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Microalgae an Alternative Sustainable Source of Squalene

Squalene (dehydro triterpenic hydrocarbon, $C_{30}H_{50}$), an unsaponifiable lipid, is a basic intermediary metabolite for the biosynthesis of sterols and triterpenes in plants and animals. It is found in high abundance in certain fish oils, especially shark liver which contributes 50-60% of the world's production, with the rest coming from vegetable oils. The major end-users of squalene are the pharmaceutical, food, and cosmetics industries, and recently it has been widely used in flu vaccine production as an adjuvant. Estimated demand for squalene is 1,000-2,000 tons per annum. The livers of approximately 3000 sharks are typically required to produce just 1 ton. Nearly 6 million deep sea sharks are thus killed every year to meet the global demand, which is highly unethical. The global squalene market is projected to reach USD 211.7 million by 2021 and is predicted to register a CAGR of 10.2% between 2016 and 2021. Bloom, a non-profit organization dedicated to marine conservation, and The Food and Agricultural Organization (FAO) reported the over-exploitation of shark species for commercial reasons. Furthermore, shark liver, which is a major source of squalene (800mg g^{-1} oil), is expensive to extract in high purity for human use, free from contaminants such as polychlorinated biphenyls, polycyclic aromatic hydrocarbons, heavy metals (Mercury), and other fat-soluble toxins. In this context, the development of technologies for producing squalene from renewable biomass sources has received increasing attention.

Several plant oil sources, such as olive oil (around 30% of the global supply of squalene, containing 1.7-6.7mg g^{-1}), palm oil (0.25-0.54mg g^{-1}), and rice bran (2.5-3.0mg g^{-1}), have been used. However, they are characterised by low squalene content. The highest levels of squalene reported in plant oils is in Amaranth seeds (60-80mg g^{-1}) although the crop is not amenable to high volume commercialization. The production of squalene has also been proposed from microorganisms, particularly from the natural or genetically modified yeast *Saccharomyces*, but it is present in very low amounts (0.041 mg g^{-1} of biomass).

On the other hand, microalgae could be an alternative source for squalene since levels in the range of 30mg g^{-1} to 198 mg g^{-1} have been reported in genera of the Thraustochytriales, namely, *Thraustochytrium, Aurantiochytrium,* and *Schizochytrium*. These microalgae produce squalene under heterotrophic conditions and may, therefore, be manipulated through fermentation. The addition of exogenous chemical stimulators, namely terbinafine and the oxylipin, methyl jasmonate, resulted in an increased yield of squalene by 43% and 60% respectively. Hence squalene accumulation can be enhanced by media manipulation. By comparison, quantification of squalene in photoautotrophic green alga, e.g. *Botryococcus* sp., *Chlamydomonas* sp., is lacking although the key genes responsible for squalene synthesis have been reported. My research focuses on large scale screening of the squalene content and other high value products from microalgae, towards restoring the marine ecosystem and reducing the dependence on shark or other fish based products.