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NOTES ON THE TAXONOMY AND ECONOMIC POTENTIAL OF A RED SEAWEED *MERISTOTHECA PAPULOSA* (MONT.) J. AGARDH (FAMILY SOLIERIACEAE) IN INDIA

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Abstract: *Meristotheca* J. Agardh is one of the economically important seaweeds and belongs to the family Solieriaceae of the division Rhodophyta. Although the genus is represented by 18 taxa in the world, in India so far only one taxon *Meristotheca papulosa* (Mont.) J. Agardh has been reported. The present article highlights the taxonomy and economic perspectives of this species in reference to the Indian coast.

Keywords: Economic importance, *Meristotheca papulosa*, Rhodophyta, Solieriaceae, Taxonomy

INTRODUCTION

India is endowed with a coastline of about 7500 km in length, stretching into nine maritime states and four union territories. The diverse coastal habitats support wide range of marine floral diversity. So far, 865 taxa of seaweeds have been reported from India, which includes 442 taxa of Rhodophyta, 212 taxa of Chlorophyta and 211 taxa of Phaeophyta (Rao & Gupta, 2015). While exploring and documenting the economically important seaweeds of the Indian coast, the author could find some interesting information on the taxonomy and economic potential of the red seaweed *Meristotheca papulosa* (Mont.) J. Agardh. Taxonomically, this species belongs to the family Solieriaceae of the division Rhodophyta, and well recognized with its foliose thallus with fleshy to cartilaginous textures. Globally, this family is represented by 22 genera, while in India,it is presently represented by six genera namely *Agardhiella* F.Schmitz, *Eucheuma* J.Agardh, *Kappaphycus* Doty, *Meristotheca* J. Agardh, *Sarconema* Zanardini and *Solieria* J. Agardh and nine species, as shown in table 1. The genus *Meristotheca* was established by J. Agardhin 1872 (Agardh, 1872) with just two species namely *M. papulosa* and *M. duchassaingii*. Geographically, it is widely distributed in the Indo-Pacific regions (Faye *et al.*, 2005; Lideman *et al.*, 2012) through the tropics of both hemispheres (Watt *et al.*,2003; Borlongan *et al.*,2021). The genus is characteristically distinguished from other genera of the family Solieriaceae by its foliose thallus, a 360^{o}periaxial-cell rotation around the successive cells of the central-axial filaments, and nemathecial aggregations of its carpogonial branches (Watt *et al.*, 2003; Maria *et al.*, 2017). The genus exhibits Isomorphic life cycle (Kim *et al.*, 2019). Presently, there are 18 species of *Meristotheca* in the world (Guiry and Guiry, 2023). However, in India it is represented by only one taxon *i.e. Meristotheca papulosa* (Mont.) J. Agardh (Raoand Gupta, 2015; Yadav *et al.*, 2018), which is also the lectotype species of the genus, designated by Schmitz in 1889(Guiry and Guiry, 2023). Therefore, considering the importance of this species, a detailed taxonomic account has been provided, with highlights on economic potential and scope of its sustainable utilization in the Indian coast.

Table 1. List of the taxa under the family Solieriaceae in Indian coast

Sl. No.	Genus	Name of the species
1.	**Agardhiella** F.Schmitz	**Agardhiella subulata** (C. Agardh) Kraft & Wynne
2.	**Eucheuma** J.Agardh	**Eucheuma denticulatum** (Burm. f) Collins & Hare.
3.	**Kappaphycus** Doty	**Kappaphycus alvarezii** (Doty) Doty &P.C.Silva
4.		**Kappaphycus cottonii** (Weber-van Bosse) Doty ex P.C. Silva
5.		**Kappaphycus striatum (**F. Schmitz) Doty ex P.C. Silva
6.	**Meristotheca** J. Agardh	**Meristotheca papulosa** (Mont.) J. Agardh
7.	**Sarconema** Zanardini	**Sarconema filiforme** (Sond.) Kylin
8.	**Solieria** J. Agardh	**Solieriadura** (Zanardani) Schmitz
9.		**Solieriaindica**J. Agardh

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Taxonomic account of *Meristotheca papulosa* (Mont.) J. Agardh

Meristotheca papulosa (Mont.) J. Agardh in Acta Univ. Lund. 8(8): 37. 1877; V. Krishnam. & H.V. Joshi, Checkl. Ind. Mar. Alg. 21. 1970; Untawale *et al*., List Mar. Alg. India 31. 1983; P.C. Silva *et al*., Cat. Benth. Mar. Alg. Ind. Ocean 335. 1996; Desikachary *et al*., Rhodophyta 2 (2B):139. 1998; Jha *et al*., Seaweeds Gujarat 149.2009; P.S.N. Rao & R.K. Gupta, Algae India 3: 50. 2015; Yadav *et al*., Indian J. Mar. Science 47(5): 1044. 2018; Palanisamy *et al*., Seaweeds Kerala, India 142, figs. plate 63 A-I. 2020. *Kallymenia papulosa* Mont., Ann. Sci. Nat. Bot. Ser. 3(13): 246. 1850. *Eucheuma papulosum* (Montagne) Cotton &Yendo, Kew Bull. 220. 1914. **(Fig. 1, A-D).**

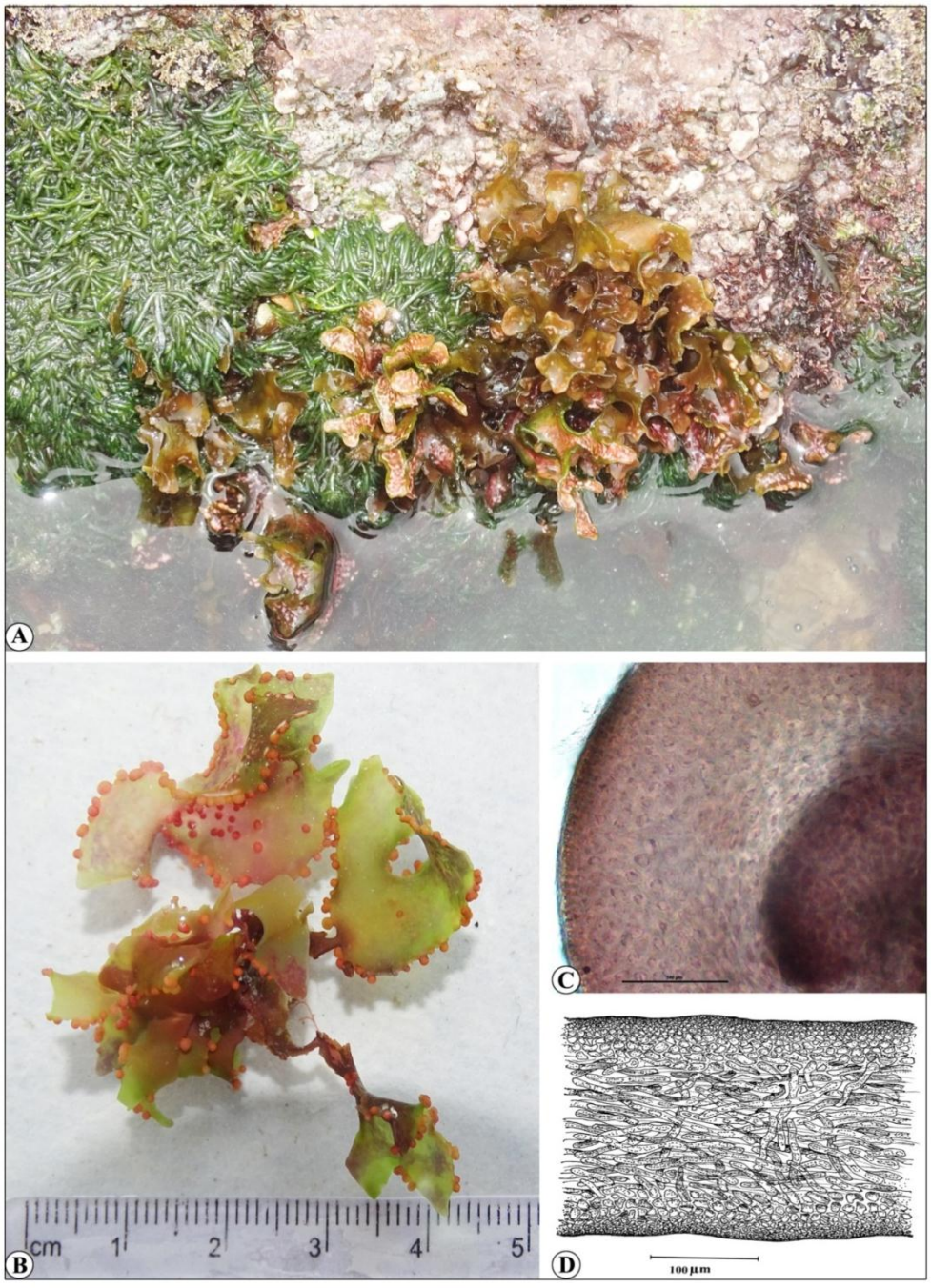

Fig. 1: Meristotheca papulosa (Mont.) J. Agardh: **A.** Habit showing vegetation on an exposed rock during low tide at Thirumullavaram coast; **B.** Closeup of a thallus showing cystocarps; **C** Microscopic image of cross section surface of a cystocarp; **D.** An illustration of T.S. of a thallus showing cortical and medullary cells.

Type locality: Hodeida, Yemen (Montagne, 1850)
Thallus dark-rose red, frondose, flat, 5-20 cm long, 2-7 cm wide, cartilaginous, fleshy, erect, epilithic. Holdfast small, crustose or discoid, 0.5-2 mm across, firmly attached on rocky substrata in intertidal zones. Stipe small, cylindrical - slightly compressed, gradually flattened upwards, up to 1 cm long, 1-5 mm broad, sometimes indistinct. Fronds foliose, up to 18 cm long, tufted, irregularly pinnately-palmately dissected, lobed; lobes usually uniformily flat, elongate or irregular, surface smooth in young thallus, turns rough or enrolled when mature; margins entire - irregularly proliferated; apex obtuse, acute or narrow lobed. *Microscopic characters*: Cells in surface view squarish, spherical or elongated, 2.5-12 µm across, irregularly arranged. In cross section, thallus 200-500 µm thick, multi-layered, consisting of outer epidermal layer, middle 5-7-layered cortex and central medulla; epidermal cells small, isodiametric, 8-14 µm across, compact; cortical cells spherical to stellate, outer cortical cells comparatively smaller, 12-25 µm across, inner cells progressively increasing towards medulla, subspherical to elongate, 25-45 µm long; medulla 120-250 µm thick, cells elongated-tubular, sometimes spathulate, joined, loosely interwoven, 70-200 × 6-25 µm. Carpogonial branches usually found on ultimate laterals, 3-celled; cystocarps borne along the margins and on marginal proliferations, usually oval - spherical, 200-920 µm across.
Occurrence: Usually throughout the year. Moderate.
Distribution: **INDIA**: Gujarat (Dwarka, Adri, Okha, Veraval), Kerala (Thirumullavaram), Maharashtra and Tamil Nadu.
Global distribution status: **Asia:** India, Pakistan, Sri Lanka, Indonesia, Philippines, Vietnam, China, Japan, Korea, South China Sea, Taiwan, Egypt, Jordan, Oman, Red Sea, Saudi Arabia, South Arabian coast, Yemen. **Africa:** Madagascar, Somalia, South Africa. **Australia** and **Central Polynesia (Pacific Ocean).**
Notes: This species is usually lithophytic in nature and found growing in association with other seaweeds such as *Asparagopsis taxiformis*, *Bryopsis plumosa*, *Caulerpa peltata*, *Gelidium micropterum*, *Gelidiella acerosa* and *Valoniopsis pachynema* in small crevices on calcareous and coralline rocks in heavy surf-exposed areas of intertidal region.
Specimens examined: INDIA**:** **Kerala**: Kollam Distr.: Thirumullavaram, 12.09.2011, *M. Palanisamy & S.K. Yadav*127095 (MH); 20.03.2012, *M. Palanisamy & S.K. Yadav* 127613 (MH); 21.03.2012, *M. Palanisamy & S.K. Yadav*127628 (MH); 05.07.2012, *M. Palanisamy & S.K. Yadav* 127686 (MH); 18.02.2013, *M. Palanisamy* 128467 (MH); 16.06.2013, *M. Palanisamy & S.K. Yadav* 128842 (MH); 03.10.2013, *M. Palanisamy & S.K. Yadav* 129446 (MH); 17.09.2015, *S.K. Yadav*126431 (MH).

Economical potential of *Meristotheca papulosa* (Mont.) J. Agardh
Seaweeds are the potential marine resources and has been used by the human since long times in various ways such as food, fodder and also as raw materials for various industries (Tseng, 2004; Yadav *et al.*, 2015, 2018; Yadav, 2022). Globally about 7.5 – 8 million tons of wet seaweeds are being produced every year and about 42 countries are actively involved in the commercial utilization of seaweed resources (McHugh, 2003; Khan and Satam, 2003). Besides, about221 species of seaweeds are economically utilized in the world, including 145 species for food and 110 species for phycocolloids (Chennubhotla *et al.*,2013; Nedumaran and Arulbalachandran, 2014). In India, about 94 taxa of seaweeds have been enumerated with economic potential (Yadav, 2020). The commercial values of the species of *Meristotheca* is known in various forms in many parts of the world, particularly in the south east Asian countries (McHugh, 2003; White and Wilson 2015; Pereira, 2016, 2018; Anggadiredja, 2009; Hwang *et al.*, 2020; Borlongan *et al.*, 2021). Therefore, the economical potentials of *M. papulosa*primarily in the food and pharmaceutical industries and its conservation measures are discussed here as given below:
***Food industries*:** *Meristotheca papulosa* has been used in the production of *carrageenan*, a natural thickening agent widely used in food industries (Fujiki and Kikutani, 1977; Usov *et al.*, 2001) and also been utilized as an important natural source of valuable bioproduct (FAO, 2014). In Japan, China and Korea *M. papulosa* are edible and often used in salads and sashimi garnishes. In Japan, it is widely cultivated for food industries and bioactive compounds (Shinmura and Tanaka, 2008; Lideman *et al.*, 2011; Kawaguchi, 2012; Borlongan *et al.*, 2021). During 1995–2004, the annual production of this species from Kagoshima coast of Japan alone reached 160–400 t of wet weight, valuing approximately US$2,000,000 (Shinmura and Tanaka 2008; Lideman *et al.* 2012) and it is estimated that approximately 1000 t of fresh *Meristotheca* is produced annually (Kawaguchi, 2012). Besides, it is also used as natural feed in Japanese abalone (*Haliotis diversicolor* - a large marine snail) *'tokobushi'* (Alcantara and Noro, 2005). Similarly, In Korea, it has been reported from the Jeju Island, where it is harvested by women divers from natural populations for various purposes (Kim *et al.* 2016). Besides, in Indonesia, this species has been consumed traditionally as food in the form of sweetened jellies (Anggadiredja, 2009; Borlongan *et al.*, 2021).
***Therapeutic potentials*:** This species is also known to have several bio active compounds of the rapeutic importance. The extracts of *M. papulosa* has been shown to enhance Ig production by B cells, Tumor

Necrosis Factor (TNF) production by macrophages and stimulate human lymphoytes to proliferate (Liu *et al*., 1997; Mariya and Ravindran, 2013). The ketosteroidchole s t -4-en-3-one was isolated from this species as metabolic intermediate in the bioconversion of cholesterol to steroid hormones (Kanazawa and Yoshioka, 1971). The perusal of literature also revealed that the extract from *M. papulosa* was found to induce the proliferation of murine and human lymphocytes in vitro which could be applied clinically for the modulation of immune functions (Liu *et al*., 1997; Shan *et al*., 1999). The extracts of this species also exhibited antimicrobial activity (Lee *et al*., 2013) against *Helicobacter pylori* (a gram-negative, helical bacterium causing chronic gastritis, peptic ulcers, and gastric cancer) and anti-inflammatory activities (Khan *et al*., 2008). In Indonesia, this species has been used as herbal medicine for treatment of goiter, scrofula, and hemorrhoids (Anggadiredja, 2009; Borlongan *et al*., 2021). Besides, it is also interesting to note that this species contain light emitting substances, which has high potential applications in the generation of organic light-emitting diode (OLED) devices (Jung *et al*. 2015; Borlongan *et al*., 2021).

Conservation measures:

The utilization of any marine resources should be done in sustainable ways, keeping in view that its natural population in the wild should not be affected. Due to the over exploitation and uncontrolled harvesting of *M. papulosa* for various commercial purposes in Japan, its natural population have been decreasing (Shinmura and Tanaka 2008; Borlongan *et al*., 2021). Therefore, this species has been designated as a near-threatened category (NT) of the IUCN by the Japanese Ministry of Environment (Red List 4th edition in 2015 and 5th edition in 2020) and it has not been harvested in Jeju, Japan since 2007 (Kim *et al*., 2019; Yang *et al*., 2023). Moreover, climate change and global warming have altered the geographic distribution of macroalgae, greatly affecting their conservation and sustainable utilization (Zhou *et al*. 2023). Similarly, in Korea, the quantity of harvested raw materials of *Meristotheca papulosa* has continuously declined from 161 tons in 1990 to 11 tons in 2004 and no production was recorded after 2007 (Kim *et al*. 2019). Therefore, in order to overcome the problem of decline in natural population of *M. papulosa*, the Korean scientists are making efforts for restoration of this species and its sustainable utilization (Gao *et al*. 2017; Kim *et al*. 2019; Hwang *et al*., 2020). Besides, mariculture and several other measures and alternative methods such as experimental tank culture (Kimura, 1992; Ohno *et al*., 2002), callus induction and thallus regeneration (Huang and Fujita, 1997) and photosynthetic responses (Lideman *et al*., 2012; Borlongan *et al*., 2020) etc. have been developed for sustainable utilization of this promising alga.

In India, the utilization of this economically important alga is almost negligible, probably because of the lack of sufficient information and limited distribution of this species. Presently, there is no any report on the commercial cultivation and utilization of *Meristotheca papulosa* from any parts of the country. Therefore, more intensive research and innovations are required for the sustainable utilization of the potentiality of this promising marine resource, which would also support the livelihood activities of the coastal communities and contribute in the blue economy of the country.

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REFERENCES

Agardh, J. (1872). *Bidrag till Florideernessystematik*. Lunds Universitets Års-Skrift, Afdelningen for Mathematikoch Naturvetenskap, **8**(6): 1-60.

Google Scholar

Alcantara, L.B. and Noro, T. (2005).Effects of macroalgal type and water tem Haliotisperature on macroalgal consumption rates of the abalone diversicolor Reeve. *Journal of Shellfish Research*, **24**:1169-1177.

Google Scholar

Anggadiredja, J.T. (2009). Ethnobotany study of seaweed diversity and its utilization in Warambadi, Panguhalodo areas of East Sumba district. *Journal of Teknologi Lingkungan*, **10**: 297-310.

Google Scholar

Borlongan, I.A., Suzuki, S., Nishihara, G.N., Kozono, J. and Terada, R. (2020). Effects of light quality and temperature on the photosynthesis and pigment content of a subtidal edible red alga *Meristotheca papulosa* (Solieriaceae, Gigartinales) from Japan. *Journal of Applied Phycology*,**32**:1329-1340.

Google Scholar

Borlongan, I.A., Terada, R. and Hurtado, A. (2021).Concise review of the genus *Meristotheca* (Rhodophyta: Solieriaceae). *Journal of Applied Phycology*, **33:** 167-181. https://doi.org/10.1007/s10811-020-02288-w

Google Scholar

Chennubhotla, V.S.K., Rao, M.U. and Rao, K.S. (2013).Exploitation of marine algae in Indo-Pacific

region. *Seaweed Research and Utilisation*, **35** (1&2): 1-7.

Google Scholar

Chennubhotla, V.S.K., Rao, M.U. and Rao, K.S. (2013).Commercial importance of marine macro algae. *Seaweed Research and Utilisation*, **35** (1&2): 118-128.

Google Scholar

FAO (2014). *Specifications for certain food additives: Carrageenan*. FAO JECFA Monographs **16**. FAO and WHO, Rome, 7-12.

Google Scholar

Faye, E.J., Shimada, S., Kawaguchi, S. and Masuda, M. (2005).Characterization of the edible red alga *Meristotheca papulosa* (Solieriaceae, Gigartinales) from Japan. *Phycological Research*, **53**(3): 234-245.

Google Scholar

Fujiki, H. and Kikutani, M. (1977). Mucilaginous polysaccharides of the Solieriaceae family: part II. Chemical compositions and minimum concentrations for gelation of the polysaccharide fractions from *Meristotheca papulosa*. *The Japanese Society for Food Science and Technology*, **24**:179-185 (in Japanese with English abstract).

Google Scholar

Gao, X., Choi, H.G., Park, S.K., Lee, J.R., Kim, J.H., Hu, Z.M., and Nam, K.W. (2017). Growth, reproduction and recruitment of *Silvetia siliquosa* (Fucales, Phaeophyceae) transplants using polyethylene rope and natural rock methods. *Algae*,**32**: 337-347.

Google Scholar

Guiry, M.D. and Guiry, G.M. (2023).AlgaeBase.World-wide electronic publication, National University of Ireland, Galway.https://www.algaebase.org/ searched on 27 July 2023.

Google Scholar

Huang, W. and Fujita, Y. (1997). Callus induction and thallus regeneration of the red alga *Meristotheca papulosa* (Rhodophyta, Gigartinales). *Botanica Marina*, **40**: 55-61.

Google Scholar

Hwang, E. K., Choi, H. G. and Kim, J. K. (2020).Seaweed resources of Korea" *Botanica Marina*, **63** (4): 395-405. https://doi.org/10.1515/bot-2020-0007.

Google Scholar

Jha, B., Reddy, C.R.K., Thakur, M.K. and Rao, M.U. (2009). *Seaweeds of India: The Diversity and Distribution of Seaweeds in Gujarat Coast*. CSMCRI, Bhavnagar. 215 pp.

Google Scholar

Jung, S.M., Lee, H.S., Lee, H.J., Kang, S.G., Son, J.S., Jeon, J.H., Chae, H.B. and Shin, H.W. (2015). Screening and identification of bioorganic light-emitting substances from marine macrophytes. *Algae*,**30**: 171-179.

Google Scholar

Kanazawa, A. and Yoshioka, M. (1971).Occurrence of cholest-4-en-3-one in *Meristotheca papulosa* in red alga. *Bulletin of the Japanese Society for the Science of Fish*,**37**: 397-403.

Google Scholar

Kawaguchi, S. (2012).Other red algae. *In:* Watanabe MM *et al*. (eds) Handbook of algae - their diversity and utilization. NTS, Tokyo, 633-637 (in Japanese).

Google Scholar

Khan, M.N.A., Choi, J.S., Lee, M.C., Kim, E., Nam, T.J., Fujii, H. and Hong, Y.K. (2008).Anti-inflammatory activities of methanol extracts from various seaweed species. *Journal of Environmental Biology*, **29**: 465-469.

Google Scholar

Khan, S.I. and Satam, S.B. (2003). Sea weed Mariculture: scope and potential in India. *Aquaculture Asia*, **4**(4): 26-28.

Google Scholar

Kim, B.Y., Choi, H.G. and Ko, J.C. (2019). Growth and maturation of natural population of *Meristotheca papulosa* in Jeju Island. *Korean Journal of fisheries and aquatic sciences*, **52**: 59-66.

Google Scholar

Kim, J.K., Pereira, P. and Yarish, C. (2016). Tolerances to hypo-osmotic and temperature stresses in native and invasive *Gracilaria* species. *Phycologia*, **55**: 257-264.

Google Scholar

Kimura, O. (1992). Studies on producing seedling of *Meristotheca papulosa*: experiment on seed collection and indoor cultivation of *Meristotheca papulosa*. *Report on Kumamoto Prefect Fish Res Cent*,*Ohyano*, 47-50 (in Japanese).

Google Scholar

Lee, B.B., Choi, J.S., Moon, H.E., Ha, Y.M., Kim, M.S., Cho, K.K. and Choi, I.S. (2013).*Helicobacter pylori* Inhibition of growth and urease of by Korean edible seaweed extracts. *Botanical Sciences*, **91**:515-522.

Google Scholar

Lideman, N.G.N., Noro, T. and Terada, R.(2011). In Vitro Growth and Photosynthesis of Three Edible Sea weeds, Betaphycusgelatinus, Eucheumaserra and *Meristotheca papulosa* (Solieriaceae, Rhodophyta). *Aquaculture Science*, **59**(4): 563-571.

Google Scholar

Lideman, N.G.N., Noro, T. and Terada, R. (2012). Effect of temperature and light on the photosynthetic performance of two edible seaweeds: *Meristotheca coacta* and *Meristotheca papulosa*. *Aquaculture Science*, **60**: 377-388.

Google Scholar

Liu, J.N., Yoshida, Y., Wang, M.Q., Okay, Y. and Yamashita, U. (1997). B cell stimulating activity of seaweed extracts. *International Journal of Immunopharmacology*, **19**: 135-142.

Google Scholar

Maria, L.N.R, Dreckmann, K.M. and Sentíes, A. (2017). *Meristotheca cylindrica sp. nov*.

(Solieriaceae, Rhodophyta) from the southern Gulf of Mexico. *Phycologia*, **56** (4): 423-429.
Google Scholar

Mariya, V. and Ravindran, V.S. (2013). Biomedical and pharmacological significance of marine macro algae-review. *Indian Journal of Geo Marine Science*, **42**(5): 527-537.

McHugh, D.J. (2003). A guide to the seaweed industry. FAO Fisheries Tech. Paper: 441: 105.
Google Scholar

Montagne, C. (1850). Pugillusalgarumyemensium, quascollegeruntannis 1847-1849, clarr. Arnaud et Vaysière. Annales des Sciences Naturelles, *Botanique, Troisièmesérie***13**: 236-248.
Google Scholar

Nedumaran, T. and Arulbalachandran, D. (2014). Seaweeds: A Promising Source for Sustainable Development. *Environmental Sustainability*, 65-88.
Google Scholar

Ohno, M., Yano, M., Hiraoka, M., Oka, N. and Taniguchi, M. (2002). Tank culture of *Eucheuma serra* and *Meristotheca papulosa* using with deep sea water. *Bulletin of Marine Sciences and Fisheries, Kochi University*,**20**: 35-40 (in Japanese).
Google Scholar

Palanisamy, M., Yadav, S.K. and Murthy, G.V.S. (2020). *Seaweeds of Kerala coast, India*. Botanical Survey of India, Kolkata.i-lxxx + 200 pp.
Google Scholar

Pereira, L. (2016). *Edible seaweeds of the world*. CRC Press, Boca Raton. 463 pp.
Google Scholar

Pereira, L. (2018). *Therapeutic and nutritional uses of algae*. CRC Press, Boca Raton. 673 pp.
Google Scholar

Rao, P.S.N. and Gupta, R.K. (2015).*Algae of India, Vol 3: A checklist of Indian Marine Algae (Excluding Diatoms & Dinoflagellates)*. Botanical Survey of India, Kolkata.93 pp.
Google Scholar

Schmitz, F. (1889). Systematische Übersicht der bisherbekannten Gattungen der Florideen. *Flora oder Allgemeinebotanische Zeitung*, **72**: 435-456, pl. XXI.
Google Scholar

Shan, B.E., Yoshida, Y., Kuroda, E. and Yamashita, U. (1999). Immunomodulating activity of seaweed extract on human lymphocytes in vitro. *International Journal of Immunopharmacology*, **21**: 59-70.
Google Scholar

Shinmura, I. and Tanaka, T. (2008). Useful algae in Kagoshima prefecture III: Rhodophyceae. *Japanese Journal of Phycology*,**56**: 123-128 (in Japanese).
Google Scholar

Tseng, C.K. (2004). The past, present and future of phycology in China. *Hydrobiologia*, **512**: 11-20.
Google Scholar

Usov, A.I., Podkorytova, A.V. and Yoon, H.D. (2001). Structure of a sulfated galactan from *Meristotheca papulosa* (Rhodophyta, Solierieacea) from South Korea. Abstract 2.2.8 XVIIth International Seaweed Symposium, South Africa.
Google Scholar

Watt, N.J., Chiovitti, A., Craik, D.J. and Kraft G.T. (2003).The cell wall galactans from Australian representatives of the genus *Meristotheca* (Solieriaceae, Rhodophyta).*Phycologia*,**42**: 572-581.
Google Scholar

White, W.L. and Wilson, P. (2015).World seaweed utilization. In: Tiwari, B. and Troy, D. (eds) *Seaweed sustainability: food and non-food applications*. Academic Press, Cambridge, 7-26.
Google Scholar

Yadav, S.K. (2020). A Review on the economic potential of sea weeds in India. *International Journal of Advanced Research in Biological Sciences*,**7**(12): 15-28.
Google Scholar

Yadav, S.K. (2022). Sea weeds: Are these weeds or resources? *International Journal of Bioresource Science*, **9**(2): 69-73.
Google Scholar

Yadav, S.K., Palanisamy, M. and Murthy, G.V.S. (2015). Economically important seaweeds of Kerala coast, India - A Review. *Elixir Biosciences*,**82**: 32147-32152.
Google Scholar

Yadav, S.K., Palanisamy, M. and Murthy, G.V.S. (2018). New records of two red seaweeds from Kerala coast, India. *Indian Journal of Geo Marine Sciences*, **47**(05): 1042-1046.
Google Scholar

Yang, M.Y., Kang, J.C., Fujita, D. and Kim, M.S. (2023). Molecular phylogeny and genetic diversity of the economic seaweed *Meristotheca* (Gigartinales, Rhodophyta) in the northwest Pacific, with a description of *M. pilulaora* sp. nov. *Journal of Applied Phycology*. https://doi.org/10.1007/s10811-023-03135-4.
Google Scholar

Zhou, W., Li, B., Xu, H., Liang, Z., Lu, X., Yang, L. and Wang, W. (2023). Potential distribution of two economic laver species-*Neoporphyrahaitanensis* and *Neopyropiayezoensis* under climate change based on MaxEnt prediction and phylogeographic profiling. *Ecological Indicators*, **150**: 110219.
Google Scholar