AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 03, Issue: 07 (July, 2026)
Available online at http://www.agrimagazine.in
©Agri Magazine, ISSN: 3048-8656

Chlorella: The Green Superfood You Need to Know About

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Chlorella vulgaris is a unicellular green microalga that has attracted growing scientific and commercial interest as a nutrient-dense food source. It is recognized for its high-quality protein, essential vitamins, minerals, and bioactive compounds such as carotenoids, chlorophyll, and polysaccharides. Research has demonstrated that this microalga exhibits antioxidant, anti-inflammatory, immunomodulatory, antiviral, anticancer, antidiabetic, lipid-lowering, and detoxifying properties. Beyond its nutritional value, chlorella has shown the capacity to bind and remove heavy metals from biological systems and polluted environments, while also supplying carotenoids and polyunsaturated fatty acids that are absorbed into human plasma after consumption. Its expanding applications span functional foods, nutraceutical supplements, animal feed, and environmental remediation. This article synthesizes current evidence on the composition, biological activities, and practical uses of chlorella, highlighting why it continues to be described as a green superfood with multifaceted relevance to human health and sustainability.

Introduction

Chlorella vulgaris is a green microalga that has become widely recognized for its exceptional nutritional value and therapeutic potential (Mendes et al., 2024). It contains key nutrients including high-quality proteins, essential vitamins, minerals, and an array of bioactive compounds such as carotenoids, chlorophyll, and polysaccharides (Mendes et al., 2024). These compounds have been shown to exhibit a wide spectrum of biological activities, including potent antioxidant, anti-inflammatory, immunomodulatory, antiviral, anticancer, antidiabetic, lipid-lowering, and detoxifying effects (Mendes et al., 2024). The microalga is increasingly applied as a functional food ingredient, a nutraceutical supplement in animal feed, and a promising therapeutic agent for combatting chronic diseases (Mendes et al., 2024). Chlorella vulgaris is described as a popular food ingredient that is widely used in industry, with an increasing market size and value (Maurício et al., 2023). Several edible strains of Chlorella vulgaris with different organoleptic characteristics are now commercialized to meet diverse consumer needs (Maurício et al., 2023). The beneficial health effects associated with Chlorella vulgaris have been linked to the presence of multiple nutrients and antioxidants acting together, including its carotenoid content (Serra et al., 2021). This combination of nutritional richness and documented bioactivity underlies its growing recognition as a functional food and therapeutic resource (Mendes et al., 2024).

Source: https://www.navchetanakendra.co.in/chlorella-vulgaris-extract-powder-ayurvedic-medicine-manufacturer-11283786.html

Nutritional Composition of Chlorella

Chlorella vulgaris is valued for its dense concentration of proteins, vitamins, minerals, and pigment compounds (Mendes et al., 2024). Among its bioactive constituents, carotenoids, chlorophyll, and polysaccharides are particularly emphasized for their contribution to the microalga's overall nutritional profile (Mendes et al., 2024). Comparative analysis of four commercialized Chlorella vulgaris strains, namely C-Auto, C-Hetero, C-Honey, and C-White, revealed that the strain grown autotrophically, C-Auto, contained a higher lipid content than the other strains along with higher levels of omega-3 polyunsaturated fatty acids (Maurício et al., 2023). In contrast, the C-Hetero, C-Honey, and C-White strains were found to contain higher levels of omega-6 polyunsaturated fatty acids (Maurício et al., 2023). The lipidome signature also differed between strains, with C-Auto showing a higher content of polar lipids esterified to omega-3 polyunsaturated fatty acids, while C-White showed a higher content of phospholipids esterified to omega-6 polyunsaturated fatty acids (Maurício et al., 2023). Beyond lipids, Chlorella vulgaris has been documented to contain a noteworthy amount of carotenoids, including lutein, β-carotene, and zeaxanthin (Serra et al., 2021). A human intervention study quantified a single 6 g dose of dried marine Chlorella vulgaris as containing 7.08 mg of lutein, 1.88 mg of β-carotene, and 1.47 mg of zeaxanthin (Serra et al., 2021). This same dose also supplied polyunsaturated fatty acids and trace elements, including linoleic acid, docosahexaenoic acid, and iodine (Serra et al., 2021). Collectively, this composition profile underscores why Chlorella vulgaris is regarded as a concentrated source of multiple nutrient classes within a single biomass (Mendes et al., 2024).

Antioxidant and Anticancer Potential

Chlorella vulgaris has been investigated for its antioxidant capacity, which is closely tied to its content of bioactive vitamins and pigments (Hamouda et al., 2022). Supplementation of Chlorella vulgaris cultures with vitamins including thiamine, riboflavin, pyridoxine, and ascorbic acid significantly increased the alga's total carbohydrate, total protein, pigment content, and antioxidant activity (Hamouda et al., 2022). The methanol extract of Chlorella vulgaris, particularly when supplemented with thiamine, was tested in vitro against four human cancer cell lines: prostate cancer (PC-3), hepatocellular carcinoma (HEPG-2), colorectal carcinoma (HCT-116), and epithelioid carcinoma (HeLa) (Hamouda et al., 2022). The extract demonstrated antitumor activity across these cell models, supporting the relevance of chlorella-derived compounds as candidates for further anticancer research (Hamouda et al., 2022). At the same time, broader reviews of the species have reported that its bioactive compounds exhibit potent antioxidant, anti-inflammatory, antiviral, and anticancer effects (Mendes et al., 2024). Chlorella vulgaris has additionally shown notable antimicrobial activity against a wide range of bacterial and fungal pathogens, attributable to bioactive compounds including peptides, fatty acids, and polysaccharides (Mendes et al., 2024). These compounds have been demonstrated to inhibit the growth of Gram-positive bacteria such as Staphylococcus aureus and Bacillus subtilis, as well as Gram-negative bacteria such as Escherichia coli and Pseudomonas aeruginosa (Mendes et al., 2024). Taken together, this body of evidence positions chlorella as a multifunctional bioactive resource extending beyond simple nutrition into the realm of disease-modulating potential (Mendes et al., 2024).

Role in Detoxification of Heavy Metals

One of the most distinctive properties attributed to chlorella is its capacity to counteract toxicity caused by heavy metal exposure (Mendes et al., 2024). In an experimental study, adult male rats exposed to cadmium chloride exhibited disturbed liver and kidney architecture, altered hematological parameters, and elevated levels of liver enzymes including ALT, AST, and ALP, alongside increased blood urea (Farag et al., 2023). Cadmium exposure was also shown to place hepatic and renal cells under oxidative stress through upregulated lipid peroxidation, raising immunoglobulin G levels and inducing pro-inflammatory cytokines such as IL-1β and TNF-α, which in turn caused hepatic hemorrhage, irregular

hepatocytes, and kidney tubular degeneration (Farag et al., 2023). When Chlorella vulgaris was administered alongside cadmium chloride, it helped regulate the cellular protein translation process through the NF-kB and Nrf2 signaling pathways, thereby preventing oxidative damage and restoring cellular redox homeostasis (Farag et al., 2023). This intervention improved cell survival and tolerance against the oxidative damage caused by cadmium, highlighting the anti-inflammatory and antioxidative properties of Chlorella vulgaris in counteracting metal-induced toxicity (Farag et al., 2023). Chlorella vulgaris has similarly been studied for its capacity to remove heavy metals from contaminated environments (Ahammed et al., 2023). In a controlled remediation experiment using polluted river water, both Chlorella vulgaris and the cyanobacterium Anabaena variabilis significantly reduced pollutant load and heavy metal concentrations over a twenty-day treatment period (Ahammed et al., 2023). Chlorella vulgaris was found to be more effective than Anabaena variabilis at removing calcium, magnesium, chromium, and manganese from the polluted water (Ahammed et al., 2023). This dual evidence, from internal physiological protection in animal models to external environmental remediation, illustrates the broad detoxifying relevance of this microalga (Mendes et al., 2024).

Bioavailability and Human Health Benefits

Despite extensive documentation of chlorella's nutrient content, the question of how efficiently these compounds are absorbed by the human body has historically received less attention (Serra et al., 2021). To address this gap, a human intervention study was conducted in eleven healthy male volunteers to evaluate the bioavailability of carotenoids following a single dose of dried marine Chlorella vulgaris (Serra et al., 2021). Participants followed a low-carotenoid diet for one week prior to the trial, after which blood samples were collected over a seventy-two-hour period following ingestion to measure plasma carotenoid concentrations using high-performance liquid chromatography (Serra et al., 2021). The results showed that plasma concentrations of lutein, β-carotene, and zeaxanthin were all significantly increased relative to baseline following the single dose (Serra et al., 2021). β-carotene displayed the highest peak plasma concentration and area under the curve among the three carotenoids measured, while zeaxanthin showed comparatively lower bioavailability values (Serra et al., 2021). The study also assessed, for the first time in a post-prandial context, the absorption of polyunsaturated fatty acids and trace elements, confirming that linoleic acid, docosahexaenoic acid, and iodine were detectable in plasma after chlorella intake (Serra et al., 2021). These findings collectively support the use of Chlorella vulgaris as a source of carotenoids, polyunsaturated fatty acids, and essential trace elements with associated health benefits that extend beyond simple nutrient content to demonstrated physiological uptake (Serra et al., 2021). This evidence of confirmed bioavailability strengthens the broader claim that chlorella functions as a nutritionally active, rather than merely nutrient-rich, dietary component (Mendes et al., 2024).

Applications in Food, Feed, and Environmental Sustainability

The applications of Chlorella vulgaris extend across several sectors, including its growing role as a functional food ingredient, a nutraceutical supplement in animal feed, and a therapeutic agent relevant to chronic disease management (Mendes et al., 2024). Within the food industry, different commercialized strains of Chlorella vulgaris are selected based on variation in organoleptic characteristics to meet specific consumer and formulation needs (Maurício et al., 2023). Strains with higher omega-3 polyunsaturated fatty acid content, such as C-Auto, may be favored in formulations targeting cardiovascular or anti-inflammatory benefits, while strains richer in omega-6 fatty acids may suit other functional food applications (Maurício et al., 2023). Beyond direct nutritional use, Chlorella vulgaris has demonstrated value in environmental sustainability through its phycoremediation capacity (Ahammed et al., 2023). In comparative trials, both Chlorella vulgaris and Anabaena variabilis proved to be effective, low-cost, and eco-friendly agents for treating polluted river water contaminated with nutrients and heavy metals (Ahammed et al., 2023). The treatment

process also raised the pH of the polluted river water, while substantially lowering pollutant concentrations, indicating that microalgal cultivation can simultaneously generate valuable biomass while contributing to water quality restoration (Ahammed et al., 2023). The resulting biomass produced through such remediation processes can be further processed for applications including biofuel and other bio-based products, reflecting a circular approach that links environmental cleanup with resource recovery (Ahammed et al., 2023). When combined with its documented roles in antioxidant defense, detoxification, and nutrient bioavailability, this versatility across food, feed, and environmental domains illustrates the broad practical relevance of Chlorella vulgaris in addressing both human health and sustainability challenges (Mendes et al., 2024).

Conclusion

Chlorella stands out among microalgae for the breadth of benefits it offers across nutrition, health, and environmental sustainability. Its rich content of proteins, essential fatty acids, vitamins, and pigments such as carotenoids provides a strong nutritional foundation, while documented antioxidant, anti-inflammatory, antimicrobial, and anticancer properties extend its relevance well beyond basic nutrition. Evidence from animal studies shows that chlorella can help protect organs from heavy metal-induced toxicity, while environmental trials confirm its ability to remove pollutants from contaminated water. Human studies further show that key nutrients from chlorella, including carotenoids and polyunsaturated fatty acids, are measurably absorbed into the bloodstream after consumption. As research continues to validate its diverse applications in functional foods, animal feed, and environmental remediation, chlorella's standing as a green superfood appears well supported, making it a microalga worth understanding for anyone interested in nutrition and sustainable health.

References

1. Ahammed, M. S., Baten, M. A., Ali, M. A., Mahmud, S., Islam, M. S., Thapa, B. S., Islam, M. A., Miah, M. A., & Tusher, T. R. (2023). Comparative evaluation of Chlorella vulgaris and Anabaena variabilis for phycoremediation of polluted river water: Spotlighting heavy metals detoxification. Biology, 12(5), 675. https://doi.org/10.3390/biology12050675
2. Farag, M. R., Alagawany, M., Mahdy, E. A. A., El-Hady, E., Abou-Zeid, S. M., Mawed, S. A., Azzam, M. M., Crescenzo, G., & Abo-Elmaaty, A. M. A. (2023). Benefits of Chlorella vulgaris against cadmium chloride-induced hepatic and renal toxicities via restoring the cellular redox homeostasis and modulating Nrf2 and NF-KB pathways in male rats. Biomedicines, 11(9), 2414. https://doi.org/10.3390/biomedicines11092414
3. Hamouda, R. A., Abd El Latif, A., Elkaw, E. M., Alotaibi, A. S., Alenzi, A. M., & Hamza, H. A. (2022). Assessment of antioxidant and anticancer activities of microgreen alga Chlorella vulgaris and its blend with different vitamins. Molecules, 27(5), 1602. https://doi.org/10.3390/molecules27051602
4. Maurício, T., Couto, D., Lopes, D., Conde, T., Pais, R., Batista, J., Melo, T., Pinho, M., Moreira, A. S. P., Trovão, M., Barros, A., Cardoso, H., Silva, J., Domingues, P., & Domingues, M. R. (2023). Differences and similarities in lipid composition, nutritional value, and bioactive potential of four edible Chlorella vulgaris strains. Foods, 12(8), 1625. https://doi.org/10.3390/foods12081625
5. Mendes, A. R., Spínola, M. P., Lordelo, M., & Prates, J. A. M. (2024). Chemical compounds, bioactivities, and applications of Chlorella vulgaris in food, feed and medicine. Applied Sciences, 14(23), 10810. https://doi.org/10.3390/app142310810
6. Serra, A. T., Silva, S. D., Pleno de Gouveia, L., Alexandre, A. M. R. C., Pereira, C. V., Pereira, A. B., Partidário, A. C., Silva, N. E., Bohn, T., Gonçalves, V. S. S., Real, G., Escudero, P., Fernández, N., Matias, A. A., & Bronze, M. R. (2021). A single dose of marine Chlorella vulgaris increases plasma concentrations of lutein, β-carotene and zeaxanthin in healthy male volunteers. Antioxidants, 10(8), 1164. https://doi.org/10.3390/antiox10081164