger* and inhibition zone of 12, 20 and 19 mm against *P. janthinellum*, respectively. There was no inhibition zone showed by the control against *A. niger* or *P. janthinellum*. The present investigation revealed that methanol extract was the most active fraction against both of the tested fungi *A. niger* and *P. janthinellum*. Considering the sensitivity of the microorganisms, it was noted that *P. janthinellum* was more sensitive to different extracts than *A. niger*. However, results revealed that all of the tested extracts showed higher antifungal effects at higher concentration than the standards fluconazole, ketoconazole and amphotericin B.

### 3.2. GC-MS analysis

GC-MS analysis of the crude extracts of three seaweed species was carried out in order to investigate the presence of bioactive compounds, which might be responsible for antifungal potency (Tables 5–8). The results showed that methanol and ethyl acetate extract contained important bioactive compounds mainly steroids, fatty acids and esters of fatty acids. In addition, some high molecular weight hydrocarbons like cyclohexane, 1,2-benzendicarboxylic acid, hexane, dodecane and octane were observed (Tables 5–8).

#### Table 5

| Composition of methanol extract of selected seaweed species. |
|---------------------------------|-----------------|-----------------|-----------------|
| Species                  | Compound name                        | RT (min) | Area (%) | Molecular weight (g/mol) |
|-----------------|---------------------------------|-----------------|-----------------|-----------------|
| U. lactuca      | Palmitic acid                      | 18.12         | 48.79         | 256.42          |
|                 | Squalene                          | 25.27         | 2.07          | 410.71          |
| S. tenerrimum   | Myristic acid                      | 15.58         | 2.77          | 228.37          |
|                 | Methyl palmitate                   | 17.73         | 37.38         | 270.45          |
|                 | Stearic acid methyl ester          | 19.25         | 3.47          | 298.50          |
|                 | Methyl oleate                      | 19.42         | 19.95         | 296.48          |
| L. obtusa       | Arachidonic acid                   | 20.89         | 3.85          | 304.46          |
|                 | Erucic acid methyl ester           | 22.84         | 1.32          | 352.59          |
|                 | Arachidonic acid methyl ester      | 20.84         | 7.25          | 318.50          |
|                 | Stigmasterol                       | 32.94         | 4.59          | 412.69          |
|                 | 15-hydroxyprogesterone             | 36.16         | 1.63          | 330.46          |
|                 | Squalene                          | 25.27         | 10.52         | 410.71          |
|                 | Tetradecanol                       | 16.63         | 2.36          | 214.39          |
|                 | Palmitic acid methyl ester         | 17.70         | 8.55          | 270.45          |
|                 | DTB                               | 17.78         | 4.82          | 206.32          |
|                 | Palmitic acid                      | 18.10         | 15.70         | 256.42          |
|                 | Beta sitosterol                    | 29.15         | 5.16          | 414.70          |

DTB: 2,6-Di-tert-butylphenol (antioxidant and UV stabilizer). RT: Retention time.

The chloroform extract showed only two fatty acids like palmitic and stearic acid with hydrocarbons like dibutyle phthalate, 1,2 benzendicarboxylic acid and squalene (precursor of sterol) (Table 7) while hexane extract contained palmitic acid, stigmasterol and some hydrocarbons (Table 8). 2,6-Di-tert-butyphenol (antioxidant and UV stabilizer) and 15-hydroxyprogesterone were detected only from methanol extract of *L. obtusa* and *S. tenerrimum* respectively. Fatty acids like palmitic acid (saturated fatty acid), myristic acid (saturated fatty acid), arachidonic acid (essential polyunsaturated
omega 6 fatty acid), stearic acid (saturated fatty acid), erucic acid (mono unsaturated omega 9 fatty acid), oleic acid and linolenic acids (omega 3 fatty acid) were recorded from GC-MS analysis of different extracts; while different sterols were also detected, such as stigmasterol, 15-hydroxyprogesterone, beta sitosterol and fucosterol. In terms of peak area, palmitic acid was detected as a major compound in all the studied species. Moreover, palmitic acid, methyl oleate, stearic acid methyl ester, stigmasterol, arachidonic acid methyl ester, squalene, beta sitosterol, 2,6-Di-tert-butylphenol and tetradecanol were recorded as major compounds in methanol extract in terms of peak area (Table 5).

### Table 6
Composition of ethyl acetate extract of selected seaweed species.

| Species       | Compound name          | RT (min) | Area (%) | Molecular weight (g/mol) |
|---------------|------------------------|----------|----------|--------------------------|
| *U. lactuca*  | Cyclohexane            | 18.76    | 8.79     | 84.16                    |
|               | 1,2-benzendicarboxylic acid | 19.08 | 1.20     | 166.13                   |
|               | Oleic acid methyl ester | 21.01    | 2.40     | 296.50                   |
|               | Stearic acid           | 21.49    | 0.40     | 284.47                   |
|               | Erucic acid            | 23.47    | 0.59     | 338.57                   |
|               | Squalene               | 26.84    | 0.83     | 410.71                   |
|               | Stigmasterol           | 34.74    | 4.42     | 412.69                   |
| *S. tenerrimum* | Fucosterol            | 32.87    | 12.29    | 412.69                   |
|               | Oleic acid             | 19.81    | 6.83     | 282.46                   |
|               | Stearic acid           | 19.99    | 1.36     | 284.47                   |
|               | Linolenic acid         | 21.26    | 0.73     | 278.43                   |
| *L. obtusa*   | Squalene               | 25.28    | 0.83     | 410.71                   |
|               | Myristic acid          | 16.07    | 2.39     | 228.37                   |
|               | Palmitic acid          | 18.23    | 36.42    | 256.42                   |
|               | Palmitic acid methyl ester | 19.61 | 1.18     | 256.42                   |
|               | Squalene               | 26.66    | 0.51     | 284.47                   |
|               | Beta-sitosterol        | 29.13    | 1.54     | 414.70                   |

RT: Retention time.

### Table 7
Composition of chloroform extract of selected seaweed species.

| Species       | Compound name          | RT (min) | Area (%) | Molecular weight (g/mol) |
|---------------|------------------------|----------|----------|--------------------------|
| *U. lactuca*  | Dibutyle pthalate      | 18.61    | 1.45     | 278.34                   |
|               | 1,2-benzendicarboxylic acid | 19.09 | 1.20     | 166.13                   |
|               | Oleic acid methyl ester | 21.01    | 2.40     | 296.50                   |
|               | Stearic acid           | 21.49    | 0.40     | 284.47                   |
|               | Erucic acid            | 23.47    | 0.59     | 338.57                   |
|               | Squalene               | 26.84    | 0.83     | 410.71                   |
|               | Stigmasterol           | 34.74    | 4.42     | 412.69                   |
| *S. tenerrimum* | Fucosterol            | 32.87    | 12.29    | 412.69                   |
|               | Oleic acid             | 19.81    | 6.83     | 282.46                   |
|               | Stearic acid           | 19.99    | 1.36     | 284.47                   |
|               | Linolenic acid         | 21.26    | 0.73     | 278.43                   |
| *L. obtusa*   | Squalene               | 25.28    | 0.83     | 410.71                   |
|               | Myristic acid          | 16.07    | 2.39     | 228.37                   |
|               | Palmitic acid          | 18.23    | 36.42    | 256.42                   |
|               | Palmitic acid methyl ester | 19.61 | 1.18     | 256.42                   |
|               | Squalene               | 26.66    | 0.51     | 284.47                   |
|               | Beta-sitosterol        | 29.13    | 1.54     | 414.70                   |

RT: Retention time.

### Table 8
Composition of hexane extract of selected seaweed species.

| Species       | Compound name          | RT (min) | Area (%) | Molecular weight (g/mol) |
|---------------|------------------------|----------|----------|--------------------------|
| *U. lactuca*  | Hexane                 | 24.29    | 0.50     | 168.00                   |
|               | Octane                 | 26.66    | 8.36     | 242.00                   |
|               | Cyclohexylamine        | 36.82    | 9.94     | 141.00                   |
| *S. tenerrimum* | Palmitic acid       | 19.61    | 0.82     | 256.42                   |
|               | Stigmasterol           | 34.30    | 8.57     | 412.69                   |
| *L. obtusa*   | Dodecane               | 40.09    | 4.71     | 226.00                   |
|               | Cyclohexylamine        | 36.78    | 6.44     | 141.00                   |

RT: Retention time.

### 4. Discussion

Plant substances continue to serve as important source of drugs for the world population and several plant-based drugs are in clinical use. The metabolic and physiological capacity of marine organisms allows them to survive in complex habitat types and provides a great potential for production of secondary metabolites which are not found in terrestrial environments. Thus, marine algae are among the richest sources of known and novel bioactive compounds.[20]

In the present study, the highest extraction yield was recorded for the methanol extract of *U. lactuca* (53.46%); whereas the lowest yield was also recorded in chloroform extract of the same species (0.5%). As compared to the results of the present study, Wang et al.[21] showed considerable variations in extraction yield among different seaweed species such as green, red and brown algae. From the studied seaweed species, the extraction yields of methanol extracts were higher than those of other solvent extracts with decrease in polarity which indicated that most of the soluble components in seaweeds were high in polarity. Herrero et al.[22] also reported that the polarity of solvents significantly affects the extract yield of *Spirulina* microalgae wherein the highest yield was recorded in ethanol extract as compared with other higher and lower polarity solvents extracts. The application of serial exhaustive extractions involves successive extraction with solvents of increasing polarity from non polar to a more polar solvent in order to ensure that a wide polarity range of compounds could be extracted. Green[23] has successfully applied terrestrial plants, and it is worth investigating the case of seaweed extracts. Rajauria et al.[24] noticed that extraction by using 60% aqueous methanol for *Himanthalia elongata* produced a much higher yield (6.8%) as compared to extraction by 100% methanol (1.2%).

The results from the present research revealed that the strongest antifungal activity was exhibited by the methanol extract and the least by the chloroform and hexane extract. Stronger antifungal activity was found in methanol extract of *U. lactuca* compared to other extracts suggesting that a particular solvent is required for extracting antimicrobial substances within the seaweeds. Manilal et al.[25] and Rangaiah et al.[26] reported that methanol extract exhibited higher antimicrobial activity than n-hexane and ethyl acetate extracts, which is in close to our results. This variation in the results may be due to difference in species used, time and place of sample collection. It is worthy to mention that using solvents such as chloroform and hexane, inhibitory activity was not observed clearly in the same species. This result could be related to the presence of bioactive metabolites in this species of algae, which are not soluble in one solvent but might be soluble in the other one. Karthikaidevi et al.[27] obtained the similar results and suggested
that a particular solvent is required to extract some antimicrobial substances within the algae, and therefore the inhibitory activity will increase when several solvents are used in the extraction.

The antifungal effects of extracts were comparable to the standard antifungal agent: fluconazole, ketoconazole and amphotericin B, and were found to be active against both the fungal strain tested. In the present investigation, it was observed that the maximum inhibition zone was found in polar solvent extracts like methanol, ethyl acetate and chloroform extracts. Thinakaran and Sivakumar[28] recorded that fungal mycelial growth was strongly inhibited by methanol and ethyl acetate extracts, which is in agreement with the present investigation. Salem et al.[29] also reported that ethyl acetate was the best solvent for isolation of antimicrobial compounds from the tested marine algae followed by methanol. The steroids, fatty acids, esters of fatty acids and other hydrocarbons were recorded in polar solvents like methanol and ethyl acetate rather than less polar solvent like hexane. This indicates that polarity of the solvent is associated with extraction of important compounds that are responsible for antifungal activity. Previous reports on the most effective solvent for the extraction of antimicrobials have various results. González del Val et al.[30] selected methanol as solvent for extraction of antimicrobial compounds for red, green and brown seaweeds. Shanmughapriya et al.[31] found methanol: toluene (3:1) as the best solvent for extracting antimicrobials from fresh algae. The same author also reported that ethanolic extracts had no antibacterial activity. Whereas, Khallil et al.[32] reported that chloroform, ethanol and cyclohexane extracts had antifungal potential; whereas acetone and ethyl acetate extracts exhibited the lowest antifungal activity, which is in contrast with the present study. Their study also revealed that the tested fungi exhibited variable responses to the tested seaweed extracts depending upon the applied solvent, tested seaweed and fungal species.

Plaza et al.[33] also identified several volatile compounds in ethanol extracts of brown seaweeds Himantalia elongata. The compounds include fatty acids, alkanes, phenols and compounds such as phytol (2-hexadecen-1-ol, 3,7,11,15-tetramethyl) and neophytadiene. The compounds 1,2-benzene dicarboxylic acid, bis-(2-ethylhexyl) ester and fatty acids have been evaluated against many microbes as antimicrobials agents[34,35]. Lauric, palmitic, linolenic, oleic, stearic and myristic acids are known to be potential antibacterial and antifungal agents[36,37]. Similarly in the present study, these compounds were found in methanol and ethyl acetate extract of all the three species. Antimicrobial activity has usually been attributed to long-chain unsaturated fatty acids (C16-C20), including palmitoleic, oleic, linoleic and linolenic acids, while long chain saturated fatty acids, including palmitic and stearic acids were less effective[38]. Steroid may serve as an intermediate for the biosynthesis of downstream secondary natural products and it is believed to be a biosynthetic precursor for cardenolides in plants. Marine algae have been shown to be good source of unsaponifiable, nontoxic sterols that have medicinal value[39,40]. In the present study palmitic acid (saturated fatty acid), myristic acid (saturated fatty acid), arachidonic acid (essential polyunsaturated omega 6 fatty acid), stearic acid (saturated fatty acid), erucic acid (monounsaturated omega 9 fatty acid), oleic acid and linolenic acids (omega 3 fatty acid) were recorded and different sterols such as stigmasterol, 15-hydroxyprogesterone, beta sitosterol and fucosterol were also found in methanol and ethyl acetate extract which might be responsible for the highest antifungal activity in the present study. Further, detailed analysis is required to evaluate spectral composition, effectiveness and potential use of seaweed compounds for medicinal purposes.

Conflicts of interest statement

We declare that we have no conflict of interest.

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