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Contribution of biological activity of some secondary metabolites of two seaweeds against some pathogenic bacteria isolated from patients in hospitals of Thi-Qar Province

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***Abstract*---**Because of their ability to generate a variety of physiologically active metabolites, seaweeds play an important role in the creation of new products for medical and pharmaceutical research. They are being studied as potential targets in the search for novel antibiotic compounds to combat antibiotic resistance. Furthermore, the use of natural antibiotics could meet customer desire for products that do not have pharmaceutical side effects. Our results showed antimicrobial activity of two algal species Focus vesiculosus and Macrocystis pyrifera against four human pathogenic bacteria by agar well diffusion method. Four concentrations of algal extract (25, 50, 75, and 100 mg/ml) were used. It was observed that aqueous extract of Focus vesiculosus was most effective against K. pneumonia with maximum inhibition zone of 17.50 mm at 75 mg/ml, while the minimum inhibition zone (6.66mm) was found in case of K. pneumonia at concentration 50 mg/ml. In the case of aqueous and ethanolic extracts of Macrocystis pyrifera, the inhibition zone was the highest (16.16 mm) against P. aeruginosa at 50 mg/ml in aqueous extract, while the lowest inhibition zone (7.00 mm) was in case of Staphylococcus aureus at concentration 50 mg/ml. While pathogenic bacteria were inhibited to variable degrees at doses less than 100 mg/ml, certain bacterial strains developed resistance to algal extracts at low concentrations. The chemical composition analysis of the two algal extracts revealed that the chemical composition analysis comprised of various organic components, according to the results of gas chromatography–mass spectrometry (GC-MS) analysis.

Keywords---antimicrobial, seaweeds, pathogenic bacteria, secondary metabolites.

Introduction

Algae are an important part of biodiversity, ecology and the aquatic environment. They are photosynthetic autotrophic eukaryotic organisms, generally aquatic. These organisms do not constitute a single phylogenetic group. They are distributed throughout the tree of life of eukaryotes and thus form a polyphyletic group. The majority of the identified algae are unicellular and compose the phytoplankton at the base of the food chains of marine, fresh and brackish waters. The groups of Euglenophytes, Cryptophytes, Haptophytes, Glaucophytes and Dinoflagellates have only unicellular algal species. On the other hand, the groups of Stramenopiles, Rhodophytes and Chlorophytes are composed of both unicellular and multicellular species and multicellular species, both simple and complex. In this manuscript, we will be interested in only complex multicellular algae, i.e. macro-algae.

The macro-algae also form a polyphyletic group. They are divided into three major lineages: green algae (Chlorophytes), red algae (Rhodophytes) and brown algae (Phaeophyceae). These last three are with the animals, the fungi and the green fungi and green plants, the only major groups of Eukaryotes made up of complex multicellular organisms. The acquisition of complex multicellularity was achieved independently. Chlorophytes and Rhodophytes belong like land plants to the like terrestrial plants to the phylum Archaeplastida while brown algae belong to the phylum Stramenopiles or Heterokonta (Baldauf, 2008). This phylum emerged more than a billion years ago from a unicellular eukaryotic ancestor common to all known eukaryotic lineages (Yoon et al., 2004) and which also contains oomycetes and diatoms (Baldauf, 2008). The different characteristics of this group have been acquired during several endosymbiotic events.

Laminaran and mannitol content vary considerably according to algal species, age and part of the thallus, and seasons. Meanwhile, the extraction of these reserve polysaccharides is usually with acid solution (Rioux and Turgeon, 2015). Laminaran has been reported to possess various biological activities. Laminarin of A. nodosum and L. hyperborean demonstrated an antioxidant and antibacterial activities (Kadam et al., 2015). Antiviral, anticoagulant, and antiproliferative activities were also reported from the laminaran (Devillé et al., 2007). As for mannitol, the bioactivity reported was its efficacy in protecting the photosynthetic apparatus from low salinity damage (Lobban and Harrison, 1997).

Among the bioactive compound contained in marine algae, polysaccharides and polyphenols are the two most studied especially related to their biological activity. Brown Algae are one of marine algae group well-known for their strong antioxidant pro perty shown by this compound. However, other studies have also stated that this compound has a vast array of potential as antimicrobial, anticancer, antihypertensive, antidiabetic, antiallergic, etc (Wijesinghe and Jeon, 2012). Strong correlation between the total phenolic content and antioxidant activity in brown Algae has been reported by many previous studies (Wang et al.,

2009; Eom et al., 2011; Namvar et al., 2013). In general, the antioxidant properties work by inhibiting the initiation or propagation reactions by inactivating or scavenging free radicals. Therefore, it restrains or inhibits completely the lipid oxidation (Gupta and Abu-Ghannam, 2013).
The present study was an attempt to Study the biological effects of the extracted chemical compounds by used aqueous and ethanoic as a solvent from tow marine algae Focus vesiculosus and Macrocystis pyrifera.

Materials and Methods

Patients and methods

A 100 swab samples were collected from patients at Al-Imam Al-Hussein Teaching Hospital and Special Clinics in Thi-Qar province\ Southern of Iraq, during the period from 15 October 2021 to 15 March 2022, the patients age range from 1.5 to 70 years from both gender. Swabs taken from patients are transported directly to the laboratory by conveyors.

Culturing of samples

Selected samples were labelled and cultivated on blood agar and MacConkey agar for swab grown on MacConkey agar only incubated overnight at 37C in an incubator in aerobic and anaerobic conditions. For *K. pneumonia* suspected from swab sample make subculture on blood agar and MacConkey agar. *Proteus mirabilis* grows on the blood agar plate in successive waves to form a thin filmy layer of concentric circles swarming; *P. mirabilis* does not swarm in the MacConkey agar medium and form smooth, pale or colourless colonies. The colonies of *P. aeruginosa* are colourless due to the lack of lactose fermentation which is of great importance in differentiating *P. aeruginosa* from other bacteria present in the specimen, especially from gram-positive bacteria, *S. aurous* on blood agar, growth occurs abundantly within 18 to 24 hours. Round, raised, opaque, yellow to golden yellow colonies of 1-2mm in diameter are seen with or without beta hemolysis. As explained in Frol and Iurp, (2012), by taking D.W. by loop full and a single colony from culture was taken by a loop placed on a clean slide and spread, then wait to dry and to fix by heat, staining by gram stains and examined the bacterial cell under the microscope (oil immersion).

Analytical profile index

The API-20 system was used to diagnose isolated bacteria *S. aureus* and Enterobacteriaceae, and this system consists of a container bar containing 20 biochemical reactions distributed in single microtubes.

Preparation of extracts

Twenty grams of dried powder of *Focus vesiculosus* and *Macrocystis pyrifera*. previously prepared in the college of science was extracted once with 200 ml of aqoeous, and other with 200 ml of ethanol and by Soxhlet continuous extraction; the solution was filtered by using Whatman No.13 filter paper then the filtrate

was concentrated under reduced pressure on a rotary evaporator at 50°C and dried at 25°C, the extract were collecting in sterilized glass tubes until use.

Results

Isolation and identification of pathogenic bacteria

The results of the current study indicated that 63% had growth for pathogenic bacteria, while 37% were negative growth. The study results indicated that the most frequently infecting bacteria isolated from patients was *P. aeruginosa* 36.4%, which was followed by *E. coli* and *S. aureus* 18.6%. On the contrary, the minimum infecting bacteria isolated were Enterococcus 6.9%. In a further four reports there was a combined infection of *S. aureus* and *E. coli* (4.8%), *P. mirabillis* and *E. coli* (2.8%), and *K. pneumonia* and *E. coli* (1.8%), as shown in Figure 1.

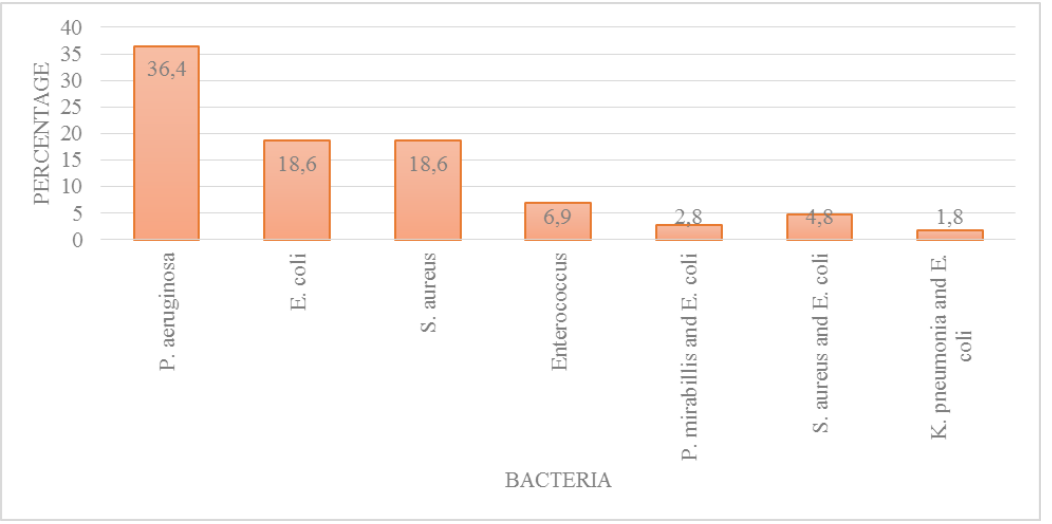

Figure 1. Percentage Identification of pathogenic bacteria

Organic compounds extract from focus vesiculosus by ethanol extract

The chemical analysis showed the presence of four different chemical compounds, depending on the retention time, as shown in Table 1. The highest percentage was recorded for the compound (2-Pyridiyl) methyl Pyridine-1,3-dicarboxylate and was 47.90, while the lowest percentage was for the compound Erucylamide and with a percentage of 7.82 as in Table 1.

Table 1
Chemical compounds in aqueous Extract of *Focus vesiculosus* by GC-MS

No	RT (min)	Area (Ab*s)	Area%	Name
1	34.767	6332125	10.63	m-Nitrophthalic acid
2	37.185	20052475	33.65	Bis(2-ethylhexyl) isophthalate
3	37.642	4656787	7.82	Erucylamide

4	43.043	28543436	47.90	(2-Pyridiyl)methyl Pyridine-1,3-dicarboxylate

Organic Compounds Extract from Focus vesiculosus by aqueous Extract

The organic compounds were extracted from *F. vesiculosus* using GC-Mass technology, and the results showed as in the table 2 that the ethanol extract contained ten organic compounds, each of which took a specific distance within the time of retention, and the organic compounds with the greatest effectiveness on the isolated bacteria were those with the greatest distance from other organic compounds. The highest percentage was recorded for the compound Ethyl iso-allocholate and was 85.03, while the lowest percentage was for the compound Dodecamethylcyclohexasiloxane and with a percentage of 0.37 as in table 2.

Table 2
Chemical compounds in aqoueus Extract of *Focus vesiculosus* by GC-MS

No	RT (min)	Area%	Name
1	14.443	0.37	Dodecamethylcyclohexasiloxane
2	18.065	0.56	6-methylthio[1]benzothieno[2,3-c]quinoline
3	20.094	1.83	Guaiol
4	21.422	0.59	Bulnesol
5	21.749	0.82	(-)-anymol
6	24.131	0.98	Isopropyl Myristate
7	25.832	0.66	Methyl palmitate
8	34.778	2.38	Isooctyl phthalate
9	37.19	6.78	3-Octene, (E)-
10	42.41	85.03	Ethyl iso-allocholate

Organic compounds extract from macrocystis pyrifera by ethanol extract

Depending on the retention time, the chemical analysis revealed the existence of tewenty different chemical compounds, as indicated in Table 3. The product Mannitol had the maximum percentage of 56.00, while the compound Tetracosamethyl-cyclododecasiloxane had the lowest percentage of 0.65, as shown in Table 3.

Table 3
Chemical compounds in ethanolic Extract of *Macrocystis pyrifera* by GC-MS

No	RT (min)	Area%	Name
1	6.032	1.40	1-Methoxy-5-trimethylsilyloxyhexane
2	12.451	1.73	Silane, trimethyl[(1-methylundecyl)oxy]-
3	15.081	1.39	4-Pyranone, 2,3-dihydro-
4	17.271	0.77	Heptanoic acid, 6-oxo-, trimethylsilyl ester
5	17.577	1.03	1-Methyl-1-n-pentyloxy-1-silacyclobutane
6	17.961	9.56	d-Allose
7	20.083	3.28	D-glycero-D-gulo-Heptonic acid, .delta.-lactone
8	21.349	0.65	Tetracosamethyl-cyclododecasiloxane
9	23.196	0.97	Benzyl benzoate

10	26.88	56.00	Mannitol
11	31.415	0.78	Tricosane
12	32.785	1.20	Tetracosane
13	34.103	1.50	Pentacosane
14	34.762	6.30	m-Nitrophthalic acid
15	35.369	2.01	Eicosane
16	36.588	2.47	Heptacosane
17	37.18	5.28	Di-2-ethylhexyl isophthalate
18	37.766	1.25	Eicosane
19	38.145	0.73	p-Menth-8(10)-en-9-ol, cis-
20	38.908	1.09	Oleic acid, 3-(octadecyloxy)propyl ester

Organic compounds extract from macrocystis pyrifera by aqueous extract

The results indicated the presence of three types of chemical compounds in the aqueous extract of mycorrhizal algae, which have an almost overlapping effect on bacterial growth inhibition, as shown in Table 4. The highest percentage was recorded for the compound Trilinolein and was 97.40, while the lowest percentage was for the compound Bis (2-ethylhexyl) phthalate and with a percentage of 1.24 as in table 4.

Table 4
Chemical compounds in aqoueus Extract of *Macrocystis pyrifera* by GC-MS

No	RT (min)	Area (Ab*s)	Area%	Name
1	34.772	2356992	1.24	Bis(2-ethylhexyl) phthalate
2	37.19	2606123	1.37	Bis(2-ethylhexyl) terephthalate
3	45.051	185649692	97.40	Trilinolein

Activity of algal extracts

The antibacterial activity of aqueous and ethanol extracts of *F.vesiculosus and M. pyrifera* were investigated using inhibition zone method against selected human pathogens such as *Staphylococcus aureus, Pseudomonas aeruginosa , Proteus mirabilis and Klebsiella pneumonia* (Tables 5). The activity of the aqueous and ethanolic extract (25, 50,75 and 100 µg /µl) of both marine algae were tested against four bacteria (*Pseudomonas aeruginosa , Proteus mirabilis* and *Klebsiella pneumonia*) Gram-negative bacteria and (*Staphylococcus aureus*) gram positive bacteria. The evaluation of the antibacterial activity of the tested extract is based on the measurement of the zone of bacterial growth inhibition. The results of the antibacterial tests against aqueous and ethanol extracts of the two algae show a growth inhibition in different level. The zone of inhibition was observed on the petri dishes with both extracts (aqueous and ethanolic). However, both the extracts of two algae had an antibacterial effect against these four bacteria. The results of the antibacterial tests show that the extract of *F.vesiculosus* and *M. pyrifera* has an antibacterial activity. This activity is revealed against Gram-negative bacteria (*Pseudomonas aeruginosa, Proteus mirabilis and Klebsiella pneumonia*) and Gram-positive bacteria (*Staphylococcus aureus*). On the other hand, the activity was about low, intermediate and high according to zone inhibition (Table 5).

Against *S. aureus*, the total aqueous extract of *F.vesiculosus* showed high activity in all four concentration (25%, 50%, 75% and 100%), The aqueous extract of *F.vesiculosus* has an inhibitory activity greater than 15 mm in diameter against *S. aureus* while the extract extracted with ethanol of *M. pyrifera* showed a low activity. The extract with ethanol of *F.vesiculosus* showed a low inhibitory action, the inhibition diameter obtained was less than 10 mm. The aqueous extract of *M. pyrifera* has an inhibitory activity arrange between 10 to 15 mm in diameter against *S. aureus*.

The highest inhibition value against *S. aureus* with aqueous extract of *F.vesiculosus* was 18.840mm it was in 100% concentration. While the lowest inhibition value with ethanol extract of M. pyrifera, it was 7.000mm in 25% concentration (Table 5). According to the results obtained in Table 5, it is clear to us that the 100% concentration of the aqueous and ethanol extract of the two algae was more effective in inhibiting the bacteria *S. aureus* than the rest of the concentrations used. *P. aeruginosa*, which is also a Gram-negative bacterium, showed low resistance to the ethanol extracts of *M. pyrifera* alga. While interesting activity was observed for the total extract and the extract prepared in aqueous and ethanol for *F.vesiculosus* and aqueous extract of *M. pyrifera* (Table 5). Based on the results presented in Table 5 the extract of the algae *F.vesiculosus and M. pyrifera* shows a low zone of inhibition (less than 10mm) against *P. mirabillis and K. pneumoniain* the presence of aqueous and ethanolic extracts. This result indicates a moderate sensitivity of these bacteria to the extract. From the results reported in Table 5 it can be seen that the aqueous extract of *F.vesiculosus* presents higher than 15mm of inhibition zone against the *S. aureus P. aeruginosa* strains in all concentrations uses, on the other hand the ethanolic extract of the same alga has a considerable antibacterial effect against the *P. aeruginosa and K. pneumonia* strain in 75% and 100% concentrations.

Table 5
Diameter of inhibition obtained for the different extracts of F.vesiculosus and M. pyrifera against different used strains (Mean ± SD)

Algal extracts	*F.vesiculosus*		t test	*M. pyrifera*		t test
	aqueous	ethanol		aqueous	ethanol	
Bacteria	Concentration 100% (A)		p. value	Concentration 100% (A)		p. value
S. aureus	15.80 ± 1.10^{c}	9.266 ± 0.75^{b}	< 0.01	12.33 ± 0.75^{bc}	8.833 ± 1.07^{b}	0.010
P. aeruginosa	17.20 ± 1.61^{c}	17.13 ± 1.70^{d}	0.945	13.53 ± 0.98^{cb}	8.633 ± 0.83^{b}	0.030
P. mirabillis	13.06 ± 1.00^{b}	13.33 ± 0.75^{c}	0.732	11.50 ± 0.43^{b}	12.00 ± 1.05^{c}	0.491
K. pneumonia	15.50 ± 0.88^{c}	16.63 ± 0.73^{d}	0.164	14.20 ± 1.56^{d}	13.16 ± 0.86^{c}	0.373
Control	0.000 ± 0.00^{a}	0.000 ± 0.00^{a}		0.000 ± 0.00^{a}	0.000 ± 0.00^{a}	
LSD	1.92	1.74		1.66	1.56	
Bacteria	Concentration 75% (B)		p. value	Concentration 75% (B)		p. value

S. aureus	16.33 ± 0.47^{c}	8.866 ± 1.36^{b}	< 0.01	8.333 ± 0.87^{b}	7.333 ± 0.87^{b}	0.234
P. aeruginosa	16.20 ± 0.81^{c}	14.16 ± 1.67^{c}	0.132	8.333 ± 1.05^{b}	13.16 ± 0.20^{e}	< 0.01
P. mirabillis	12.66 ± 1.25^{b}	13.66 ± 0.61^{c}	0.158	8.333 ± 0.58^{b}	8.000 ± 0.10^{c}	0.386
K. pneumonia	17.50 ± 2.16^{c}	13.86 ± 1.76^{c}	0.087	13.50 ± 0.95^{c}	12.33 ± 0.20^{d}	0.107
Control	0.000 ± 0.00^{a}	0.000 ± 0.00^{a}		0.000 ± 0.00^{a}	0.000 ± 0.00^{a}	
LSD	2.17	2.32		1.44	0.75	
Bacteria	Concentration 50% (C)		p. value	Concentration 50% (C)		p. value
S. aureus	15.50 ± 1.24^{c}	7.667 ± 1.10^{b}	< 0.01	8.666 ± 0.70^{b}	7.000 ± 0.51^{b}	0.030
P. aeruginosa	15.66 ± 0.80^{c}	12.66 ± 0.37^{c}	< 0.01	16.16 ± 1.05^{c}	8.066 ± 1.25^{bc}	< 0.01
P. mirabillis	7.333 ± 0.95^{b}	7.000 ± 1.12^{b}	0.715	7.333 ± 0.87^{b}	8.500 ± 0.85^{c}	0.174
K. pneumonia	7.833 ± 1.06^{b}	6.667 ± 0.55^{b}	0.168	8.000 ± 1.35^{b}	8.500 ± 0.17^{c}	0.560
Control	0.000 ± 0.00^{a}	0.000 ± 0.00^{a}		0.000 ± 0.00^{a}	0.000 ± 0.00^{a}	
LSD	1.67	1.39		1.66	1.31	
Bacteria	Concentration 25% (D)		p. value	Concentration 25% (D)		p. value
S. aureus	15.50 ± 0.70^{c}	13.16 ± 0.86^{c}	0.022	8.666 ± 0.70^{b}	7.500 ± 0.69^{b}	0.111
P. aeruginosa	15.66 ± 0.70^{c}	15.83 ± 0.45^{d}	0.749	11.50 ± 1.05^{c}	13.50 ± 0.45^{c}	0.039
P. mirabillis	8.500 ± 0.26^{b}	7.666 ± 0.92^{b}	0.209	7.833 ± 0.86^{b}	8.333 ± 0.83^{b}	0.511
K. pneumonia	8.500 ± 0.26^{b}	8.000 ± 1.35^{b}	0.564	8.666 ± 0.86^{b}	7.333 ± 0.87^{b}	0.113
Control	0.000 ± 0.00^{a}	0.000 ± 0.00^{a}		0.000 ± 0.00^{a}	0.000 ± 0.00^{a}	
LSD	0.86	1.55		1.43	1.19	

Every two averages in the above table have the same small letter, there is no significant difference between them, and every two different letters have a significant difference between them. The effectiveness of the extract increases with the introduction of letters as (a, b. c .etc.)

Discussion

The extraction of secondary compounds by used two types of solvents (aqueous and ethanol) were studied for extraction the crude extract of (*Focus vesiculosus* and *Macrocystis pyrifera*) by using Soxhlet method, allowed us to calculate the yield of the extract which is expressed as percentage per 100g of dry ground seaweed. The value obtained is higher than that of (Aleng *et al.*, 2009) who report

a low yield of dry extract of the same species, evaluated at 2.8% (ethanol extraction) and 0.17% (chloroform extraction). In this study, a probably higher dry yield value could have been obtained from the same algal species studied but collected in the winter period. This is confirmed by the study of (Ghezzen, 2014) who found after monitoring the evolution of the crude extract yield during a year a significantly lower decrease in the the evolution of the gross extract yield during one year, a significantly lower decrease in between January (11.235%) and April (5.696%) for the same species of red algae Cystoseira stricta.

According to Michel *et al* (2012), the yield of extractions with solvents of increasing polarity depends on the nature of the solvent used and the chemical properties of the molecules to be extracted. Similarly, the extraction method (maceration, decoction, infusion) also plays an important role in determining the yield as well as the chemical composition of the extracts prepared (Tefiani, 2015). However, because *P. mirabillis K. pneumonia* is known to have a high level of inherent resistance to a wide variety of antimicrobial and antibiotic drugs, it should be highlighted that it was the only organism that showed extremely low activity with the tested extracts (50 mg/ml). Twenty macroalgal extracts were investigated for resistance to this clinical pathogen that causes severe nosocomial infections (Christabell *et al.*, 2011). The extraordinarily limited permeability of the P. aeruginosa outer membrane barrier has been hypothesized as the fundamental mechanism of this natural multidrug resistance (Solórzano-Santos & Miranda-Novales, 2012).

It is difficult to compare these results with those in the literature because the use of different extraction methods reduces the possibility of comparison between studies (Trabelsi *et al.*, 2010). Recent studies have shown that the contents of phenolic compounds vary considerably from one species to another and within the same species, due to extrinsic (temperature, climate...), genetic (variety and species origin), physiological (degree of plant maturation, organs used) and storage time (Maisuthisakul *et al.*, 2007; Ksouri *et al.*, 2009). The results of the percentage inhibition of the chemical compounds free radical by the ethanolic crude extract of the both algae are shown in Table 5. These results are compared to the percent inhibition by a potent free radicals of chemical compounds used in this study. The values obtained for our species are not in agreement with these results. This may be due to the species effect, which may influence the antiradical activity (Djilali and kherouni, 2016).

The results of the antibacterial tests show that the *Focus vesiculosus* and *Macrocystis pyrifera* extract has antibacterial activity. This activity is revealed against (*Pseudomonas aeruginosa*, *Proteus mirabilis* and *Klebsiella pneumonia*) Gram-negative bacteria and (Staphylococcus aureus) gram-positive bacteria. (Table 5). *P. aeruginosa, S. aureus*, and *Enterococcus* were the most common bacteria responsible for bacteremia, pneumonia, burn infection, and sepsis infection in both the community and the hospital (Ma *et al.*, 2020). Prolonged hospital stays contamination of burns wards, the nature of the burn damage itself, as well as extensive diagnostic and therapeutic treatments, are all variables that affect the emergence of infection in burns patients (Esposito and Simone, 2017). The inhibition of the *Focus vesiculosus* and *Macrocystis pyrifera* extract remains considerably higher when compared to the commercial antibiotics used

as standards in this study (Erythromycin, Clidaamycin, Cephalothin, Vancomycin, Cefixime, Ceftazidime, Netilmicin and Clavulanic Acid) and results were indicated in (Tables 5). Depending on the extent of the zone of inhibition on the petri dish, our four bacterial strains can be classified into one of the following categories: Susceptible, Intermediate, or Resistant.

The antimicrobial activity induced by the two extracts, aqueous and ethanolic, of the *F. vesiculosus* and *M. pyrifera* indicates that the extraction process carried out allowed us to have natural substances with an inhibitory effect on the growth of *Pseudomonas aeruginosa, Proteus mirabilis, Klebsiella pneumonia and Staphylococcus aureus*). This result is in agreement with that obtained by other researcher (Moujahid *et al.*, 2014) highlighting the antimicrobial effect of *Ulva* on Gram positive (*Streptococcus pyodenes, Streptococcus pneumoniae*) and Gram-negative (*Escherichia coli*) bacterial strains. Because seaweeds are exposed to both light and high oxygen concentrations, their surroundings are hostile. Free radicals and other strong oxidizing agents can be formed because of these causes. Seaweeds, on the other hand, rarely suffer from substantial photodynamic damage during their metabolism. These findings suggest that seaweed cells have developed defense mechanisms and chemicals (Matsukawa *et al.*, 2007).

Natural compounds are important in the development of pharmaceuticals. Therefore, the search for new natural chemicals from algae could lead to new areas of pharmacological research. There have been many reports of biologically active chemicals isolated from algae, confirming their potential to create metabolites with a wide range of pharmacological and biological properties (Jeyaseelan *et al.*, 2012). Marine algae and plants have produced the most bioactive chemicals that have been studied extensively. There are about 15,000 natural products known. Algae appear to be a promising group for discovering novel biochemically active chemicals, according to research into medications derived from natural sources (Blunt *et al.*, 2005, Sire *et al.*, 2017). In the case of treatment of mutant strains of bacteria, many antibiotics are no longer effective. Trimethoprim and sulphamethoxazole, according to an evolutionary study of antimicrobial resistance after treatment with multiple antibiotics in *E. coli* (Sire *et al.,* 2017), can no longer be used as empirical therapies for community-acquired UTIs.

Conclusion

With its phytochemical composition, seaweed can be used as a resource of antibacterial agents. The ethanolic extracts of two algae *Focus vesiculosus* and *Macrocystis pyrifera* showed the most prominent effect against the tested gram-positive and gram-negative bacteria strains, while *Focus vesiculosus* extracts were more efficient against all tested pathogenic bacteria; This pathogenic suppression could be due to the chemical makeup of extracts containing manitol. However, such extracts could be a good alternative to antibiotics and could be used as effective therapeutic agents against pathogenic bacteria without causing any threat to health.

References

Esposito, S. and Simone, G. De. (2017). Update on the main MDR pathogens : prevalence and treatment options.

Baldauf, S. L., 2008. “An overview of the phylogeny and diversity of eukaryotes”. J Syst Evol, 46(3), 263-273

Matsukawa, R., Dubinsky, Z., Kishimoto, E., Masaki, K., Masuda, Y., Takeuchi, T., Chihara, M., Yamamoto, Y., Niki, E. and Karube, I. (2007) A Comparison of Screening Methods for Antioxidant Activity in Seaweeds. Journal of Applied Phycology, 9, 29-35.

Jeyaseelan, E.C., Kothai, S., Kavitha, R., Tharmila, S. and Thavaranjit, A.C. (2012) Antibacterial Activity of Some Selected Algae Present in the Costal Lines of Jaffna Peninsula. International Journal of Pharmaceutical & Biological Archives, 3, 352-356.

Blunt, J.W., Copp, B.R., Munro, M.H.G., Northcote, P.T. and Prinsep, M.R. (2005) Marine Natural Products. Natural Product Reports, 22, 15-61.

Sire, J., Nabeth, P., Perrier-Gros-Claude, J., Bahsoun, I., Siby, T., Macondo, E., Gaye-Diallo, A., Guyomard, S., Seck, A., Breurec, S. and Garin, B.T. (2017) Antimicrobial Resistance in Outpatient Escherichia coli Urinary Isolates in Dakar, Senegal. The Journal of Infection in Developing Countries, 1, 263-268.

Yoon, H. S., Hackett, J. D., Ciniglia, C., Pinto, G., & Bhattacharya, D., 2004. “A molecular timeline for the origin of photosynthetic eukaryotes”. Molecular biology and evolution, 21(5), 809-818.

Rioux, L.E., Turgeon, S.L. and Beaulieu, M. (2015) Structural Characterization of Laminaran and Galactofucan Extracted from the Brown Seaweed Saccharina longicruris. Phytochemistry, 71, 1586-1595.

Kadam, S.U., Tiwari, B.K., Smyth, T.J. and O’Donnell, C.P. 2015. Optimization of ultrasound assisted extraction of bioactive components from brown seaweed Ascophyllum nodosum using response surface methodology. Ultrasonics Sonochemistry 23: 308–316.

Devillé, C., Gharbi, M., Dandrifosse, G. and Peulen, O. 2007. Study on the effects of laminarin, a polysaccharide from seaweed, on gut characteristics. J Sci Food Agr 87: 1717–1725.

Lobban, C.C. and Harrison, P.J. 1997. Seaweed Ecology and Physiology. Cambridge University Press, Cambridge, UK, .

Wijesinghe, W.A.J.P. and Jeon, Y.J. 2012. Biological activities and potential industrial applications of fucose rich sulfated polysaccharides and fucoidans isolated from brown seaweeds: A review. Carbohydr Polym 88: 13–2.

Wang, T., Jónsdóttir, R. and Ólafsdóttir, G. 2009. Total phenolic compounds, radical scavenging and metal chelation of extracts from Icelandic seaweeds. Food Chem 116: 240–248.

Namvar, F., Mohamad, R., Baharara, J., Zafar-Balanejad, S., Fargahi, F. and Rahman, H.S. 2013. Antioxidant, antiproliferative, and antiangiogenesis effects of polyphenol-rich seaweed (Sargassum muticum). BioMed Res Int 2013.

Eom, S., Kang, Y., Park, J., Yu, D., Jeong, E., Lee, M. and Kim, Y. 2013. Enhancement of polyphenol content and antioxidant activity of brown alga Eisenia bicyclis extract by microbial fermentation. Fisheries and Aquatic 14: 192–197.

Gupta, S., Cox, S. and Abu-Ghannam, N. 2013. Effect of different drying temperatures on the moisture and phytochemical constituents of edible Irish brown seaweed. Food Sci Technol 44: 1266–1272.

Frol, R. I. V. and Iurp, V. (2012). Microbial Susceptibility, Virulance Factors, and Plasmid Profile of Uropathogenic Escherichia coli Strains Isolate from Children in Jahrom, Iran. Archives of Iranian Medicine Journal, 15(5), 312–316.

Alang G., Kaur R., Singh A., Budlakoti P., Singh A., Singla P., (2009). Antimicrobial activity of ulva lactuca extracts and its fractions, Asparagopsis armata (Bonnemaisoniales). Université De Bretagne Occidentale.

Michel T., Destandau E., Le Floch G., Lucchesi M.E., Elfakira C., (2012). Antimicrobial, antioxidant and phytochemical investigations of sea buckthorn (Hippophaë rhamnoides L.) leaf, stem, root and seed, Food Chemistry, 131(3). 754-760.

Trabelsi, K.; Touir, J.; Soulié-Märsche, I.; Martín-Closas, C.; Soussi, M.; Colin, J.P. Découverte des Charophytes de l'Albien Dans la Formation Kebar (Tunisie Centrale): Implications Paléoécologiques et Paléobiogéographiques. Ann. Paléontol. 2010, 96, 117–133.

Djilali, S ., kherouni, N., 2016. Etude comparative de l'activité antimicrobienne des extraits éthanolique et méthanolique d'algues marines. Mémoire de Fin de Cycle master en Biotechnologie Microbienne. Bejaia, Université Abderrahmane Mira, 31.

Ma, Y., Wang, C., Li, Y., Li, J., Wan, Q., Chen, J., Tay, F. R. and Niu, L. (2020). Considerations and Caveats in Combating ESKAPE Pathogens against Nosocomial Infections.

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