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Research Article

PROXIMATE COMPOSITION AND PHYSICOCHEMICAL PROPERTIES OF RED SEAWEED *HYPNEA VALENTIAE* (TURNUR) AND THEIR POTENTIAL OF ANTIOXIDANT ACTIVITIES

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ABSTRACT

The present study focused on proximate composition, moisture, ash, lipid, protein, carbohydrate, dietary fiber and physicochemical properties to determine the water holding capacity, oil holding capacity, and water swelling capacity of *H. valentiae* red seaweed. The antioxidant properties of methanol extract were performed by superoxide and nitric oxide radical scavenging activity. The superoxide scavenging radical (50-250 μg/mL) was an inhibition of 89.06 ± 0.44μg/mL which is significantly higher than the standard ascorbic acid 75.67 ± 0.20μg/mL. Nitric oxide assay observed that (15-100 μg/mL) exhibited the maximum nitric oxide scavenging was 87.22 ± 0.80μg/mL which is significantly higher than the standard ascorbic acid 74.35 ± 0.67μg/mL. The results were establishing the potential of the seaweed was exploited the nutritional value and pharmaceutical applications.

Keywords: Marine algae, *Hypneavalentiae*, proximate composition and Antioxidant activity.

INTRODUCTION

Seaweed is marine algae are saltwater living simple plants are red, brown and green algae depending on their biochemical composition and nutritional assessment (Lorenzo *et al*., 2017). Most algae have root-like structures known as holdfasts that anchor the plant rocks and other substrates. Seaweeds consumed in Asian countries are used as part of the daily diet. Nowadays seaweed species consumed that are classified based on brown 66.5%, red 33% and green 5% have the potential to provide dietary energy from carbohydrates in Asian countries (Charles and Alamsjah 2019). Food duality in red seaweed includes proximate, nutritional and anti-nutritional analysis. Seaweeds are an excellent nutritious food source because despite their low caloric content and presence of anti-nutritional compounds, they are abundant in necessary nutrients such as protein, essential amino acids, vitamins, minerals and some biochemical compounds non-nutrient components such as dietary fiber and polyphenols (Rosemary *et al*., 2019). Seaweed produced polyunsaturated fatty acids, antioxidant potentials such as phenolic acids and flavonoids, polysaccharides and proteins (Barba *et al*., 2015). Phenolic metabolites found in seaweeds known as phlorotannins which are polymers of phloroglucinol have been produced with strong antioxidant ability (Agregán *et al*., 2017).

Recently, these seaweed polysaccharides have drawn interest as various sources of dietary fibers and other soluble carbohydrates such as glucans, fucoidan, alginate laminarin, agar and carrageen an. The glucans and fucoidan are potential health benefits also including anti-inflammatory, antioxidant and antitumor properties. Agar and carrageen and are used as thickening, stabilizing agents which have potentially been used for pharmacological industries (Garcia-Vaquero *et al*., 2021;Agregán *et al*., 2017). The *Hypnea* species J. Agardh is distributed in

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tropical and subtropical seasons. Therefore, *Hypnea*is a large genus in which 60 species is currently accepted within the family Rhodophyceae. *Hypnea* is widely employed in food, feed, medicine and numerous bioactive compounds from these seaweed extracts have been tested for biological and physiological activities. The current research was conducted to the proximate composition and physicochemical parameters from red seaweed *H. valentiae*, and to extract the quantify their antioxidant activities in comparison to that standard ascorbic acid determined in vitro assays superoxide radical scavenging and nitric oxide radical activity.

MATERIALS AND METHODS

Collection and processing of seaweed

The red seaweed, *H. valentiae* (Turnur) was collected from Mandapam (Lat. 09o 28' 177 N, Long. 79o 18' 536 E) Southeast coastline of Ramanathapuram District, Tamil Nadu, India. The seaweed specimen identification number was 1759. The sample was properly cleaned with seawater to remove all undesired pollutants such as sand particles and epiphytes, and then thoroughly cleaned with tap water to discard all salt on the surface. The water was drained away, and the seaweed was laid out on blotting paper to absorb any remaining moisture before being shade dried at room temperature for 3 days and crushed into a fine powder (Palani *et al*., 2022).

Proximate analysis

The proximate composition of *H. valentiae* was determined by the method by (Matanjun *et al*., 2009). The moisture content was examined by using infrared techniques according to moisture at 120˚C moisture content was measured as a percentage by weight of the sample (Syad *et al*., 2013). The ash content was determined by heating at 525˚C overnight (Chan and Matanjun 2017). Lipid content was evaluated by the soxhlet equipment by gravimetric techniques according to a constant weight at 105˚C. The Kjeltec method determined the amount of protein content (Nx6.25) (Wong and Cheung 2000). The carbohydrate content (%) was evaluated by Bharathi *et al*., (2021). The content of total dietary fiber content (TDF), soluble dietary fiber content (SDF) and insoluble dietary fiber content (IDF) was determined by the enzymatic hydrolysis method (Rasyid, 2017).

Physicochemical properties

To various physical and functional analyses, such as, water holding capacity (WHC), oil holding capacity (OHC) and water is swelling capacity (WSC).

Water holding capacity (WHC)

Water holding capacity of the sample was determined based on previously described by the method (Chan and Matanjun 2017) with slightly modifications. The water holding capacity was evaluated to the Equations.

$$\text{(g/g)} = \frac{\text{fresh weight of sample(g) – dry weight of sample(g)}}{\text{dry weight of sample(g)}}$$

Oil holding capacity (OHC)

Oil holding capacity of the sample was estimated according to previously described by the method (Chan and Matanjun 2017)with slightly modifications. The oil holding capacity was evaluated to the Equations.

$$\text{(g/g)} = \frac{\text{fresh weight of sample(g) – dry weight of sample(g)}}{\text{dry weight of sample(g)}}$$

Water swelling capacity (WSC)

The water swelling capacity of the powder was evaluated to previously describe by the method (Chan and Matanjun 2017) with slightly modifications. The water swelling capacity of seaweed powder was measured to the Equations.

$$\text{(ml/g)} = \frac{\text{volume of sample(ml)}}{\text{dry weight of sample(g)}}$$

Statistical analysis

The result were analyzed with standard values are expressed as mean ± standard error (SEM). One way variance analysis (ANOVA) and variance and standard values compare the effect of temperature on the physicochemical properties using SPSS system. A significant difference was considered at the levels of $p < 0.05$.

Antioxidant activity

Superoxide radical scavenging activity

The superoxide radical scavenging activity assay was based on the ability of sulfated polysaccharides to inhibit the photochemical reduction of nitro-blue tetra-zolium (NBT) in the riboflavin–light–NBT system as described previously (Costa *et al*., 2010).

$$\text{scvenging effect (\%)} = \frac{1 - A\,sample\,560}{A\,Control\,560} \times 100$$

Nitric oxide radical scavenging activity

This assay was evaluates the ability of different constituents to scavenge NO scavenging activity comparison with the positive control. The method was developed by Gülcin, (2006).

RESULT AND DISCUSSION

The current work investigated the nutritional assessment of the marine red seaweed *H. valentiae* was determined (Table.1). The several parameters as well as proximate composition and physicochemical parameters were evaluated. The proximate composition of moisture, ash, lipid, protein, carbohydrate, dietary fiber and physicochemical properties determine the yield, moister content, water holding capacity, oil holding capacity, and water swelling capacity. Analysis of moisture content shows the *H. valentiae* was found to be (12.17 ± 0.57) of DW respectively. The previous study had shown the growth of microorganisms with high moisture is an important criterion in moisture content determining the shelf-life and quality of processed seaweed meals (Rohani-Ghadikolaei *et al*., 2012).

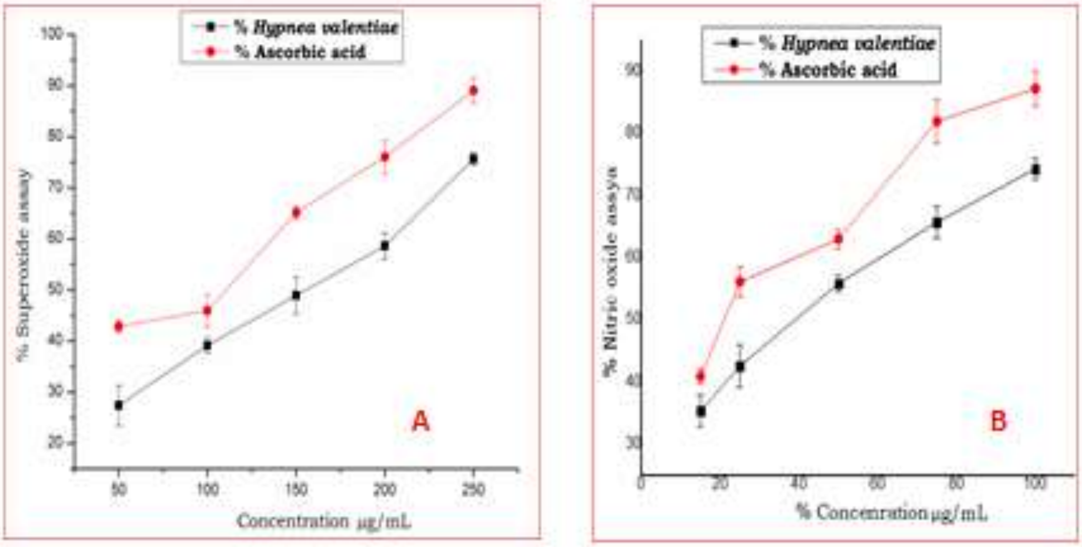

Figure 1. Antioxidant ability of Hypneavalentiae A. Superoxide radical scavenging activity, B. Nitric oxide radical scavenging activity

Table 1. Proximate composition of *Hypneavalentiae* mg/100g.

Proximate composition	Seaweed powder
	Hypneavalentiae
Carbohydrate	42.07±0.88
Protein	26.79±0.37
Lipid	1.03±0.31
Total dietary fiber	0.48±0.28
Soluble fiber	0.23±0.35
Insoluble fiber	0.25±0.01
Ash	13.03±0.84
Moisture	12.17±0.57

All values represent the mean of triplicates ± Standard deviation

Table 2. Physicochemical properties of *Hypnea valentiae.*

Parameters	Seaweed powder
	Hypnea valentiae
Water holding capacity (g/g)	12.28±0.59
Oil holding capacity (g/g)	2.54±0.69
Water swelling capacity (ml/g)	3±0.57

All values represent the mean of triplicates ± Standard deviation

Table3. Antioxidant activity of *Hypnea valentiae* methanol extract.

Extract/ Positive control	Superoxide	Nitric oxide
	(50-250µg/mL)	(10-160µg/mL)
Hypneavalentiae	89.06±0.44	87.22±0.80
L-Ascorbic acid	75.67±0.20	74.35±0.67

The amount of ash content of *H. valentiae* was (13.03 ± 0.84) DW. Based on the finding was *Ulva lactuca* and *Kappaphycus alvarezii* higher than reported by (10.5%) (Abirami and Kowsalya, 2011). This result ash content *Ulvalactuca* was (11.2%) (Bharathi *et al*., 2021). In this study was much higher than that recorded by *Ulva lactuca*, *Jania rubens* and *Pterocladia capillacea* for seasonal variation in spring, summer and autumn (Khairyand El-Shafay, 2013). The crude lipid content shows the *H. valentiae* was (1.03 ± 0.31) DW. In this report similarly the total crude lipid content observed was 0.028 ± 0.14 g/g and 0.0272 ± 0.36 g/g of DW respectively for *G. acerosa* and *S. wightii* (Syad *et al*., 2013). Jati *et al*., (2019) was *S. linifolium* presented (2.16%), (Jeon *et al*., 2010; Sakthivel and Devi 2015) was seaweed has crude lipid fraction have useful for various components such omega-3 polyunsaturated fatty acids, fucoxanthin and the peroxisomal gene expressions before further undertaking human clinical trials.

The protein content in *H. valentiae* was examined (26.79 ± 0.37) DW. (Abdel-Khaliq *et al*., 2014)Reported that the protein content was 17.6% *Ulva fasciata, Ulva intestinalis* and *Ulva lactuca*. In this similarly reported the amount of crud protein content observed was 0.61±0.07 mg/g and 1.482±0.20 mg/g of DW for *G. acerosa* and *S. wightii* respectively (Syad *et al*., 2013). Carbohydrate is one of major compound in the proximate analysis. The carbohydrate content *H. valentiae* was examined in this study (42.07±0.88) DW. Carbohydrate is the most important component of the metabolisms as it supplies the energy needed for respiration and other metabolic processes. In this result reported the carbohydrate content observed was 41.52 ± 0.45 *Gracilari achangii* (Chan and Matanjun 2017). This previous result has reported the carbohydrate content was 58.1% *U. lactuca* (Rasyid, 2017). The total dietary fiber content was comprised in this study (0.48 ± 0.28) DW *H. valentiae*. Current reviews have determined that seaweed dietary fibers exhibit important functional groups such as antioxidant, anti-mutagenic, anticoagulant, and antitumor properties it has been playing a major role in the modification of lipid metabolisms (Macagnan *et al*., 2016). This dietary fiber is strong resistant to digestion, which provides bulk to feces, holds water, acts as a site for ion-exchange, and binds organic molecules (Collar and Angioloni, 2010). In this result indicate fiber content ranged from 19.6 to 64.9% *Fucus vesiculosus*, *Laminaria digitata* (Ruperez and Saura-Calixto, 2001).

The physicochemical parameters determine the water holding capacity, oil holding capacity, and water swelling capacity determined. Analysis of moisture content shows the *H. valentiae* was found to be (12.17 ± 0.57) of DW respectively. In our results were SC (3 ± 0.57), WHC (12.28 ± 0.59), and OHC (2.54 ± 0.69) of *H. valentiae* shown in the (Table 2). In this previous result the SC, WHC, and OHC of *G. changii* at various temperatures significantly increased, due to the increase in the solubility of the fibers and protein presence in *G. changii*. In this report the WHC was Rainy season and summer season *Ulva pertusa* 7.78 ± 0.29, 8.39 ± 0.54 (g/g DW), OHC was 1.65 ± 0.10R, 1.42 ± 0.03 (g oil/g DW), SSWC was 4.00 ± 0.55, 4.58 ± 1.10 (ml/g DW) and *U. intestinalis* WHC was 6.42 ± 0.32R, 14.96 ± 0.66S (g/g DW), OHC was 12.84 ± 0.69, 4.83 ± 0.09S (g oil/g DW), SSWC was 4.41 ± 0.06, 4.00 ± 0.55 (ml/g DW) as reported by Benjama and Masniyom (2011). In this previous study physicochemical parameters SC, WHC, and OHC of *G. acerosa* at 25 ◦C 37 ◦C various temperatures SC 4 ± 0, 5 ± 1.41, WHC 3.06 ± 0.14, 3.08 ± 0.14 and OHC 0.91 ± 0.02, *S. wightii* at 25◦C 37◦C various temperatures SC 8.75 ± 1.7, 6 10 ± 0, WHC 4.75 ± 0.14, 5.72 ± 0.14 and OHC 1.32 ± 0.08 as reported by Syad *et al*., (2013). The physicochemical analysis of *H. valentiae* was significantly high values of SC, WHC and OHC. The SC of *H. valentiae* seaweed is used for the different protein conformations and the water binding sites protein molecules. WHC for the application in food industry used as a functional ingredient for meat products and is produced low calorie food products such as extruded snacks, corn flakes, cookies, and crackers. OHC is another important property of food ingredients for emulsions and high fat food products.

The present study determined the antioxidant properties of *H. valentiae* methanol extract performed by superoxide and nitric oxide radical scavenging activity (Figure 1 and Table 3). The radical scavenging indicates that *H. valentiae* (50-250 µg/mL) exhibited the maximum superoxide radical activity was 89.06 ± 0.44µg/mL which is significantly higher than the standard ascorbic acid 75.67±0.20µg/mL. Nitric oxide assay observed that *H. valentiae* (15- 100 µg/mL) exhibited the maximum nitric oxide scavenging was 87.22 ± 0.80µg/mL which is significantly higher than the standard ascorbic acid 74.35 ± 0.67µg/mL.

Antioxidants have mutagenic and toxic properties, which have shifted attention than naturally occurring antioxidants. Antioxidant activities free radical scavenges such as peroxide, hydro peroxide reduce the level of oxidative stress and prevent oxidative stress diseases. This previous result has *T. ornata* (1000 µg/mL) inhibited the superoxide scavenging property of (61.86 ± 1.27%) which is higher than the standard gallic acid (52.63±1.15%) (Vijayabaskar and Shiyamala, 2012).*Sargassumsp* shows the scavenging activity of (493.92 ± 0.10 %) (Shobharani *et al*., 2014).*Gracilaria edulis* indicate that scavenging activity of 77.46 ± 0.40%, *H.valentiae* shows a scavenging activity of 73.18 ± 0.32% (Mahendran *et al*., 2021). In this report *T. ornata* (1000 µg/mL) inhibited the nitric oxide scavenging activity of (39.8 2.07%) higher than the standard gallic acid (33.63±2.07%) (Benjamaand Masniyom, 2011). This study was nitric oxide radical (81.2 ± 4.1% and 76.69 ± 3.1 %) *Colpomenia sinuosa*(Vijayabaskar *et al*., 2022).*Sargassumsp* shows nitric oxide scavenging activity of (663.14 ± 1.04 %) (Shobharani *et al*., 2014). These results show that *Haligrasps* and *G. acerosa* (100 µg/ml) had scavenging activity of 39.8 ± 3.52 and 33.3 ± 1.7% respectively, similar to the standard BHT (33 ± 2.07%) (Devi *et al*., 2008).

CONCLUSION

The study was designed with red seaweed *H. valentiae* rich source of nutritional aspects. The proximate composition and physicochemical properties evaluate the moisture, ash, lipid, protein, carbohydrate, and dietary fiber. It should be noted *H. valentiae* presents the highest protein and carbohydrate contents. It has been suggested that seaweed conformed have potential food supplements that are used in the food industry. Because red seaweed has found to good source of essential nutrients their commercial value can be enhanced by marketing products. The extracts of seaweed contained different levels of total polyphenolic compounds and in vitro possessed the antioxidant ability. Moreover, the present investigation implied that *H. valentiae* extracts are capable of potential antiradical properties. This research provides firsthand data regarding the potential of red seaweeds to develop natural sources of antiradicals, food supplements, nutraceutical, having various functional food and therapeutic applications.

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REFERENCES

Lorenzo, J.M., Agregán, R., Munekata, P.E., Franco, D., Carballo, J., Şahin, S., Lacomba, R. and Barba, F.J., (2017). Proximate composition and nutritional value of three macroalgae: *Ascophyllumnodosum*, *Fucusvesiculosus* and *Bifurcariabifurcata*. *Marine Drugs*, 15(11), p.360.

Charles, A. L., &Alamsjah, M. A. (2019). Application of chemometric techniques: An innovative approach to discriminate two seaweed cultivars by physico-functional properties. *Food Chemistry*, 289, 269-277.

Rosemary, T., Arulkumar, A., Paramasivam, S., Mondragon-Portocarrero, A., & Miranda, J. M. (2019). Biochemical, micronutrient and physicochemical properties of the dried red seaweeds *Gracilariaedulis* and *Gracilariacorticata*. *Molecules,* 24(12), 2225.

Barba, F. J., Grimi, N., &Vorobiev, E. (2015). New approaches for the use of non-conventional cell disruption technologies to extract potential food additives and nutraceuticals from microalgae. *Food Engineering Reviews*, 7(1), 45-62.

Agregán, R., Munekata, P. E., Domínguez, R., Carballo, J., Franco, D., & Lorenzo, J. M. (2017). Proximate composition, phenolic content and in vitro antioxidant activity of aqueous extracts of the seaweeds *Ascophyllumnodosum, Bifurcariabifurcata* and *Fucusvesiculosus*. Effect of addition of the extracts on the oxidative stability of canola oil under accelerated storage conditions. *Food Research International*, 99, 986-994.

Garcia-Vaquero, M., Rajauria, G., Miranda, M., Sweeney, T., Lopez-Alonso, M., &O'Doherty, J. (2021). Seasonal variation of the proximate composition, mineral content, fatty acid profiles and other phytochemical constituents of selected brown macroalgae. *Marine drugs*, 19(4), 204.

Palani, K., Balasubramanian, B., Malaisamy, A., Maluventhen, V., Arumugam, V.A., Al-Dhabi, N.A., ValanArasu, M., Pushparaj, K., Liu, W.C. and Arumugam, M., (2022). Sulfated Polysaccharides Derived from *Hypneavalentiae* and Their Potential of Antioxidant, Antimicrobial, and Anticoagulant Activities with In Silico Docking. *Evidence-Based Complementary and Alternative Medicine*, 2022.

Matanjun, P., Mohamed, S., Mustapha, N. M., & Muhammad, K. (2009). Nutrient content of tropical edible seaweeds, *Eucheumacottonii*, *Caulerpalentillifera* and *Sargassumpolycystum*. *Journal of Applied Phycology*, 21(1), 75-80.

Syad, A. N., Shunmugiah, K. P., &Kasi, P. D. (2013). Seaweeds as nutritional supplements: Analysis of nutritional profile, physicochemical properties and proximate composition of *G. acerosa* and *S. wightii*. *Biomedicine & Preventive Nutrition*, 3(2), 139-144.

Chan, P. T., &Matanjun, P. (2017). Chemical composition and physicochemical properties of tropical red seaweed, *Gracilariachangii*. *Food Chemistry*, 221, 302-310.

Wong, K. H., & Cheung, P. C. (2000). Nutritional evaluation of some subtropical red and green seaweeds: Part I—proximate composition, amino acid profiles and some physico-chemical properties. *Food Chemistry*, 71(4), 475-482.

Bharathi, S., Dinesh Kumar, S., Sekar, S., Santhanam, P., Divya, M., Krishnaveni, N., Pragnya, M. and Dhanalakshmi, B., (2021). Experimental evaluation of seaweeds liquid extracts as an alternative culture medium on the growth and proximate composition of Picochlorummaculatum. Proceedings of the National Academy of Sciences, *India Section B: Biological Sciences*, 91(1), 205-215.

Rasyid, A. (2017). Evaluation of nutritional composition of the dried seaweed *Ulvalactuca* from Pameungpeuk waters, *Indonesia.Tropical Life sciences Research*, 28(2), 119.

Costa, L.S., Fidelis, G.P., Cordeiro, S.L., Oliveira, R.M., Sabry, D.D.A., Câmara, R.B.G., Nobre, L.T.D.B., Costa, M.S.S.P., Almeida-Lima, J., Farias, E.H.C. and Leite, E.L., (2010). Biological activities of sulfated polysaccharides from tropical seaweeds. *Biomedicine & Pharmacotherapy*, 64(1), 21-28.

Gülcin, İ. (2006). Antioxidant and antiradical activities of L-carnitine. *Life sciences*, 78(8), 803-811.

Rohani-Ghadikolaei, K., Abdulalian, E., & Ng, W. K. (2012). Evaluation of the proximate, fatty acid and mineral composition of representative green, brown and red seaweeds from the Persian Gulf of Iran as potential food and feed resources. *Journal of food science and technology*, 49(6), 774-780.

Abirami, R. G., &Kowsalya, S. (2011). Nutrient and nutraceutical potentials of seaweed biomass *Ulvalactuca* and *Kappaphycusalvarezii*. *Nong Ye KeXue Yu JiShu*, 5(1).

Khairy, H. M., & El-Shafay, S. M. (2013). Seasonal variations in the biochemical composition of some common seaweed species from the coast of Abu Qir Bay, Alexandria, Egypt. *Oceanologia*, 55(2), 435-452.

Jati, B. N., Nuraeni, C., Yunilawati, R., &Oktarina, E. (2019, October). Phytochemical screening and total lipid content of marine macroalgae from Binuangeun beach. *In Journal of Physics: Conference Series* (Vol. 1317, No. 1, p. 012103). IOP Publishing.

Jeon, S. M., Kim, H. J., Woo, M. N., Lee, M. K., Shin, Y. C., Park, Y. B., & Choi, M. S. (2010). Fucoxanthin-rich seaweed extract suppresses body weight gain and improves lipid metabolism in high-fat-fed C57BL/6J mice. *Biotechnology Journal*, 5(9), 961-969.

Sakthivel, R., & Devi, K. P. (2015). Evaluation of physicochemical properties, proximate and nutritional composition of *Gracilariaedulis* collected from Palk Bay. *Food chemistry*, 174, 68-74.

Abdel-Khaliq, A., Hassan, H. M., Rateb, M. E., &Hammouda, O. (2014). Antimicrobial activity of three *Ulva*species collected from some Egyptian Mediterranean seashores. *International Journal of Engineering Research and General Science*, 2(5), 648-669.

Macagnan, F. T., da Silva, L. P., &Hecktheuer, L. H. (2016). Dietary fibre: The scientific search for an ideal definition and methodology of analysis, and its physiological importance as a carrier of bioactive compounds. *Food Research International*, 85, 144-154.

Collar, C., &Angioloni, A. (2010). An approach to structure-function relationships of polymeric dietary fibres in foods: significance in breadmaking applications (pp. 91-114). *Wageningen Academic Publishers, the Netherlands*.

Ruperez, P., &Saura-Calixto, F. (2001). Dietary fibre and physicochemical properties of edible Spanish seaweeds. *European Food Research and Technology*, 212(3), 349-354.

Benjama, O., &Masniyom, P. (2011). Nutritional composition and physicochemical properties of two green seaweeds (*Ulvapertusa* and *U. intestinalis*) from the Pattani Bay in Southern Thailand. *Sonklanakarin Journal of Science and Technology*, 33(5), 575.

Vijayabaskar, P., &Shiyamala, V. (2012). Antioxidant properties of seaweed polyphenol from *Turbinariaornata* (Turner) J. Agardh, 1848. *Asian Pacific Journal of Tropical Biomedicine*, 2(1), S90-S98.

Shobharani, P., Nanishankar, V. H., Halami, P. M., &Sachindra, N. M. (2014). Antioxidant and anticoagulant activity of polyphenol and polysaccharides from fermented *Sargassum sp*. *International Journal of Biological Macromolecules*, 65, 542-548.

Mahendran, S., Maheswari, P., Sasikala, V., jayaRubika, J., &Pandiarajan, J. (2021). In vitro antioxidant study of polyphenol from red seaweeds dichotomously branched gracilaria*Gracilariaedulis* and robust sea moss *Hypneavalentiae*. *Toxicology Reports*, 8, 1404-1411.

Vijayabaskar, P., Lekameera, R., &Somasundaram, S. T. (2022). Determination of Antioxidant Property of Brown Alga *Colpomeniasinuosa*. *Current Topics in Agricultural Sciences Vol.* 6, 19-28.

Devi, K. P., Suganthy, N., Kesika, P., &Pandian, S. K. (2008). Bioprotective properties of seaweeds: in vitro evaluation of antioxidant activity and antimicrobial activity against food borne bacteria in relation to polyphenolic content. *BMC Complementary and Alternative Medicine*, 8(1), 1-11.