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EUGLENA SP. – A COMPREHENSIVE REVIEW ON THE HABITATS, CHARACTERISTICS, NUTRITIONAL VALUES, COMMERCIALIZATION OPPORTUNITIES AND CONSERVATION STATUS

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Abstract:

This study comprehensively reviews various facets of Euglena sp., encompassing its distribution, characteristics, nutritional values, commercialization opportunities, and conservation status. Studying distribution patterns provides valuable information on the various habitats where Euglena sp. can be found, enhancing our knowledge of its biological range. Thorough examinations of its morphological and physiological traits offer a detailed depiction of this microbe. Uncovering Euglena sp.'s nutritional values reveals its potential as a rich source of proteins, lipids, and essential vitamins, positioning it as a promising candidate for applications in the food, feed, pharmaceuticals, and biofuel industries. The review finds and discusses potential commercialization opportunities based on Euglena sp.'s valuable attributes. Notably, the absence of a specific conservation status emphasizes the need for broader conservation measures, recognizing the ecological significance of microorganisms in ecosystem dynamics. This research contributes to a holistic understanding of Euglena sp., offering valuable insights for ecological, biotechnological, and conservation considerations.

Keywords:

Characteristics, Commercialization, Conservation, Euglena, Habitat, Microalgae, Nutrition

Introduction

Microalgae can be used as a sustainable, renewable, and alternative source of raw materials for biofuels. Microscopic, photosynthetic organisms that can thrive naturally in watery environments are called unicellular microalgae. Most microalgae are eukaryotic and photosynthetic due to their chlorophyll pigments that support photosynthesis. (Erfianti et al., 2023). The *Euglenaceae* family exemplifies how microalgae may adapt to harsh environmental conditions, such as highly acidic environments, by converting sunlight into chemical energy. Approximately 35,000 species of microalgae have been documented in literature, with an estimated total of 200,000 to 800,000 species on Earth (Guo et al., 2019). One of the freshwater microalgae that grows readily in tropical climates is *Euglena sp*. These microalgae can thrive in heterotrophic environments and can travel with the help of their flagella to access light and nutrient sources (Timotius et al., 2022). *Euglena* sp. can be commercially viable for large-scale

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cultivation since it rapidly produces several metabolites such as feed protein, paramylon-form carbohydrates, and lipids from its biomass. The microalgae contain elevated levels of carotenoid and chlorophyll pigments. (Gissibl et al., 2019). Euglenas inhabit brackish and freshwater environments, such as ponds with an abundance of organic waste. Certain species in lakes or ponds can produce red or green "blooms" (Belfiore et al., 2021).

Insufficient information and evidence exist regarding the distribution, features, nutritional values, marketing prospects, and conservation status of *Euglena* sp. Euglena sp. poses a multifaceted challenge because of its wide distribution, distinctive traits, and potential for commercial use. Widely found in aquatic environments, the lack of a comprehensive understanding of its distribution hampers effective conservation efforts. Euglena's remarkable characteristics, such as photosynthesis and nutrient-rich composition, offer promising nutritional benefits and commercialization opportunities, particularly in the food and biofuel industries. However, the exploitation of Euglena raises concerns about its conservation status, as large-scale cultivation may affect ecosystems. Various microalgae species offer variable amounts and types of lipids, protein, and carbohydrates, which can be influenced by changing their growth circumstances (Gonçalves et al., 2014). Striking a balance between harnessing its commercial potential and ensuring sustainable practices is crucial for addressing the intricate interplay of distribution, characteristics, nutritional values, and conservation status within the context of *Euglena* sp.

The aim of this review highlights the recent findings on the distribution, characteristics, nutritional values, commercialization opportunities and conservation status of *Euglena* sp., This review thoroughly examines *Euglena* sp., providing useful insights into its ecological importance, its uses, and the necessity for a comprehensive approach to conservation efforts that include microorganisms. The findings enhance the existing knowledge base, guiding future study and aiding decision-making in ecology, biotechnology, and conservation.

Methodology

The data collection for this manuscript entailed the methodical extraction of information from electronic databases, namely Google Scholar (https://scholar.google.com/), PubMed (https://pubmed.ncbi.nlm.nih.gov/), Scopus (https://www.scopus.com/), and ResearchGate (https://www.researchgate.net) (Shaik Farid et al., 2024). The search queries utilized in these databases incorporated keywords such as *Euglena* sp.,' 'distribution of *Euglena* sp.,' 'health benefits of *Euglena* sp.,' 'medical properties of *Euglena* sp,' 'ecology of *Euglena* sp,' 'commercialization of *Euglena* sp.,' 'phytoremediation in *Euglena* sp.,' and 'Conservation status of *Euglena* sp.

Findings

Geographic Distribution of Euglena sp.

Euglena sp. is distributed worldwide, primarily in freshwater environments, although some species can also be found in brackish water and marine habitats (Esteban et al., 2015). These single-celled organisms are commonly found in ponds, lakes, slow-moving rivers, and other freshwater bodies where the conditions are conducive to their growth. Euglena species thrive in a variety of water conditions, ranging from slightly acidic to slightly alkaline, and they are often associated with organic-rich environments.

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The distribution of *Euglena* sp. is influenced by factors such as sunlight availability, temperature, and nutrient levels (Reddy et al., 2023). These organisms are phototrophic, relying on sunlight to perform photosynthesis, which is a crucial process for their survival. As a result, Euglena sp. tends to be more abundant in surface waters where sunlight penetrates, allowing them to synthesise nutrients.

Euglena's adaptability to a wide range of environmental conditions contributes to its global distribution. This adaptability, coupled with its ability to form resting cysts that can survive harsh conditions, enables Euglena to persist in different ecosystems (Kings et al., 2017). However, the specific distribution patterns can vary among distinct species of Euglena, emphasising the importance of detailed studies to understand the ecology and geographical ranges of individual taxa. Such insights are essential for effective conservation and management strategies, especially in the face of environmental changes and potential anthropogenic impacts on aquatic ecosystems. Table 1 shows the distribution of *Euglena* sp.

Table 1: Distribution of *Euglena* sp.

Findings	Authors (Year)
Highlighted that *Euglena* sp. is widely distributed in freshwater environments.	Sultana et al. (2024)
Reported the presence of *Euglena* sp. in areas with high organic content.	Häder & Hemmersbach (2022)
Identified *Euglena sp.* in marine environments, including coastal waters and brackish habitats, indicating a broad adaptability.	Hernández Márquez et al. (2024)
Found *Euglena* sp. in extreme environments such as hot springs and regions with low pH, demonstrating its extremophilic nature.	Sittenfeld e. al. (2002)
Documented *Euglena* sp. in polluted water bodies, including industrial wastewater, where it acts as a bioindicator.	Nam et al. (2023)

Characteristics of Euglena sp.

The microorganism Euglena has specific characteristics that makes it an intriguing species (Bio, 2023). There are 152 various kinds of species in the general group that is the Euglena genus. It is an organism with small flagella, which resemble whip-like tails and aid in movement. Its cell wall is not rigid, in contrast to other organisms. Although Euglena does not have a cell wall, its chloroplasts are usually well defined. Euglena can perform photosynthesis because of these unique structures, which are like those found in plants. Euglena can use sunlight to generate its own energy through this process. Euglena's food could vary under certain situations. In a lack of sunlight and in the presence of organic matter, Euglena feeds on other protozoans. Euglena has an uncommon ability to alter its features. Heat and antibiotic streptomycin may reduce levels of chlorophyll in Euglena. It could change its state from plant-like to animal-like. Figure 1 shows a diagram of *Euglena* sp.

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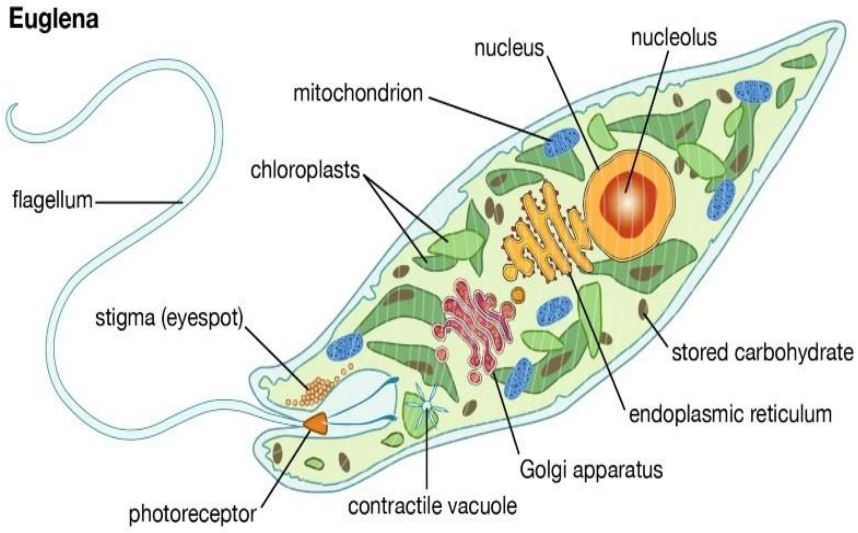

Figure 1: A Diagram of *Euglena* sp.

Source: Encyclopædia Britannica (2025)

Nutritional values of Euglena sp.

It is crucial to examine the various nutritional components in every species of Euglena to evaluate their nutritional worth. A wide range of nutrients, including vitamins, minerals, amino acids, unsaturated fatty acids, and the β-glucan paramylon, are known to be present in *Euglena* sp. (Umei et al., 2022; Nwoye et al., 2017; Bianchi et al., 2015). *Euglena* sp. has been shown to require both vitamin B12 (cyanocobalamin) and vitamin B1 (thiamine) in their natural environment. (Al-Ashra et al., 2014). Furthermore, Euglena gracilis has been found to be rich in alpha-tocopherol, making up more than 97% of all the tocopherols accumulated by this species (Ogbonna, 2009). Paramylon, a storage polysaccharide present in Euglena, has been recognized for its prebiotic properties. (Bhattad et al., 2021).

Euglena species exhibit several types of nutrition, such as autotrophy, heterotrophy, and mixotrophy (Chen et al., 2022b). This diversity in nutritional modes further emphasizes the need to comprehensively study the nutritional values of different Euglena species.

Euglena sp. includes a variety of essential elements including vitamins, minerals, amino acids, unsaturated fatty acids, and paramylon. The several ways in which different *Euglena* sp. obtain nutrition highlight the need of fully understanding their nutritional composition. Table 2, Table 3, Table 4, Table 5 and Table 6 show the presence of vitamin, mineral, amino acids, fatty acids and paramylon respectively.

Table 2: Presence of Vitamin in *Euglena* sp.

Findings	Authors (Year)
Identified the presence of B-vitamins, especially B12 and folic acid, in *Euglena* sp., highlighting its potential as a source of these vitamins.	Inwongwan et al. (2019)
Found that *Euglena* sp. contains vitamin E and carotenoids, suggesting its potential as a natural supplement for antioxidants.	Tamaki et al. (2022)

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Highlighted the presence of vitamins A, C, and E in *Euglena* sp. and their role in promoting human health, particularly in preventing oxidative stress.	Bedard et al. (2024)
Reported on the prominent levels of thiamine and riboflavin in *Euglena* sp., suggesting its potential as a natural source of these B-vitamins for supplementation.	Watanabe et al. (2017)
Highlighted the bioavailability of vitamin B12 in *Euglena* sp. and its use in addressing B12 deficiencies, especially in plant-based diets.	Mollin et al. (1976)

Table 3: Presence of Mineral in *Euglena* sp.

Findings	Authors (Year)
Reported concentrations of iron and magnesium in *Euglena* sp.	Kings et al. (2017)
Reported the presence of zinc in *Euglena* sp.	Falchuk et al. (1975)
Highlighted the accumulation of zinc and copper in *Euglena* sp.	Einicker-Lamas et al. (2002
Highlighted calcium effect in *Euglena sp.* under different growth conditions	Murray, J. M. (1979)
Analysed potassium accumulation in *Euglena* sp.	Fan et al. (2022)
Highlighted manganese as a significant trace element in *Euglena sp.*	Fan et al. (2022)
Found elevated levels of sodium in *Euglena* sp.	Bedard et al. (2024)

Table 4: Presence of Amino Acids in *Euglena* sp.

Findings	Authors (Year)
Highlighted the presence of essential amino acids like leucine and lysine in *Euglena* sp.	Moniruzzaman et al. (2023)
Highlighted a concentration of glutamine and arginine in *Euglena sp.*	Yoshioka et al. (2020)
Highlighted the presence of non-essential amino acids, such as alanine and aspartic acid, in *Euglena* sp.	Kott & Wachs (1964)
Analysed amino acid profiles and found significant amounts of methionine and phenylalanine in *Euglena* sp.	Zhu et al. (2024)
Highlighted the amino acid composition of *Euglena* sp. and found a balance between essential and non-essential amino acids	Umetani et al. (2024)
Highlighted *Euglena sp.* has the ability to synthesize various amino acids under dark and anaerobic conditions	Yoshioka et al. (2020)

Table 5: Presence of Fatty Acids in *Euglena* sp.

Findings	Authors (Year)
Reported of unsaturated fatty acids, including oleic acid and linoleic acid, in *Euglena* sp.	Erfianti et al. (2024)
Highlighted of palmitic acid and stearic acid in *Euglena sp.* cultures	Astiti at al. (2025)
Reported the presence of both omega-3 (α-linolenic acid) and omega-6 fatty acids in *Euglena* sp.	Kang et al. (2023)

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Highlighted of docosahexaenoic acid (DHA) in *Euglena sp.* under specific growth conditions	Erfianti et al. (2024)
Highlighted fatty acid profiles and identified the presence of palmitoleic acid and arachidonic acid in *Euglena* sp.	Ruampatana et al. (2025)

Table 6: Presence of Paramylon in *Euglena* sp.

Findings	Authors (Year)
Reported paramylon as a major polysaccharide in *Euglena* sp., noting its role in energy storage.	Gissibl et al. (2019)
Highlighted the biosynthesis pathway of paramylon in *Euglena* sp., emphasizing the enzymes involved.	Singla et al. (2024)
Highlighted the structure of paramylon and its potential application in biotechnology and medicine.	Bhattad et al. (2021)
Reported the accumulation of paramylon increases under stress conditions, such as high light intensity.	Feuzing et al. (2022)
Investigated the effects of nitrogen deprivation on paramylon production in *Euglena* sp.	He et al. (2025)

Commercialization Opportunities of Euglena sp.

The commercialization of Euglena presents numerous opportunities for the development and production of commercial products. *Euglena gracilis,* a flexible photosynthetic single-celled organism, has emerged as a promising prospect for research and commercial use. (Xia et al., 2021). It has the capability to synthesize essential amino acids, which have considerable commercial applications (Rodríguez-Zavala et al., 2010). *Euglena gracilis* is a valuable source of commercially significant metabolites, including vitamins, wax esters, paramylon, and amino acids. (Khatiwada et al., 2020). It is considered a highly promising species for use as microalgal feedstock in functional meals and biofuels. (Toyama et al., 2019). The potential for biodiesel production from *Euglena gracilis* is also highlighted, given its high fatty acid content (Chen et al., 2022a). The commercialization of Euglena production is focused on the "5Fs of Biomass" strategy, which involves developing and producing commercial items including food, fibre, feed, fertilizer, and fuel from biomass. (Suzuki, 2017).

Other Euglena species have untapped industrial potential, offering additional opportunities for commercialization apart from *Euglena gracilis*. (Suzuki et al., 2015). Additionally, the metabolic network capacity of Euglena is not well understood, indicating the necessity for more research to maximize its commercial potential. (Inwongwan et al., 2023).

The commercialization prospects for *Euglena* sp., namely *Euglena gracilis*, are extensive and varied, encompassing the creation of bioactive substances for food, dietary supplements, and biofuels, as well as its prospective use in bioremediation and biorefineries. Yet, the production expenses for microalgae biomass, such as Euglena, are still deemed excessive for broad commercial use (Pôjo et al., 2021). Additionally, there are limitations in some countries about the sale of extracts or metabolites from selected species, including *Euglena gracilis* (Rumin et al., 2021). Therefore, while there are significant commercialization opportunities for Euglena, there are also challenges that need to be addressed to fully realize its commercial potential. Table 7 shows the commercialization prospects for *Euglena* sp.

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Table 7: The Commercialization Prospects for *Euglena* sp

Findings	Authors (Year)
Highlighted the use of *Euglena* sp. as a sustainable feedstock for biofuel production due to its high lipid content.	Kim et al. (2023)
Highlighted that *Euglena* sp. can serve as an alternative feedstock for protein-rich animal feed, especially in aquaculture.	Kottuparambil et al. (2019).
Examined *Euglena* sp. as a source of essential fatty acids, particularly omega-3, which are important for both human and animal nutrition.	Mahapatra et al. (2013)
Highlighted the potential of *Euglena* sp. as a feedstock for the production of functional foods and nutraceuticals due to its unique composition.	Kottuparambil et al. (2019)
Highlighted *Euglena* sp. as a feedstock for bioplastics materials, due to its high carbohydrate content, especially paramylon.	Lisha et al. (2022)

Current Conservation Status of Euglena sp.

As of the latest available information, there is no specific conservation status assigned to Euglena sp. The conservation status of microorganisms, including Euglena species, is not regularly assessed, or reported, as conservation efforts typically focus on more complex organisms with distinct ecological roles. In the case of Euglena, a genus of single-celled organisms, the lack of a designated conservation status does not imply insignificance; rather, it reflects the current emphasis on the conservation of higher organisms with more extensive ecological and conservation data available. As microorganisms play vital roles in ecosystem processes, broader conservation measures aimed at preserving habitats and overall biodiversity indirectly contribute to the well-being of *Euglena* sp. and other microscopic life forms.

Recommendation for Future Works Regarding Euglena sp.

Based on the comprehensive review of the distribution, characteristics, nutritional values, commercialization opportunities, and conservation status of *Euglena* sp., several key recommendations appear. Firstly, given the importance of Euglena sp. in various ecosystems and its potential as a nutrient-rich microorganism, there is a need for increased research efforts to further understand its ecological role and nutritional benefits. This could involve targeted studies on its interactions within aquatic environments and its potential applications in the food and feed industries.

Secondly, considering the emerging interest in microorganisms for sustainable nutrition, exploring commercialization opportunities for *Euglena* sp. is essential. Collaborative efforts between researchers, industries, and policymakers can help the development of innovative products, such as functional foods or supplements, harnessing the nutritional attributes of *Euglena* sp. These initiatives could contribute not only to economic opportunities but also to the promotion of sustainable and nutritious dietary practices.

Additionally, despite the current lack of a designated conservation status for *Euglena* sp., proactive conservation measures are recommended to ensure the preservation of its habitats and overall biodiversity. This may involve incorporating microorganisms like *Euglena* sp. into broader conservation strategies, as their roles in ecosystem functioning are integral.

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In summary, the findings of this review underscore the need for a multidisciplinary approach that integrates ecological understanding, commercial exploration, and conservation considerations in further research and policy development related to *Euglena* sp. This approach can foster a holistic understanding of the organism and maximize its potential benefits for both environmental sustainability and human nutrition.

Conclusion

In conclusion, the study delved into a comprehensive examination of various aspects related to *Euglena* sp., shedding light on its distribution, characteristics, nutritional values, commercialization opportunities, and conservation status. Studying the range of *Euglena* sp. provided significant insights into the various settings where it can survive, contributing to a better knowledge of its ecological niche. The examination of its characteristics elucidated key morphological and physiological features, contributing to a more nuanced understanding of this microorganism.

The investigation into the nutritional values of *Euglena* sp. uncovered its potential as a rich source of nutrients, including proteins, lipids, and essential vitamins. This nutritional profile positions Euglena sp. as a promising candidate for various applications, such as in the fields of food and feed production, pharmaceuticals, and biofuel development. The identification of commercialization opportunities underscores the economic potential of harnessing Euglena sp.'s valuable attributes for various industries, fostering innovation and sustainable practices.

However, notably, the review revealed a lack of specific conservation status for *Euglena* sp. As microorganisms like Euglena are not traditionally subjected to the same conservation assessments as higher organisms, the absence of a designated status does not diminish their ecological importance. Instead, it emphasizes the need for broader conservation measures that consider the intricate roles played by microorganisms in ecosystem dynamics.

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