

## Nutritional assessment and bioactive potential of *Sargassum polycystum* C. Agardh (Brown Seaweed)

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The phytochemical screening, nutritional composition and bioactive potential of *Sargassum polycystum* (Brown Seaweed) were investigated. The bioactive compounds of *Sargassum polycystum* showed significant activity against four human pathogens, namely, *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus*, and *Klebsiella pneumoniae*. The biochemical composition of *Sargassum polycystum* exhibited high nutritional potential of protein (14.2%), carbohydrate (25.0%), lipid (7.6%), fiber (21.3%), and ash (29.0%) than that in terrestrial plants and animal products. The *Sargassum polycystum* could be providing more opportunities for discovering new drugs which may be used as a source of healthy food for human regular diet.

**[Keywords:** Phytochemical; Nutrition; Antibacterial activity; *Sargassum polycystum*; Brown seaweed]

### Introduction

Algae are relatively simple photosynthetic plants with unicellular reproductive structure<sup>1</sup>. Much kind of ecosystem is functioning with primary productivity of green plants. In the marine ecosystems, macro algae or seaweed are potential primary producers of energy rich compounds and form the basis of the food cycle of all phytoplankton as well as zooplanktons. Based on their pigmentation and chemical nature, these are grouped as: Green algae (Chlorophyceae), brown algae (Phaeophyceae), and red algae (Rhodophyceae). Globally, 9200 species of seaweeds were reported, along with red algae comprising 6000, brown algae 2000 and green algae 1200 species<sup>2</sup>. In and around Asia coastal people, have utilized since pre historic times seaweed as a source of food, fodder, fertilizer, fungicides, and herbicides<sup>3-4</sup>. In western countries, seaweed polymers are used as a source of thickening and gelling agents in food and drug industries<sup>5-6</sup>. Seaweed has been food for coastal people and a total of 145 species of red, brown and green seaweeds are used worldwide. In Japanese meals, more than 20 species of seaweed are used, including *Nori* (*Porphyra* sp.), *Kombu* (*Laminaria* and *Saccharina* sp.) and *Wakame* (*Undaria pinnatifida*). The red seaweed *Palmaria palmata*, *Porphyra* and *Chondrus crispus* are widely used in Ireland and Scotland. The Laverweed (*Porphyra*) with oats to make laver bread

is used in California and Maine in the US, British Columbia, Nova Scotia in Canada, and in the cuisines of Brittany and Wales. Dulse is eaten in dried form as snack and mixed in salads, bread dough and curds in Iceland<sup>7-8</sup>.

Seaweeds are rich sources of proteins, lipids, polysaccharides, minerals, enzymes, anti-oxidants, phytonutrients and vitamins (A, E, C and Niacin) essential for human nutrition that has been reported in various literatures. The nutrient composition of seaweeds is varied based on their ecological and physiological conditions. Moreover, seaweed contains many essential elements like potassium, magnesium, iron and zinc. The green and red algae predominantly contain vitamins of B<sub>12</sub>, B<sub>1</sub>, pantothenic acid, folic and colonic acids and are rich sources of protein and fiber<sup>9</sup>. Thus, seaweeds are not only significant in nutrient potential, but also have pharmaceutical importance. Many studies revealed their different photochemical profiles and several biological applications. Seaweeds phytochemical plays an important role in many microbial infections<sup>10-11</sup>. Seaweeds contain large number of unique phytochemicals in the absence of terrestrial plants. The importance of seaweed products in pharmacology is known, the development of antibacterial, antifungal and antiviral substances from seaweeds is still in the rapidly growing stage of research and development.

In modern times, seaweeds are broadly utilized in manifold pharmaceutical applications, such as antimicrobial, antiviral, antibacterial, and antifungal, anti-allergic, anticoagulant, anticancer, antifouling, and anti-oxidant. The functions of these secondary metabolites are defense mechanism against herbivores, fouling organisms and pathogens<sup>12</sup>. Most of the secondary metabolites produced by seaweeds have bacterial or the antimicrobial compounds, viz., phenols, oxygen heterocyclic, terphenols, sterols, polysaccharides, dibutenolides peptides and proteins<sup>12</sup>.

The antimicrobial activity was regarded as an indicator to detect the potent pharmaceutical capacity of macro algae for its use in synthesis of bioactive secondary metabolites<sup>13-14</sup>. Seaweeds contain several bioactive compounds like antiviral, antibacterial, antifungal, antioxidant and hypertensive properties in marine macro algae from different parts of the world<sup>15,16</sup>. Several studies have been carried out on the extracts from seaweeds and their extracts were reported to exhibit antibacterial activity<sup>17</sup>. Among the macro algae, Phaeophyceae members form an important group of seaweeds having rich source of potential new drugs. Only very few studies are available on nutritional composition and bioactive potential of *Sargassum polycystum* C. Agardh. Hence, the present study focused on nutritional composition, phytochemical screening and antibacterial potential of *Sargassum polycystum* C. Agardh.

## Materials and Methods

### Collection of seaweed

The brown seaweed *Sargassum polycystum* C. Agardh was collected from Harbor beach, Tuticorin, Tamil Nadu, India (Fig. 1). The collections were made during the low tidal and sub-tidal regions (up to 1 m depth) by hand picking of seaweed. The collected materials were washed with marine water thoroughly in the field to remove the adhered epiphytes and sediment particles. The cleaned samples were packed separately in polythene bags in wet conditions and brought to the laboratory. The seaweed samples were further washed in tap water to remove salt particles followed by distilled water. The samples were dried (shade) for 15 days at room temperature. The dried samples were chopped into fine fragments with the help of a mixer. The powder samples were stored in refrigerator for further use.



Fig. 1 — *Sargassum polycystum* C. Agardh

### Preparation of seaweed extracts

Seaweed powder (15 g) were soaked in 150 ml of acetone, ethanol and water kept in a shaking incubator at 25 °C for three days and the suspension was filtered through whatman No.1 filter paper. The re-extraction process was repeated three times. The solvents, acetone, ethanol and water extracts of seaweed were used for phytochemical screening and antibacterial studies.

### Nutritional composition of seaweed

The total protein was estimated by using Lowery method<sup>18</sup>.

The total carbohydrate was estimated by using Dubois method<sup>19</sup>.

The total lipid was estimated by using Folch method<sup>20</sup>.

The crude fiber was determined by using AOAC method<sup>21</sup>.

The total ash content of seaweed was determined by using AOAC method<sup>21</sup>.

### Phytochemical screening

Chemical tests were performed for the acetone, ethanol and water extracts of seaweed using standard procedures to identify the presence of various phytochemicals<sup>22,23</sup>.

### Antibacterial activity

*Collection of pathogens (Bacteria):* The bacterial species viz., *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumoniae* were

obtained from Department of Microbiology, Periyar University, Salem, Tamil Nadu.

#### Antibacterial assay

*Preparation of media:* The growth media employed in the present study included nutrient agar and nutrient broth. The medium was adjusted to pH 7.4 and sterilized by autoclaving at 15 lbs pressure (121 °C) for 15 min. Antibacterial activity was demonstrated by disc diffusion method<sup>24</sup>.

### Results and Discussion

#### Nutritional composition of *Sargassum polycystum*

The results of nutritional composition of *Sargassum polycystum* C. Agardh are presented in Table 1. The protein, carbohydrate, lipid, fiber and ash content were exhibit in percentage of dry weight basis (% of DW). The protein content of 14.8% in *Sargassum polycystum*. The results were similar to the protein content (ranged from 4.6% - 18.3%) in *Gracillaria domingensis*, *G. birdiae*, *L. filiformis* and *L. intricata*<sup>25</sup>. The previous report also similar to the protein content ranged from 10.9–25.7% in brown seaweed and 15.5–21.3% in red seaweed<sup>26</sup>. The protein range of red and green seaweeds is 10–47% reported by earlier studies<sup>3</sup>. The protein content in three *Caulerpa* species (*C. veravelensis*, *C. scalpelliformis* and *C. racemosa*) varied and ranged between 7 and 13% DW, but was comparable with that of protein-rich foods from terrestrial plants<sup>27</sup>. The protein content of *Caulerpa* species ranged from 5.08 to 10.41%<sup>28,29,30</sup> and *Padina gymnospora* (17.1 %) <sup>31</sup>. In the present study, the protein content of *Sargassum polycystum* is similar to the previous results. In general, green and red seaweeds contain high amount of protein when compared to brown seaweeds<sup>32</sup>. However, most marine macroalgae have large amount of protein than land plants and animal products according to USDA<sup>33</sup>.

In the present study, the carbohydrate content of *Sargassum polycystum* was 25.0%. In the seaweeds

collected from Mandapam coast, the maximum level of carbohydrate content was recorded in *Turbinaria conoides* (23.9%), *Sargassum tenerimum* (23.55%), and *Sargassum wightii* (23.50%)<sup>31</sup>. The seaweed maximum lipid content was found in *Sargassum polycystum* (7.6%). In our present study also similar lipid contents of *Codium* sp., *H. floresia*, and *S. polyschides* were found as 7.1%, 12.3% and 8.2%, respectively<sup>34</sup>. Previous studies reported higher and lower values of lipid content<sup>35,36,26</sup>. In contrast, the lipid content maximum of Hawaiian seaweeds was *Dictyota dichotoma* (16.1%) and *D. sandvicenis* (20.2%)<sup>37</sup>. The fiber content value of *Sargassum polycystum* exhibited maximum of 21.3%. Earlier reports found fiber to be the most abundant component of seaweeds<sup>38,26,39,35</sup>. One of the major uses of the seaweeds is as dietary fiber, because of their high amount of polysaccharides. Dietary fiber is complex substance consisting of plant cell walls, structurally complex and chemically diverse polysaccharides and other associated substances. The present study exhibits higher fiber content than that reported in other studies like *Hypnea pannosa* (8.5%) and *Dictyota dichotoma* (2.5%)<sup>40</sup>. The present results showed higher contents than those in terrestrial plants, such as raw broccoli (2.6%), raw carrot (2.4%) and oranges (1.7%)<sup>33</sup>.

The ash content of *Sargassum polycystum* showed maximum of 29.0%. The amount of ash contents reported in the present study was similar to that reported in the previous reports, between 8 and 40%<sup>32</sup>. Most seaweeds have greater ash content than terrestrial plants and animal products<sup>41</sup>. Furthermore, the ash contents of *Sargassum polycystum* was higher than terrestrial plants, with an average value of 5-10% DW (USDA<sup>33</sup>). The variation in ash contents was also based on the seaweed species, geographical origin, their method of extraction as well as effect of food processing by drying and canning methods<sup>4,42</sup>.

#### Preliminary phytochemical screening of *Sargassum polycystum*

Table 1 — Comparison of nutritional composition *Sargassum polycystum* C. Agardh and other brown seaweeds (from previous literature)

Parameter	Other brown seaweeds from previous literature <sup>43, 44,45, 46</sup>				
	<i>Sargassum polycystum</i> C. Agardh.	<i>Padinagymnospora</i> (Kutzing)	<i>Sargassum ilicifolium</i> (Turner). C. Agarth.	<i>Sargassum vulgare</i> C. Agardh.	<i>Sargassum hystrix</i> . Var (Borgesen 1914)
Protein (%)	14.8	14.14	15.42	15.76	6.55
Carbohydrate (%)	25.0	21.40	27.33	67.80	58.72
Lipid (%)	7.6	1.89	1.43	0.45	1.90
Fiber (%)	21.3	9.1	7.2	7.73	17.00
Ash content (%)	29.0	27.4	22.32	14.20	18.5

The results of preliminary phytochemical screening of acetone, ethanol and water extracts of *Sargassum polycystum* are presented in Table 2. The acetone extract of *Sargassum polycystum* contains tannins, flavonoids, cardiac glycosides, phlobatannins, and steroids. The ethanol extract contained flavonoids, cardiac glycosides and steroids, while water extract showed phenol, amino acids and protein. Various tests were conducted qualitatively to find out the presence or absence of bioactive compounds. The chemical compounds found in *Sargassum polycystum* included tannins, flavonoids, terpenoids, cardiacglycosides, phlobatannins, steroids, phenol, amino acids and proteins, which could make the seaweeds useful for treating different ailments as having a potential of providing useful drugs for human use.

Tannins are naturally occurring plant polyphenolic compounds and are widespread among terrestrial and marine plants<sup>47,48</sup>. Tannins are known to possess general antimicrobial and antioxidant activities<sup>49</sup>. Tannins contain drugs that are used in medicine as astringent, healing agent of inflammation, leucorrhoea, gonorrhoea, burns, piles and as antidote<sup>50</sup>. Steroids may provide an intermediate for biosynthesis of downstream secondary natural products and it is believed to be a biosynthetic precursor for carotenoids in plants<sup>4</sup>. Steroids have been reported to have antibacterial potential<sup>51</sup> and are known for their relationship with sex hormones<sup>52</sup>. Saponins are considered a key ingredient in traditional Chinese medicine and are responsible for most of the observed biological effects. Saponins are known to produce inhibitory effect on inflammation. Saponins possess numerous biological properties which include anti-microbial, anti-inflammatory, anti-feedent and hemolytic effects. Flavonoids are used as, potent antioxidants and have aroused considerable interest

recently because of their potential beneficial effects on human health in fighting diseases<sup>53</sup>.

Seaweed extracts are a source of variety of phenolic compounds<sup>54,55</sup>. The present study revealed the presence of phenol content in *Sargassum polycystum*. Phenolic compounds are one of the most effective anti-oxidant agents in brown algae<sup>17</sup>. The previous report of quantitative analysis of *Padina gymnospora* revealed the presence of higher amount of phenol<sup>38,56</sup>. Phlobatannins purified from several brown algae have been reported to possess strong anti-oxidant activity which may be associated with their unique molecular skeleton<sup>57</sup>. Marine algae are a rich source of structurally novel and biologically active metabolites. Secondary metabolites produced by these algae may be potential bioactive compounds of interest to the pharmaceutical industry. It has been reported that the presence of phytoconstituents such as flavonoids, tannins and phenols help in preventing a number of diseases through free radical scavenging activity<sup>59</sup>. Preliminary phytochemical screening of various organic extracts revealed the presence of phytoconstituents, including alkaloids, anthraquinones, cardiac glycosides, flavonoids, reducing sugars, saponins and terpenoids<sup>60</sup>.

The preliminary phytochemical constituents were studied from ethanolic (70%) extract of three marine algae, viz., *Chaetomorpha antennina*, *Gracilaria corticata* and *Ulva fasciata* collected from Visakapatnam coast. The phytoconstituents such as steroids, terpenoids, alkaloids, glycoside, amino acids, carbohydrate, saponins and oils were reported from above seaweeds<sup>60</sup>. A similar result was found in *Gelidiella acerosa* which contained large amount of valuable phytochemicals like saponins, flavonoids and alkaloids, which are known for medicinal uses. The preparations of the seaweeds are also useful for

Table 2 — Phytochemical screening of *Sargassum polycystum* C. Agardh.

S.No.	Phytochemical test	Acetone	Ethanol	Water
1.	Tannins	+	-	-
2.	Saponins	-	-	-
3.	Flavonoids	+	+	-
4.	Terpenoids	+	+	-
5.	Cardiac glycosides	+	+	-
6.	Phlobatannins	+	-	-
7.	Steroids	+	+	-
8.	Phenols	-	-	+
9.	Amino acids	-	-	+
10.	Proteins	-	-	+

Present (+); Absent (-)

the common ailments, including dysentery, hypertension, urinary tract infection, and some other microbial infections among people<sup>61</sup>. The amount of total phenol and flavanoid was higher in brown seaweeds, *Padina boerghesii* and *Codium indica*<sup>62</sup>.

#### Antibacterial activity of *Sargassum polycystum*

The antibacterial activities of acetone, ethanol and water extracts of *Sargassum polycystum* were represented in (Fig. 2). Among three extracts, the acetone extracts of *Sargassum polycystum* showed maximum activity in *Staphylococcus aureus* (Fig. 1) and minimum inhibitory activity showed against *Escherichia coli*. The antibacterial activities of the seaweeds have been reported in the literature attributing them to the presence of bioactive principles, such as tannins, flavonoids, terpenoids, cardioglycosides, phlobatannins, steroids, saponins and phenols. The maximum antibacterial activity was reported in the class Rhodophyceae (80%) followed by the Chlorophyceae (62.5%) and the Phaeophyceae (61.9%)<sup>63</sup>. The antibacterial activities of four vital marine algae, viz., *Ulva lactuca*, *Sargassum wightii*, *Padina gymnospora* and *Gracilaria edulis* were examined for the human bacterial pathogens, namely, *Vibrio cholera*, *Staphylococcus aureus*, *Salmonella paratyphi*, *Shigella dysenteriae*, *Pseudomonas aeruginosa*, *Shigella boydii* and *Klebsiella pneumoniae*. Methanol extracts of seaweeds exhibited broad spectrum of antibacterial activity<sup>64</sup>. An earlier study reported that the antibacterial activity of methanol extract of seaweeds inhibited the growth of *S. aureus* and *B. subtilis* (gram positive bacterium)<sup>65</sup>. The presence of different bioactive constituents in the methanolic extract of *Champia parvula*

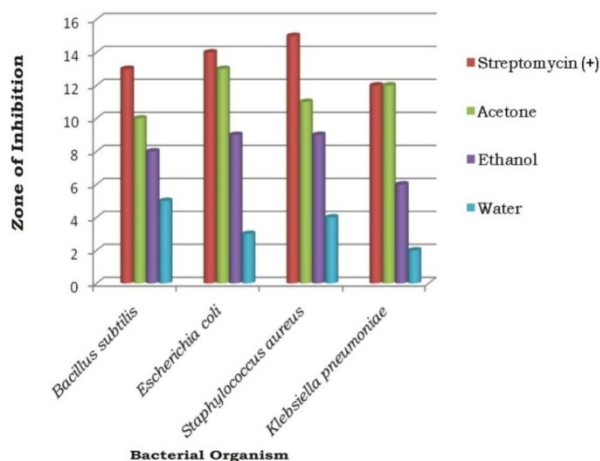


Fig. 2 — Antibacterial activity of *Sargassum polycystum* C. Agardh

could contribute to different biological activities<sup>66</sup>. In the present study, seaweeds were found to exhibit chemical compounds, such as tannins, terpenoid, cardioglycosides, phlobatannins, steroids, saponin, phenol, amino acids, and proteins. The presence of secondary metabolites in corroboration with earlier reports, it was included that for the brown seaweed, *Sargassum polycystum* has antibacterial potential. Thus, the marine algae are among the richest source of known novel bioactive compounds<sup>67,68</sup>.

#### Conclusion

The seaweed was found to have high nutritional potential which could be used as a source of healthy food for human regular diet. Three solvent extracts contained active secondary metabolites like tannins, saponins, flavonoids, terpenoids, cardioglycosides, phlobatannins, steroids, phenols, amino acids, and proteins. The *Sargassum polycystum* C. Agardh showed significant activity against four different bacterial pathogens, like *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus* and *Klebsiella pneumoniae*. The present study revealed that selected seaweed *Sargassum polycystum* C. Agardh has high nutritional value than terrestrial plants and animal products. They have potential secondary metabolites and exhibit maximum activity against bacterial pathogens. Therefore, the present investigation concluded that *Sargassum polycystum* can be used as a source to discover new drugs for various human ailments in future and they could be recommended as a good source of food for human consumption.

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