



Protein-Protein Docking Studies on Magnesium Chelatase of *Ulva fasciata* Against the Human TSHR Protein

Aarchana. G ^{a++} and Sundararaj. R ^{a#}

^a Department of Botany, Government Arts College for Men (Autonomous) Nandanam, Chennai-600035, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The course and prognosis of hypothyroidism in humans are affected by the most common mutation in the hypothyroid protein, TSHR. To facilitate the potential mutant TSHR's interaction with *Ulva fasciata*'s magnesium-chelatase, we utilize 3D *In silico* drug docking approaches. The purpose of the entire research work is to introduce the seaweed protein against the human TSHR protein using *In silico* protocols. The translated amino acid sequence and three-dimensional chemical compound were taken from the NCBI database to perform drug docking procedures. In post-docking tests, advanced 3D molecular visualization capabilities were utilized. In post-docking tests, advanced 3D molecular visualization capabilities were utilized. The findings of the docking investigation indisputably demonstrate that amino acid mutational sites are directly suppressed by magnesium chelatase. The H-bond interaction between TSHR and magnesium chelatase is shown in three dimensions utilizing concepts from molecular dynamics techniques. Ultimately, we found that *Ulva fasciata*'s pharmaceutical ingredient, magnesium chelatase, aids in the treatment of

⁺⁺ Ph.D. Research scholar, PG & Research;

[#] Associate Professor, PG & Research;

*Corresponding author: Email: archanamsc.bt@gmail.com;

hypothyroidism. Hence, we finally conclude that one of the main endocrine hormonal problems is hypothyroidism, and our research serves to demonstrate how well the seaweed *Ulva fasciata* works as a unique medicinal agent to treat this disorder.

Keywords: TSHR; *Ulva fasciata*; protein–protein docking.

1. INTRODUCTION

Thyroid-associated ophthalmopathy, also called Graves' orbitopathy (GO), is a relatively uncommon condition, with an incidence of 2.67–3.3 cases/100,000/year in females and 0.54–0.9 cases/100,000/year in males [1]. The incidence of GO varies depending on the testing method used to diagnose GO, such as clinical signs and symptoms, physical examination, and imaging techniques. It affects approximately 25% to 50% of patients with Graves disease (GD). Eye discomfort, photophobia, hazy vision, increased tear production, and double vision are common signs of GO. One or both eyes may be affected by GO's periorbital oedema, exophthalmos, eyelid recession, and alterations in eye motility. A significant portion of GO patients—roughly 5–6%—have compressive optic neuropathy or potentially blinding corneal ulcerations; these individuals may go blind. Although GO can occur at any age, it most frequently affects women between 30 and 50 years old [2]. However, men and individuals who receive a diagnosis later in life tend to have more severe cases of GO [3]. Smoking, high cholesterol, thyroid dysfunction, radioiodine therapy, low thyroid peroxidase antibodies (TPOAbs), high thyrotropin receptor antibodies (TRAbs), and low thyroglobulin antibodies (TgAbs) are traditional risk factors for GO. High thyroglobulin (Tg) [4], a selenium deficit, an imbalance in the intestinal flora, and elevated levels of *Yersinia enterocolitica* and *Escherichia coli* in the digestive tract are new risk factors for GO [5].

The biological and chemical potential of seaweeds has been covered in other papers [6-9,1-4]. Global seaweed aquaculture has generated about 30 million tons of fresh biomass in the last few decades, with a projected market value of over \$13.3 billion. More than 95% of the seaweed produced worldwide is farmed by *Laminaria/Saccharina* (35.4%), *Kappaphycus* and *Eucaema* (33.5%), *Gracilaria* (10.5%), *Porphyra* (8.6%), and *Undaria* (7.4%) [10]. Seaweeds, therefore, represent a prospective millennium market with a number of social,

economic, and ecological advantages [5,6]. Coral reefs have lost up to 67% of their historical global range, making them one of the planet's most threatened ecosystems. Furthermore, human activity and the consequences of climate change threaten the remaining intact coral reef systems, as reported in a recent report by the Global Coral Reef Monitoring Network [11,12]. Prior studies suggest that coral's secondary metabolites may have cytotoxic, anti-inflammatory, antifouling, and antimicrobial properties and benefits for bone repair and the nervous system [13,14,15,16].

Our investigation detailed the molecular interactions between the sea weed protein of *Ulva fasciata* and the human Thyroid Stimulating Hormone Receptor (TSHR). The final results clearly showed the mechanism of inhibition of magnesium chelatase with the Thyroid Stimulating Hormone Receptor.

2. METHODOLOGY

Target selection: Data from the NCBI Genpept database (YP_009220447.1 magnesium-chelatase (*Ulva fasciata*) and (AAI20973.1 TSHR protein (Human)) were utilized to conduct a molecular drug docking study. A powerful molecular visualization application called Discovery Studio was used to anticipate three-dimensional structures.

Protein Docking: HDock, an automated molecular drug docking service (<http://hdock.phys.hust.edu.cn/>), has been used in molecular drug docking research [17]. Using a 3D molecular dynamics method, the molecular affinities of TSHR protein and YP_009220447.1 magnesium-chelatase (*Ulva fasciata*) in human hypothyroidism were ascertained.

Protein–Protein docking: Post-docking experiments were conducted with the Discovery Studio software. A thorough analysis of the three-dimensional image based on the docking score (3D H-bond/Electrostatic interactions) was carried out using the molecular dynamics concept.

3. RESULTS AND DISCUSSION

The amino acid sequences corresponding to the gene-coded proteins of photosystem II protein D1 (*Ulva fasciata*) and TSHR are 349 aa and 231 aa, respectively (Fig. 1 and 2). In our research work, we use the potential inhibitor derived from algae (*Ulva fasciata*).

Marine macroalgae are eukaryotic, macroscopic, multicellular, photosynthetic organisms that are classified as belonging to the order Plantae. Seaweed is another name for these creatures. In addition to the seabed or solid rock strata beneath it, these salt-loving marine plants can also be found on the surfaces of rocks, corals, shells, pebbles, and other plants. In oceanic places where light is most abundant, marine algae typically thrive in the tidal and subtidal zones. Because of their easy response to physiological changes by creating stress-tolerant chemicals, they can endure extreme temperatures, cold temperatures, UV radiation, salinity, and desiccation. A multitude of primary and secondary metabolites are produced by them as a result of their survival. Numerous physiologically active substances with a range of

therapeutic advantages can be found in marine algae [18,19].

The complex form of the TSHR protein retrieved via the H-Dock server and photosystem II protein D1 have a 3D docking score of -256.01 kcal/mol , (Fig. 3) as illustrated in Fig. (1). Using Discovery Studio software, the H-bond interactions between photosystem II protein D1 and the TSHR protein are displayed in detail (Fig. 4,5,6,7,8). It is clear from this image that the TSHR protein and the photosystem II protein D1 protein structure have interacted non-covalently. Therefore, it may be said that, as demonstrated by earlier research, the TSHR protein will be downregulated. Our docking studies are consistent with a number of prior investigations [17-22].

Our retrieved protein's functional domain area is the *Ulva fasciata* 46 SER (44-51) *ATP/GTP-binding site motif A (P-loop)* (PS00017). Our research demonstrates that gentamicin, an antibiotic, interacts directly with the domain areas. Our study unequivocally demonstrated that the following amino acids are present at the drug-protein binding region: ARG:46, THR:40, ARG:241, GLU:34, TYR:244, GLN:33 [23-26].

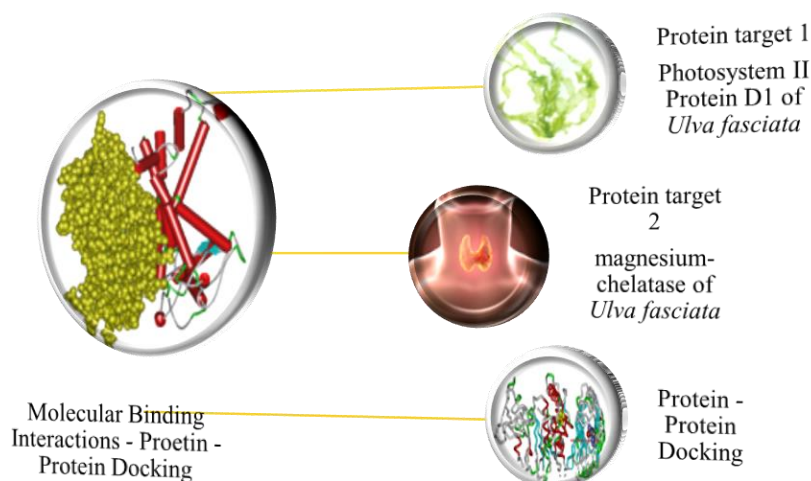


Fig. 1. Diagrammatic representations of the overview of the *Insilico* research work

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>YP_009220447.1 magnesium-chelatase subunit ChlI (chloroplast) [Ulva
fasciata]
MSEKIELESRPVFPFTSIVGQEEMKLLALILNVIDPKIGGVMVMGDRGTGKSTTVRALSDDLPLDMKVVAND
PFNSDPNDPELMSDEVADKIKNNKTLEIETKKIPMIDLPLGATEDRVCGTIDMEKALTEGKAFEPGLLA
SANRGILYVDEVNLLDDHLVDVLLDSAASGWNTVEREGISISHPARFILVSGNPEEGELRPQLLDRFGM
HAEIRTVKEPDLRVQIVEQRAAFDSDPIEFRNNYSESQKTLSEKIVKARELLKEVDLNYEFRIKISQICS
ELNVDGLRGDIVTNRAAKALTAFEGRNEVTAQDIFRVIPLCLRHLRKRKDPLETIDSGDKVRDIFKKIFS
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Fig. 2. Amino acid sequence of the sea weed, *Ulva fasciata*

>AAI20973.1 TSHR protein [Homo sapiens]
 MRPADLLQLVLLLLDLPRDLGGMGCSPPCECHQEEDFRVTCKDIQRIPSLPSTQTLKLIETHLRTIPSH
 AFSNLPNISRIYVSIDVTLQQLSHSFYNLSKVTHIEIRNTRNLTYIDPDALKELPLLKFLGIFNTGLKM
 FPDLTKVYSTDIFFILEITDNPYMTSIPVNAFQGLCNETLTLKLYNNGFTSVQGYAFNGTKLDAVYLNKN
 KYLTVIDKDAFGGVYSGPSLL

Fig. 3. Amino acid sequence of human TSHR protein

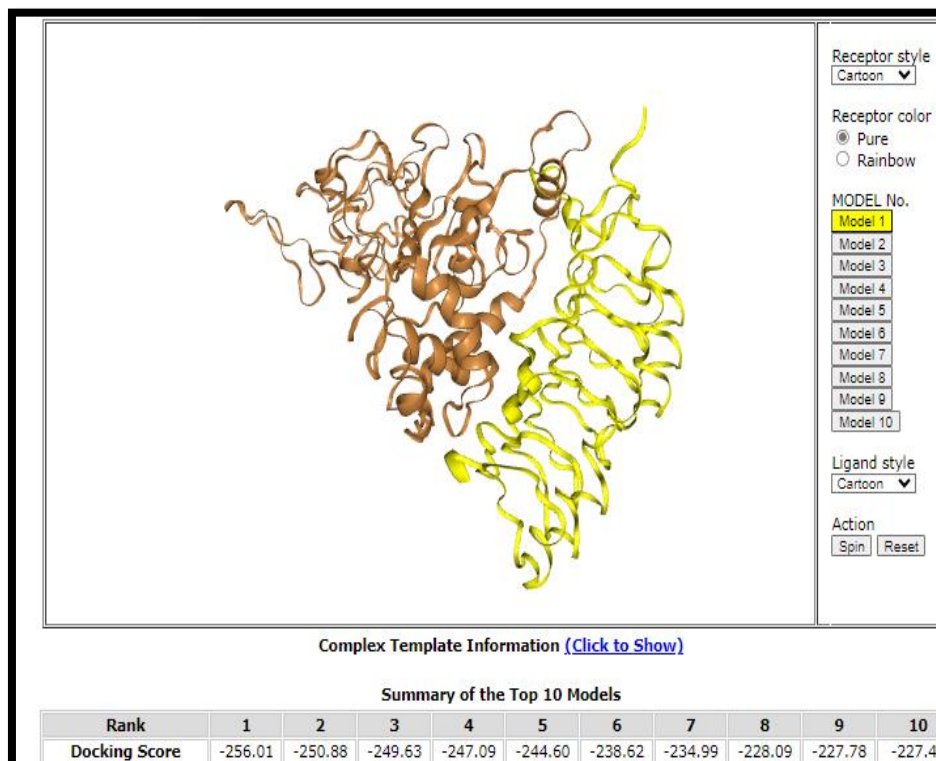


Fig. 4. Complex form of human TSHR protein and YP_009220447.1 magnesium-chelatase of *Ulva fasciata* viewed using H-Dock server with respective binding scores

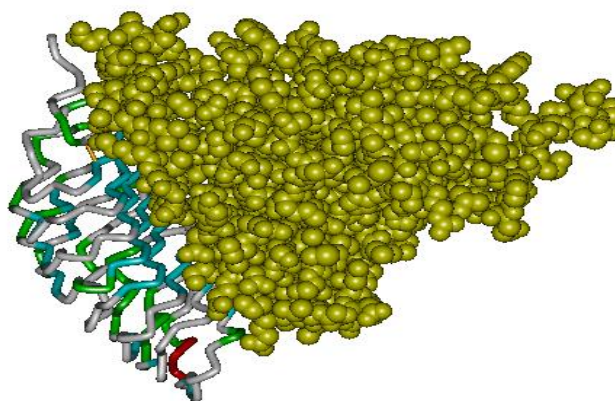


Fig. 5. Complex form of human TSHR protein and YP_009220447.1 magnesium-chelatase of *Ulva fasciata* viewed using Discovery Studio Software. Yellow coloured structure represents the TSHR protein

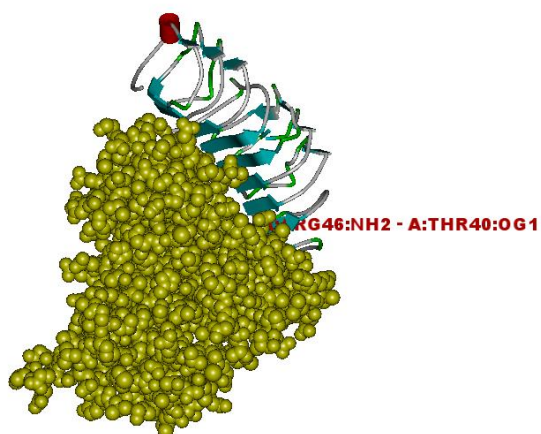


Fig. 6. 3D Complex form of human TSHR protein and magnesium-chelatase of *Ulva fasciata* viewed using Discovery Studio software (Binding Interaction Mode)

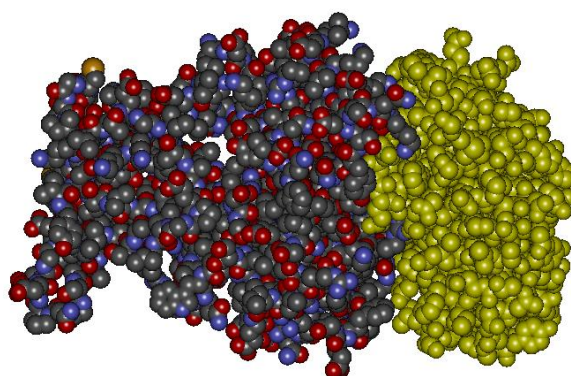


Fig. 7. 3D Complex form of human TSHR protein and magnesium-chelatase protein of *Ulva fasciata* viewed using Discovery Studio software (Binding Interaction Mode with respective amino acid labels/positions)

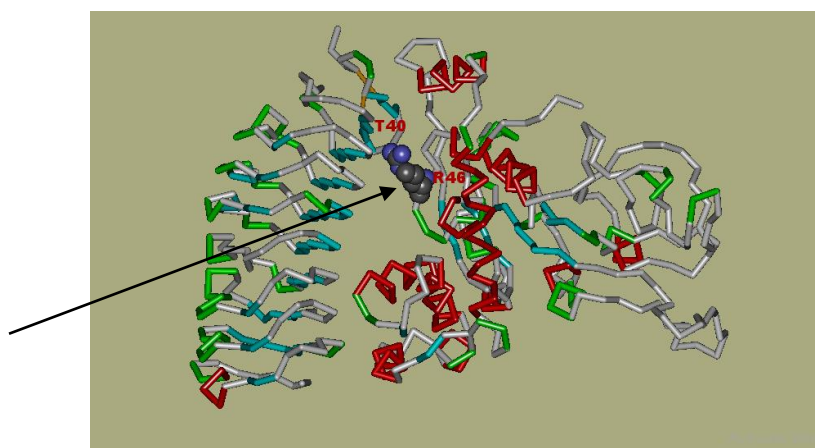


Fig. 8. 3D Complex form of human TSHR protein and magnesium-chelatase protein of *Ulva fasciata* viewed using Discovery Studio software (Arrow mark indicates the Amino acids interacting at Domain and Motif)

4. CONCLUSION

Our research clearly shows that the human hypothyroidism protein, TSHR, and the seaweed protein interact. Our unambiguous docking data clearly show that the *Ulva fasciata* magnesium-chelatase binds well to the functional domain area of the TSHR protein. The binding connection between magnesium-chelatase and TSHR protein, as determined by docking scores, defines the H-bond interaction precisely. Consequently, we draw the conclusion that the protein found in *Ulva fasciata* seaweed serves as a potential endocrinological drug that alleviates the symptoms of hypothyroidism in people. Our Insilico work unequivocally demonstrates that magnesium-chelatase may have pharmacological effects on the human TSHR protein.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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