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A Mini-Review: Metabolites of *Kappaphycus alvarezii*

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Abstrak

Tujuan dari makalah ini adalah untuk menyoroti pendekatan fisiologi dalam konteks studi rumput laut, khususnya Kappaphycus alvarezii. Pertama, ulasan mengenai rumput laut. Kedua, studi fisiologi dan metabolit pada rumput laut, terutama metabolit primer dan metabolit sekunder pada K. alvarezii dipaparkan dan dibahas. Sebagai kesimpulan, studi metabolit dapat memberikan sumber informasi utama yang dapat menjadi alat untuk menilai penerapan pendekatan berbasis bioteknologi untuk konservasi, industri, dan manajemen.

Abstract

The aim of this paper is to highlight physiology approach in in the context of seaweed studies, especially Kappaphycus alvarezii. First, introduction about seaweed are reviews. Second, physiology and metabolites studies in seaweed, especially primary metabolites, and secondary metabolites in K. alvarezii are presented and discussed. As conclusion, metabolites studies may provide key sources of information that can be tools to assess the application of biotechnological-based approaches for conservation, industry, and management

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1. Introduction

Given that roughly 44% of the world's population lives on or near the coast (United Nations Environmental Programme, 2010), seafood clearly is an important contributor to food security, particularly in coastal developing countries. The Republic of Indonesia's fisheries sector contributes significantly to the economies, livelihoods and food security of more than 60 million people who live within 30 km of the coast (Burke *et al*., 2012). Over the past several years, Indonesia's aquaculture sector has grown and has been identified and designated by government, but only a small percentage is currently developed and under active cultivation, to create jobs. As one of the largest seaweed producers in the world, the trend in seaweed production levels is experiencing fluctuations from 2011 to 2021 (Widi, 2022).

Currently, Indonesia is one of major producer *Kappaphycus* in the world, which also cultivate the greatest diversity of seaweed species. Indonesia and China are by far the largest seaweed producers with over 23 million tonnes of aggregated production. Indonesia also produces mainly the carrageenophytes *Kappaphycus* (Buschmann *et al.,* 2017). Moreover, *Kappaphycus* is one of Rhodophyta group, which one of the most ancient groups with fossil evidence stretching back billion years. Red algae have played in the earth evolution through secondary endosymbiosis. More than one billion years ago, red alga was the donor of the chloroplast in chlorophyll-*c* containing algae. These secondarily derived algae rose to prominence in marine ecosystems after the end of the Permian Period. (Vis *et al.*, 2010). Furthermore, several organisms exposed to different condition natural environment and different areas also have different characteristics. Therefore, the knowledge on *K. alvarezii* should be important to clarify their ecology in nature. This review will be focus on metabolites in *K. alvarezii* to more understand based on physiology studies.

2. Seaweed Physiology

Seaweed resources in Indonesia should be able to produce functional food products for community that contain nutrients, fiber, and high bioactive components. Therefore, the exploration of seaweed for pharmaceutical purposes should revealed important chemical prototypes for the discovery of new agents and new syntheses of compounds with biomedical application, providing both novel biologically active substances and essential compounds for human nutrition. Moreover, an increasing supply for seaweed extracts, fractions or pure compounds for the economic sector is needed. As a preliminary for future sustainability economic exploitation, both secondary and primary metabolisms have been studied (Cordoza *et al*., 2007). The primary metabolism is needed for synthesis of essential macromolecules, while the secondary metabolism is of restricted distribution (Dos Santos *et al*., 2005). The emergence of molecular biology tools, metabolic pathways have been clarified, paving the way for more understand physiology, especially seaweed metabolite by genetic engineering. (Cordoza *et al*., 2007).

Physiology of *Kappaphycus Alvarezii*

Red algae are economically important tropical seaweed which is highly demanded for its nutraceutical and pharmaceutical applications. Herein, author trying to discuss the primary and secondary of red algae namely *Kappaphycus alvarezii*. *K. alvarezii* is known for its ability to produce carrageenan; the hydrophilic colloid that can be obtained by aqueous extraction and commonly used as a stabilizer in cosmetics creams or food thickener. *K. alvarezii* also have been reported to demonstrate antibacterial properties against plant bacteria, possess antioxidant properties and has the ability to bind to mutagenic amines. (Seetharaman *et al*., 2016)

3. Primary Metabolites

Primary metabolites have roles that are essential. Primary metabolic pathway produces primary metabolites, which are directly involved in normal growth, development, and reproduction. As a part of the basic molecular structure of the cell, primary metabolites will be produced in generous quantities and have ubiquitous distribution to all organisms or cells. Primary metabolites many used in industrial that commonly developed during the growth phase, since energy metabolism are essential for growth. (Alamgir, 2018). Furthermore, agar and carrageenan are sulfated polysaccharides mainly extracted from Rhodophyceae; obtaining by water extraction from cell walls and intercellular matrix (Cordoza *et al*., 2007). These galactans have rheological features as gelling and thickening agents; making these sulfated polysaccharides are great commercial products that have been widely used in the food industry (Siahaan *et al*., 2018).

Agar

Agar is extracted from the cell wall of Rhodophyta (Alamgir, 2018). Agar is the a galactosan of agarobiose containing α(1–4)-3,6-anhydro-L-galactose and β(1–3)-D-galactose residues with a small amount of sulfate esterification (Cordoza *et al*., 2007). Agar is approximately 80% fiber that containing agaropectin and agarose; a high quality of agar, an essential material in genetic engineering and immunology (Siahaan *et al*., 2018). The low-quality agar is adopted in food products, industrial applications; the medium quality agar is utilized as the gel substrate in biological/medical/pharmaceutical; the most highly purified and upper market types are appliances for genetic engineering. The quality and content of agar depend on its specific physico-chemical characteristics but are also closely related to environmental parameters, growth and reproductive cycle. (Cordoza *et al*., 2007)

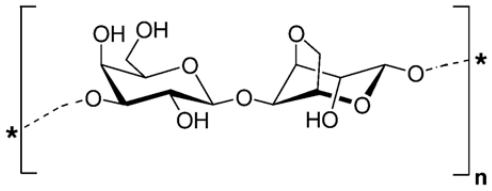

Figure 1. Agarose (Lee *et al.*, 2012)

Carrageenans

Carrageenans is commercially important highly sulfated polysaccharides (Renuga *et al*., 2013). Carrageenans or carrageenins are a family of high-molecular-weight linear sulfated polysaccharides that are extracted from Rhodophyta; having alternating backbone consisting of α(1–4)-3,6-anhydro-D-galactose and β(1–3)-D- galactose (Alamgir, 2018). They are water-soluble polysaccharides mostly containing more sulfates and their gel-forming properties are cation-dependent; exhibiting 30 to 75% of dry weight of seaweed cell walls (Siahaan *et al*., 2018). There are six forms of carrageenans most used in industry, namely, λ-carrageenan, ι-carrageenan, κ-carrageenan, μ-carrageenan, ν-carrageenan, and θ-carrageenan. Carrageenans are more widely used as emulsers/stabilizers in numerous foods (Hallmann, 2017). Carrageenans have several potential pharmaceutical uses, including antitumor, antiviral, antioxidant, anticoagulant and immunomodulation activities; λ-carrageenan showed promising antiviral activities toward diverse strains of HSV-1 and HSV-2 during virus attachment stage and λ-carrageenans also inhibited in vitro replication of the HIV (Siahaan *et al*., 2018). Currently, the market for carrageenan has grown. Moreover, *K. alvarezii* has been grown in large scale to supply carrageenan to the food industries (Cordoza *et al*., 2007).

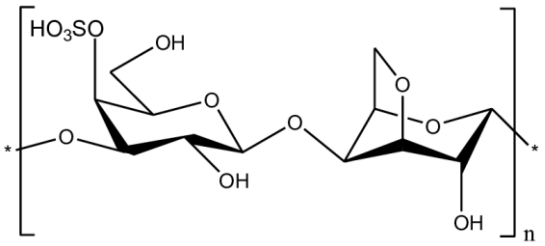

Figure 2. κ-Carrageenan (Solov'eva *et al.*, 2013)

4. Secondary Metabolites

In order to survive in a highly competitive environment, seaweed have to develop defence strategies that result in a tremendous diversity of compounds from different metabolic pathways (Cordoza *et al*., 2007). Moreover, secondary metabolites play an important role in seaweed to survive in a highly competitive environment (Alamgir, 2018).

Secondary metabolic pathway produces secondary metabolites that are typically organic compounds and are produced through the modification of primary metabolites. Secondary metabolites are not directly involved in growth and developmental processes, are not part of the basic molecular structure of the cell, are produced in small quantities and their extraction from the plant is difficult and usually performs important ecological function; secondary metabolites seem to be important primarily in ecological interactions with other species and between the plant and its environment; distribution is not ubiquitous to all organisms or cells. These are the most important active components of herbal drugs. Secondary metabolites are typically formed during the end or near the stationary phase of growth. Sometimes, it is difficult to distinguish between primary and secondary metabolites by either structure, biochemistry, or function. Plant growth regulators may be identified as both primary and secondary metabolites by because of their role in plant growth and development, a few of them are intermediates between primary and secondary metabolism. (Alamgir, 2018).

Marine organisms are a loaded source of biologically active and novel metabolites. Secondary metabolites produced by *K. alvarezii* may be importance future bioactive compounds in pharmaceutical industry. Phytochemical screening study of *K. alvarezii* extract revealed that the extract had significant quantity alkaloids, flavonoids, steroid and terpenoids (Renuga *et al*., 2013). In 2015, Kiruba and her colleagues showed that the presence of bioactive quinones, sterols and isoflavonols in *K. alvarezii*, lead to active inhibition of microbial growth in a dose-dependent manner. In 2016, Seetharaman showed that Phytochemical screening of *K. alvarezii* extract revealed that the extract contains significant quantity alkaloids, saponin, phenols, steroids, protein, phytosterols, amino acids, flavonoids, steroids, tannins that possessed antibacterial activities against the clinically isolated species of bacteria (*Staphylococcus aureus, Bacillus cereus, Pseudomons aeroginosa, Escherichia coli, Proteus vulgaris* and *Bacillus subtilis*). In 2017, Afif showed that active compounds in *K. alvarezii* indicated that 1-butanol fraction contains steroids and alkaloids. On the hand, Dolorosa also showed that *K. alvarezii* slurry also contain bioactive compound alkaloids and terpenoids in 2017. Mayore (2018) also showed that dried *Eucheuma denticulatum* and *K. alvarezii* extract with ethanol and methanol contained bioactive compounds; flavonoids, saponins, tannins, terpenoids, phenols and alkaloid. In several areas, *K. alvarezii* may containing heavy metals that are not suitable for food industries (Rajendran *et al*., 2023), instead it has the potential to be developed in pharmacology and agriculture industries, like poultry (Paul *et al*., 2020) and corn farming (Nivetha *et al*., 2024). Shihab (2023) also explained that *K. alvarezii* can do reduce inflammation treatment since it has inhibition of hyaluronidase enzyme. Furthermore, Dibha and her colleagues (2022) showed potential of *K. alvarezii* as a breast cancer drug by computational method.

Alkanoids are nitrogen-bearing molecules that make them particularly effective as medicines. Saponins are glycosides with foaming characters that have beneficial effects on human health. Phenolics are widely spread throughout the plant kingdom and having potential protective role against oxidative damage diseases. Flavonoids are anti-inflammatory, have function as shields against harmful UV radiation and maintain human healthy circulation. Tannins are widely

distributed in many plant species of plants and protect from predation and pesticides, and function in plant growth regulation. Tannins can contract the skin's tissue and thereby improving the skin's resistance to infection; have many therapeutic effects and are used in perfumes, food flavorings, and aromatherapy. (Alamgir, 2018)

5. Conclusion

Seaweeds are a possibly acceptable source of functional ingredients with biotechnology and medical applications are fully pursued and investigated of their biological activities by the scientist. Seaweed-derived bioactive materials have shown impressive biological activities. On the other hand, knowledge the particular structures and bioactivities relationship of seaweed-derived bioactive materials are still a big challenge. Therefore, physiology research is needed in development of seaweed bioactive materials in industries, conservation, and management.

Furthermore, development of seaweed processing into functional food product is an opportunity for seaweed potential application in Indonesia, which could increase the economic value of the seaweed and provide healthy food approach for community. Multidisciplinary study efforts are mandatory for increasing the understanding of the results that can be developed from seaweed resource, especialy *K. alvarezii*. Since *K. alvarezii* giving future assets for Industrial. Progressing research of *K. alvarezii* compounds is required to understand their biosynthesis and their biological effects. Metabolites studies in *K. alvarezii* may bring key sources of information that can be touch by future work to combat major challenges in seaweed cultivation; to contribute developing sound strategies for comparative research on *K. alvarezii*. Moreover, future studies should focus on metabolites studies of *K. alvarezii* that will be crucial to conservation, industry and management.

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