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NARRATIVE REVIEW

Health benefits of Chlorella vulgaris supplementation

a narrative review

HIGHLIGHTS

- Chlorella vulgaris is a nutrient-dense unicellular green microalga rich in essential amino acids, vitamins B12, C, E, K, iron and zinc — a promising functional food, particularly for plant-based diets.
- Meta-analyses indicate that daily doses ≥ 4 g of GABA-enriched Chlorella for ≥ 8 weeks significantly reduce systolic and diastolic blood pressure in mild hypertension.
- Doses of 600–1500 mg/day lower total and LDL cholesterol, with additional improvements in ALT, AST, BMI, and fasting glucose in NAFLD patients.

- Antihyperglycaemic and detoxifying effects (Hg, Pb, Sn) have been observed, alongside improvements in depression and primary dysmenorrhoea symptoms.
- Athletic studies show reduced muscle damage (LDH, CK) and improved O_2 pulse / lactate clearance, especially in short-term high-intensity efforts.
- Safety concerns include heavy-metal contamination, mismatch of declared vs. actual content, allergy in atopic individuals, and a single reported case of tubulointerstitial nephritis.

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ABSTRACT

BACKGROUND: Dietary supplements are a rapidly growing market, with many of them advertised as a remedy for various diseases, or as a healthy supplement to the everyday diet. One of these supplements is Chlorella vulgaris, a unicellular alga, advertised as a potent remedy for many civilisational diseases.

AIM: This narrative review aims to summarise current knowledge regarding supplementation with Chlorella vulgaris, with an emphasis on its clinical and sports-related use, safety, and efficacy.

MATERIALS AND METHODS: A narrative review was conducted using PubMed and Google Scholar databases concerning Chlorella vulgaris, with an emphasis on clinical trials, reviews, and meta-analyses.

RESULTS: Evidence suggests that Chlorella vulgaris supplementation may have a beneficial impact on many diseases, such as hypertension, hypercholesterolaemia, or diabetes. Moreover, it might have applications in improving physical endurance and in supplementing micronutrients in some diets. However, some concerns regarding safety, contamination, and heterogeneity of composition still remain. Nevertheless, meta-analyses show that the evidence for the health benefits is at most moderate, so more research in this area is needed.

KEYWORDS Chlorella; supplementation; hypertension; NAFLD; diabetes; physical performance; sport.

GRAPHICAL ABSTRACT

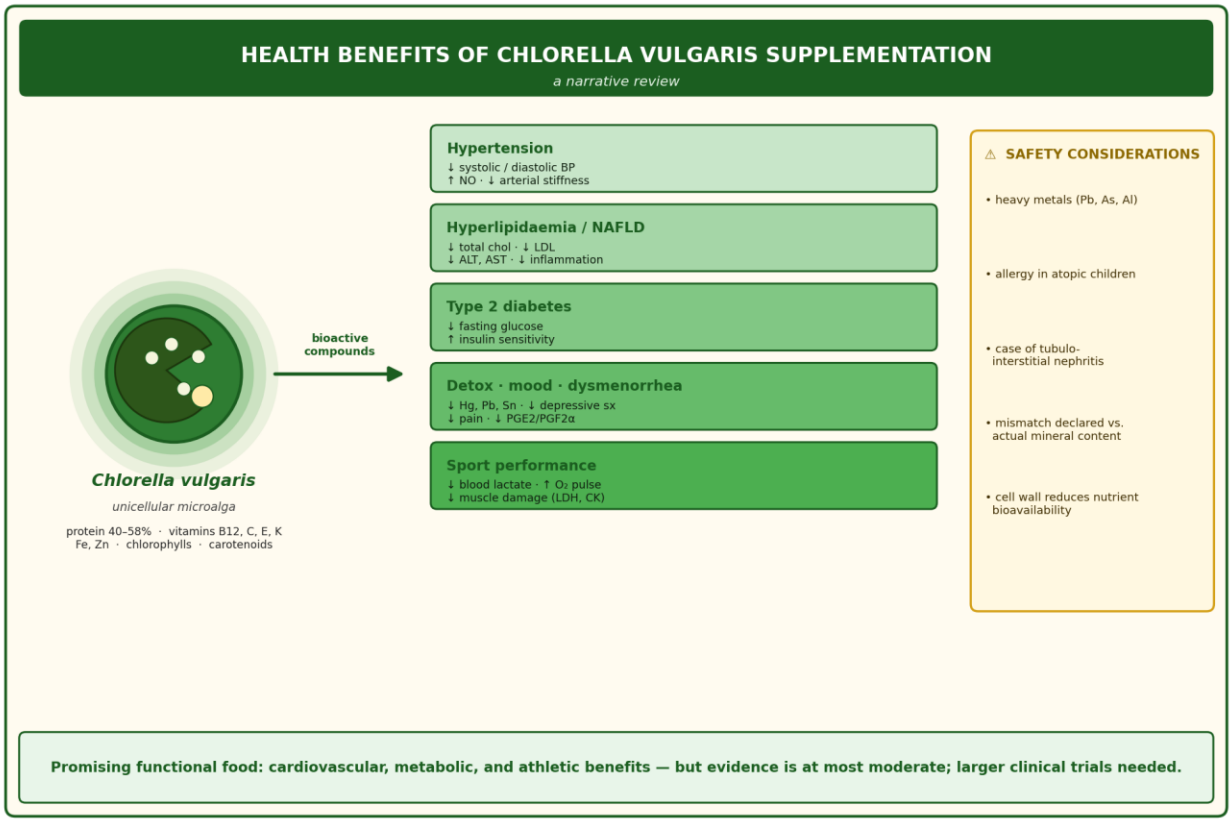

Figure 1. *Graphical overview of Chlorella vulgaris supplementation — from the cellular source and its bioactive composition (protein, vitamins B12/C/E/K, Fe, Zn, chlorophylls, carotenoids), through five clinical-outcome domains (hypertension, hyperlipidaemia/NAFLD, type-2 diabetes, detoxification/mood/dysmenorrhoea, sport performance), to key safety considerations (heavy-metal contamination, atopy, mineral-content mismatch, cell-wall–dependent bioavailability).*

PLAIN LANGUAGE SUMMARY

Chlorella vulgaris is a tiny green freshwater alga sold as a dietary supplement in tablets or powder. It is rich in protein, vitamins (including B12 — important for vegetarians and vegans), and minerals such as iron and zinc. Scientific studies suggest that taking Chlorella may help to lower blood pressure, reduce so-called ‘bad’ (LDL) cholesterol, improve fatty-liver disease, slightly lower blood sugar, and possibly help the body to get rid of heavy metals such as mercury or lead. Small studies also report fewer painful menstrual cramps and lower depressive symptoms when Chlorella is added to standard treatment, and improved sports performance — especially during short, high-intensity efforts. The effects, however, are usually moderate, and the quality of evidence varies between studies. Because Chlorella is sold as a food supplement rather than a medicine, products differ in quality: some have been found to contain too much aluminium, arsenic, or lead, while others contain less iron, magnesium or potassium than declared on the label. People with a history of allergies — particularly children — should be cautious. Overall, Chlorella looks promising as a complementary, plant-based source of nutrients and as a mild aid in several conditions, but larger and better-designed clinical trials are still needed before doctors can recommend specific doses.

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1. INTRODUCTION

Dietary supplements are concentrated sources of minerals, vitamins or other compounds, that have either a nutritional effect, or produce a physiological effect in the body. As the name suggests, they are taken to supplement the regular diet, often in various forms resembling medication, such as capsules, tablets, or other forms [1]. Despite this fact, they are legally regarded as foodstuffs in European Union, and the USA, therefore they aren't as strictly regulated, as the conventional medicines [2]. Moreover, the supplementation market is a very large business, because many people globally supplement their diet one way or the other. According to studies, around 49% of the adult population take supplements in the USA, while in the European Union these numbers vary between 10% – 64% [3], [4]. While some supplements have a proven beneficial effect on the human body, others are not well investigated, and can sometimes have adverse effects on the human body, or be disadvantageous to the overall health [2].

One of the most researched supplements is Chlorella vulgaris, a unicellular green alga, which is widely used to produce biofuel, animal feed, bioplastic, or bio-fertilizers, to treat wastewater, or as a food additive. Recently, it has been analysed for its applications in medicine, with anti-hypertensive, antioxidant, anticancer, and many other properties being investigated [5], [6]. Moreover, as one of the most effective crops to produce, with regard to mass output relative to consumption of resources, it also emerges as a cheap, and easily available product for consumption, or at least supplementation of the diet [7]. The aim of this narrative review is to cover the topic of supplementation with Chlorella vulgaris, with the emphasis on its dietary composition, potential clinical applications, as well as safety, and adverse effects of this supplement.

2. MORPHOLOGY AND PRODUCTION OF CHLORELLA VULGARIS

Chlorella vulgaris is a spherical, single-celled microalga, occurring mostly in marine, freshwater, and land habitats [8]. It is a nonmotile cell; therefore, it reproduces asexually through a division of the mother cell into 2–32 autospores, which can happen under optimal conditions within 24 hours. After maturation inside the mother cell, the daughter cells are released, and can reproduce rapidly in the same manner, thus increasing the number of these algae [6], [9]. The cell itself contains a single, big chloroplast with starch granules, as well as mitochondria, and a small nucleus with a Golgi apparatus [6]. Moreover, it can grow in various conditions, including autotrophic, heterotrophic, or mixotrophic, making it resistant to external factors [8], [9]. This trophism is connected to the intracellular production of macroelements, and microelements, with their composition, and profile depending on the environmental conditions, such as light, pH, salinity, as well as carbon, and nitrogen availability. Interestingly, the growth under heterotrophic conditions is not only cheaper, and more effective in yielding a greater biomass, but also alterations in carbon sources can lead to controlled changes in biochemical composition of these microalgae [9], [10]. Additionally, Chlorella vulgaris is a species highly resilient to growth conditions, with its resilience shown in one study to chromium (VI) concentrations of up to 40 mg/L, and salinity up to 40 ppt [11].

The production conditions depend on the intended objective. Autotrophic growth occurs mainly in open ponds, or water reservoirs, especially near industrial plants, where it is used as an absorber of nitrogen, and heavy metals. Sometimes it is used to produce Chlorella for nutraceuticals, and pharmaceuticals, but it requires more controlled, and resource-consuming, sterile environment. When it comes to heterotrophic growth, it does not need any light source, with the production aim being mainly increased biomass, which is used later for consumption, as animal feed, or for biodiesel production [6], [9], [12]. However, there are some limitations to the efficient production of Chlorella vulgaris on a mass scale, including a high risk of contamination in open systems, and on the other hand high operation, and initial investment costs in the closed

systems, as well as challenges related to scaling-up the closed systems, and maintaining sterility throughout the process, making the high-quality products difficult for producers to offer at affordable prices [13]. Nevertheless, a growing market encourages producers to seek more efficient means of producing these algae.

3. NUTRITIONAL COMPOSITION OF CHLORELLA VULGARIS

The biomass of Chlorella vulgaris is rich in high-quality proteins containing essential amino acids, structurally diverse lipids including polyunsaturated fatty acids, digestible carbohydrates, and a broad spectrum of vitamins, minerals, volatile compounds, and phytochemicals, supporting its classification as a nutrient-dense food source. Nevertheless, digestion of Chlorella vulgaris can be challenging, due to the cell wall being composed of cellulose, which cannot be digested; therefore Chlorella vulgaris should be mechanically broken down to improve nutrient absorption [14].

Proteins constitute 40–58% of the dry weight of Chlorella vulgaris, making it a protein-rich product. The digestibility of these proteins varies between 75–85% depending on the product, making them more digestible, than, for example, soybeans [15]. The quality of proteins in food depends on the essential amino acids content, as these amino acids cannot be synthesized in the human body, and must be obtained from the diet daily. It was found, that most essential amino acid content, including valine, methionine, threonine, phenylalanine, leucine, histidine, tryptophan, and lysine, exceeded the daily recommended dose established by World Health Organisation (WHO), with the exception of isoleucine, which was in some cases below the recommended level [16].

Chlorella vulgaris consists of approximately 10–20% carbohydrates, with more than 65% being part of dietary fibre in the cellulose cell walls, consisting mostly of rhamnose, galactose, and xylose. Most of the bioavailable carbohydrates are stored inside the cells in the form of starch granules, namely amylose and amylopectin [6], [15]. Interestingly, some polysaccharides isolated from Chlorella vulgaris showed antioxidative properties, and stimulated immunological responses in RAW264.7 cells [17], [18].

The content of fatty acids depends on the conditions, in which Chlorella vulgaris grows, with levels ranging from 5–40% of dry biomass in favourable conditions, and up to 58% in unfavourable growth conditions [6]. These lipids consist mostly of triglycerides, with 66% being mono- and polyunsaturated fatty acids. The largest share is accounted for by oleic, linoleic, and alpha linoleic acids. No traces of other essential omega acids, including eicosapentaenoic (EPA), docosahexaenoic (DHA), gamma linolenic, or dihomolinolenic have been detected [16].

Commercially available Chlorella products contain essential vitamins for humans, including B-complex vitamins, vitamins C, E, and K, as well as α- and β-carotenes, in various concentrations depending on the product. Conversely, they contain vitamin D only in the form of less active ergosterol and ergocalciferol, making it a poor source of active vitamin D [15]. All vitamin contents with the recommended daily intake by WHO are summarised in Table 1.

Table 1. *List of vitamins and essential compounds in various Chlorella products, and their daily recommended intake [6], [15], [19], [20].*

Vitamins	Mass (per 100 g of dry weight)	Recommended safe daily intake (WHO)
Thiamine (mg)	1.5 – 2.4	1.1 – 1.2
Riboflavin (mg)	4.8 – 6.0	1.1 – 1.3
Niacin (mg)	23.8	14.0 – 16.0
Pantothenic acid (mg)	1.3	5.0
Biotin (µg)	191.6	30.0
B12 (µg)	25.0 – 125.9	2.4
Folic acid (mg)	26.9	0.4
C (mg)	15.6 – 100.0	45
E (mg)	20.0 – 2787.0	N/A*¹
K (mg)	0.3 – 3.5	0.055 – 0.065
β-carotene (mg)	25.0 – 150.0	6.0 – 7.2*²

**¹ N/A, not applicable; *² as equivalent of daily recommended vitamin A intake*

Chlorella is a very rich source of vitamin B12. Its main sources in the diet are animal-derived foods, such as milk, meats, and fish, therefore people who follow a vegetarian, or vegan diet are at constant risk of vitamin B12 insufficiency, which can lead to megaloblastic anaemia, or myeloneuropathy [21]. Although Chlorella pyrenoidosa is richer than Chlorella vulgaris in vitamin content, both can absorb high quantities of exogenous vitamin B12, which in turn can be a source of this vitamin for individuals following strict herbivorous diets [20]. In one study observing strict vegans, the ones supplementing Chlorella, or Nori seaweed had significantly higher serum B12 levels, than those who did not supplement, suggesting that Chlorella can be a source of this vitamin for this group [22]. Moreover, Chlorella vulgaris seems to have adequate amounts of other important vitamins, including B-group vitamins, and folic acid, which is important for the prevention of neural tube defects, preterm delivery, foetal growth restriction, and anaemia, as well as vitamin C important for prevention of scurvy, and fat-soluble vitamins, such as A, E and K [23], [24].

When it comes to microelements, Chlorella vulgaris is a rich source of iron, having 200–680 mg per 100 g of dry mass, as well as zinc (550 mg per 100 g) [6]. Both elements are crucial for health, with iron being crucial for haemoglobin synthesis, and its deficiency leading to microcytic anaemia, and zinc deficiency leading to poor growth, suppression of immunity, dermatitis, and poor wound healing [25], [26]. These elements may be chelated by the phytates in grain-rich diets, particularly vegetarian and vegan diets, leading to deficiencies and associated conditions [27]. Chlorella vulgaris, with its rich content of those elements, has strong potential for use in their supplementation. Although most of the studies have involved animals, they showed that the supplementation improved iron homeostasis, as well as antioxidant defence [28].

Interestingly, the effectiveness of the supplementation may depend on the individual's intestinal environment. Nishimoto et al. observed 40 individuals with constipation in a crossover study, who received either Chlorella, or a placebo. It was found, that individuals with higher defecation rates had a greater response in blood folate increase, than those with less frequent defecation. Moreover, Chlorella ingestion significantly increased the concentration of dicarboxylic acids concentration in faeces, such as azelaic acid, suberic acid, and 6-hydroxyhexanoic acid, which may have a beneficial impact on overall, and gut health [29].

4. HEALTH BENEFITS OF CHLORELLA VULGARIS SUPPLEMENTATION

Beyond its nutritional composition, Chlorella vulgaris contains bioactive constituents such as chlorophylls, carotenoids, polyphenols, flavonoids, saponins, quinones and polysaccharides that contribute to its antioxidant capacity and modulate cellular redox balance [16]. These compounds have been associated with immunomodulatory activity, enhancement of detoxification pathways, and potential regulation of lipid and glucose metabolism, thereby influencing overall metabolic homeostasis.

4.1. Hypertension

Hypertension is regarded as the most important cardiovascular risk factor worldwide, that can be modified; therefore researchers are searching for alternative methods to alleviate this condition, one of them being Chlorella vulgaris [30]. Tsuchida et al. divided a group of sixty adult subjects, who were mildly hypertensive or had high normal blood pressure, into 4 groups, receiving 2, 4, and 6 g of γ-aminobutyric acid (GABA)-enriched Chlorella, or placebo. It was found, that after 6 weeks, the groups receiving 4 and 6 gram doses had significantly reduced their systolic, and diastolic blood pressure, with no adverse effects observed [31]. A similar study enrolled 80 adults with high normal blood pressure or mild hypertension, who also received 4 grams of GABA-enriched Chlorella, or placebo for a longer period of 12 weeks. Although three people dropped out of the study, two of them due to allergic reactions, a significant decrease in both systolic and diastolic blood pressure was observed [32]. Another study aimed to investigate the possible molecular mechanism of blood pressure reduction. It was observed that middle-aged, and older individuals, who supplemented Chlorella-derived tablets, had significantly decreased vascular stiffness, probably due to an increase of nitric oxide concentration. Interestingly, no significant reduction in systolic, and mean arterial pressure was observed; only diastolic pressure and heart rate reductions were noted by the researchers [33]. On the contrary, no statistical difference was noted among patients with non-alcoholic fatty liver disease (NAFLD), who supplemented Chlorella vulgaris with metformin, and vitamin E [34]. Nevertheless, a meta-analysis by Fallah et al. concluded, that Chlorella could significantly lower the systolic, and diastolic blood pressure, but higher doses (at least 4 grams daily), and longer durations (at least 8 weeks) seemed to be more effective [35].

4.2. Hyperlipidaemia, NAFLD

Hyperlipidaemia is another cardiovascular risk factor, that has been analysed for potential use of Chlorella. Panahi et al. compared the use of Chlorella tablets (600 mg daily) with atorvastatin, versus atorvastatin alone. 68 participants received this treatment for 8 weeks. It was concluded, that both groups had significant decrease in total cholesterol, LDL-cholesterol, as well as triglycerides, with no statistical differences between the groups [36]. An interesting study enrolled 34 healthy participants, with serum total cholesterol levels under 5.18 mmol/L. All of them received a high-cholesterol diet, with the study group receiving Chlorella, while the control group received placebo. After 4 weeks, Chlorella ingestion significantly suppressed increases in the total cholesterol, and LDL cholesterol levels. An increase in HDL cholesterol was also greater in the study group, but it was found to be statistically insignificant [37]. Another study on 51 healthy subjects found no significant differences either between, or within groups in the serum lipid profile [38].

In two studies including obese women, participants were divided into 4 groups: placebo-only, training with placebo (or training only), Chlorella only and training with Chlorella. Interestingly, no statistically significant improvement was found in the study, where the dose was lower (300 mg daily) in the groups receiving Chlorella tablets. On the contrary, in the study where participants received 900 mg of Chlorella daily, a significant improvement in triglycerides, and LDL-cholesterol was observed in all groups receiving Chlorella, and HDL-cholesterol improvement in the group receiving Chlorella and undertaking training, suggesting dose-dependent antihyperlipidemic activity of this supplement [39], [40]. In a meta-analysis by Sherafati et al., Chlorella vulgaris showed significant potential to lower total cholesterol, as well as LDL-cholesterol. No statistical improvement in HDL-cholesterol, and triglycerides was observed. Moreover, the most effective dose was established between 0 and 1500 mg daily, with no improvement at higher doses [41]. Moreover, the meta-analysis by Fallah et al. also reported similar results, even though it included different research papers, than Sherafati et al. [35]. These effects can be explained in several ways. As Chlorella vulgaris is very rich in fibre, it can bind bile acids, and fatty acids, making their reabsorption less efficient [42]. Secondly, Chlorella vulgaris has a very high carotenoid content, which by competing with the intestinal lipids, can lower their absorption. In addition, these carotenoids can attach to LDL receptors, suppressing the cholesterol production in the liver, and stimulating macrophages to absorb LDL particles from plasma [35], [43].

Hyperlipidaemia and obesity can both lead to accumulation of lipids in liver, leading to development of NAFLD, which may lead to liver cirrhosis and hepatocellular carcinoma. In one study, 60 participants with NAFLD were divided into 2 groups — the first one receiving 400 mg of vitamin E daily, and 300 mg of Chlorella, while the other received only vitamin E. After 8 weeks, a significant reduction in plasma activities of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) was noted, suggesting regression of NAFLD. Moreover, an overall improvement in fasting blood glucose, total cholesterol, LDL-cholesterol and HDL-cholesterol was noted. A statistically greater reduction in the study group was only noted in BMI, weight, ALP, and fasting blood glucose [42]. In another study, participants received a similar regimen, with 1200 mg of Chlorella daily in the study group, and both groups receiving 750 mg of metformin daily. In the study group, hepatic parameters (ALT, AST) improved significantly; moreover, HbA1c, uric acid, and triglyceride levels improved significantly only in the study group, suggesting pleiotropic effects of Chlorella vulgaris [34]. Another study observed, that supplementation with Chlorella vulgaris not only improved AST, ALT, but also reduced inflammatory markers (high-sensitivity C-reactive protein), and fasting blood glucose. Moreover, a significant improvement in insulin sensitivity was noted [44].

4.3. Type 2 diabetes

Diabetes mellitus has become a progressively increasing health problem worldwide, being one of the top 10 causes of death worldwide, and affecting almost half a billion people. If untreated, it can cause serious

comorbidities, affecting multiple organs, such as kidneys, heart, or eyes, leading to severe health impairment and potential disability [45]. Several studies have been performed on rats, suggesting an antihyperglycemic effect of Chlorella vulgaris in both streptozocin-induced, and in obesity-induced diabetes [46], [47], [48]. The two aforementioned studies conducted on patients with NAFLD showed, that Chlorella may exhibit antihyperglycemic effects, with improvement in fasting blood glucose in both studies, and improvement in insulin levels and insulin sensitivity in one study [42], [44]. Conversely, two studies — the first performed on borderline diabetic subjects, the second on elderly Japanese individuals — didn't note any significant improvement in blood glucose levels. On the contrary, reduced expression of the resistin gene in one study was noted, which could potentially improve insulin sensitivity in diabetic patients [49], [50]. Nevertheless, a meta-analysis by Fallah et al. showed, that Chlorella supplementation could improve fasting blood glucose [35].

4.4. Detoxification, depression, dysmenorrhea

Heavy metal toxicity can be a serious health problem, especially when individuals are exposed for a long period of time, leading to their accumulation in the body, and serious health problems. One of the causes of potential heavy metal exposure is amalgam fillings in teeth, or titanium implants, which over the years can release heavy metals into the bloodstream. In one study patients with such implants received a multi-supplement formula, that included Chlorella vulgaris. Heavy metal levels were measured in hair, to assess accumulation. After 90 days, a significant improvement in levels of mercury, silver, tin, chromium, vanadium, selenium, and lead was observed. Moreover, superoxide dismutase 1 activity increased, which could explain the detoxification effect. Selenium and cysteine deriving from Chlorella vulgaris could also contribute to mercury detoxification [51]. Carcinogenic, heterocyclic amines are also a major health problem. They derive mostly from meats cooked at high temperatures, including grilling, or pan-frying, and have been associated with colorectal, breast, and prostate cancers. A crossover study included young, healthy adults, to assess the effectiveness of Chlorella in detoxifying these substances. It was found, that some heterocyclic amines (namely MeIQx) were present at lower concentrations in urine, compared with placebo, with a trend toward reduction. Nevertheless, other heterocyclic amines analysed in this study did not decrease significantly. Moreover, a similar study with a larger sample, and a longer observation period should be undertaken, as this study included only 6 participants, and lasted 6 weeks [52].

An interesting study was conducted, to assess the effect of Chlorella vulgaris supplementation on major depressive disorder. Patients, along with their normal antidepressant medication, received a daily dose of 1800 mg of Chlorella, or placebo for 6 weeks. Remarkably, a significant improvement in cognitive, and somatic symptoms, as well as anxiety was observed in the study group, whereas affective symptoms did not significantly differ, meaning that Chlorella could potentially be used as an adjuvant, and safe therapy for this disorder [53].

Haidari et al. studied, whether Chlorella supplementation could help in the treatment of primary dysmenorrhea. It is one of the most common gynaecological disorders, characterized by painful cramps in the pelvic area during menstruation, with no apparent pathological cause. 44 women with this illness were divided into two groups, with the study group receiving 1500 mg of Chlorella tablets daily. Surprisingly, a significant improvement in pain severity measured on the VAS scale, duration of pain, as well as severity of systemic symptoms was noted, with no difference noted in the placebo group. Moreover, the study group had significantly reduced prostaglandin E2 and F2a levels, as well as malondialdehyde, which is an indicator of oxidative stress [54].

4.5. Sport applications

The nutrient-dense Chlorella vulgaris has also been analysed for potential use in athletic performance, to see if it could improve the physical endurance, and be applied in various sports [55]. In one study, 40 overweight men were divided into 4 groups, that either received Chlorella, or placebo, and either participated, or did not participate in exercise training. After 12 weeks, a significant rise in lactate dehydrogenase (LDH), and creatine kinase (CK) was only noted in the exercise group not receiving Chlorella, with no significant rise in the Chlorella group compared to control, suggesting a protective effect of Chlorella supplementation against exercise-induced muscle damage. Conversely, no statistical difference in VO2max, and running distance was observed between the exercising group receiving, and non-receiving Chlorella, with the only difference noted between the active, and sedentary groups [56]. A similar study enrolling 46 obese women showed a significant reduction in body fat, increase in body water, and in PPAR-γ coactivator-1α in the active group supplementing Chlorella, suggesting potential for enhancing the effect of physical activity on body composition. Similarly to the previous study, the physical activity itself improved physical endurance markers [57].

In a study enrolling 20 young, healthy adults, short-term efficacy of Chlorella supplementation was analysed. During a submaximal test, blood lactate was found to be significantly lower in the study group, and O_2 pulse significantly increased compared to placebo, while VO2max, and other physical fitness parameters did not differ between the groups [58]. Another cross-over study included 14 trained, and healthy cyclists, who received either 6 g of Chlorella daily, or placebo. It was found to have a positive effect on sprint endurance, namely average power, and peak power, with no effect on long-distance physical endurance. Moreover, it significantly improved haemoglobin levels in the study group compared to placebo [59]. In conclusion, Chlorella vulgaris can help in enhancing physical performance, especially in short-term, high-intensity activities, but more research with larger groups is needed to assess the effectiveness of this supplement.

5. ISSUES SURROUNDING CHLORELLA SUPPLEMENTATION

Despite the fact, that Chlorella vulgaris can be a potent supplement, some controversies, and problems with these products have emerged. Firstly, as Chlorella is sold as a supplement, it does not undergo such strict regulations, as drugs. Due to this, Chlorella products may have some impurities, and have a different content, than stated. Moreover, Chlorella can easily accumulate heavy metals from its surrounding, contaminating the product [7]. Rzymski et al. analysed 10 commercially available Chlorella products. They found, that two of them exceeded Tolerable Weekly Intake (TWI) set by the EC for aluminium, with one exceeding the Provisional Tolerable Weekly Intake (PTWI) set by WHO. Moreover, another two products exceeded the PTWI for organic arsenic, and four exceeded the maximum allowance limit for food supplements established by European Commission for lead. On the other hand, 6 products had less than 70% of the declared iron content, with 2 other products having lower magnesium and potassium levels, and one showing reduced calcium content. Interestingly, 6 of the analysed products had more than 200% of the declared copper content [60].

Some adverse effects have been reported as well. Tiberg et al. observed, that previously allergic children, especially those allergic to mold, had positive prick test to Chlorella antigens. This finding correlated with baseline atopy, with more reactions noted in more atopic individuals [61]. Moreover, Rzymski et al. described two adult patients with side effects after ingestion of both Spirulina, and Chlorella. The first patient suffered from nausea, general fatigue, abdominal pain, and non-itching atopic dermatitis around the neck. The second patient suffered from whole body, non-itching rash. In both cases, all of the symptoms subsided after the termination of supplementation [62]. One case of tubulointerstitial nephritis in an 11-year-old boy

supplementing Chlorella has also been described [63]. Therefore, some precautions should be taken before starting supplementation with Chlorella vulgaris, especially among children and individuals with a history of atopy.

6. CONCLUSIONS

Chlorella vulgaris is a nutrient-dense freshwater microalga with strong potential as a functional food and nutraceutical. It contains high-quality proteins with all essential amino acids, beneficial lipids, carbohydrates, vitamins, and essential minerals, making it a valuable dietary supplement — especially for plant-based diets. Scientific studies suggest that Chlorella vulgaris may support cardiovascular health, improve lipid profiles, aid in detoxification, and offer benefits in conditions such as diabetes, NAFLD, dysmenorrhoea, and even psychiatric disorders. Moreover, there are some studies, suggesting possible applications in improving sports performance. However, these effects vary in strength and quality of evidence. Despite its advantages, several limitations remain, including reduced nutrient bioavailability due to its rigid cell wall, variability in composition, and potential contamination risks. Therefore, further research and technological improvements in cultivation, processing, and formulation, as well as larger clinical studies are necessary.

7. DISCLOSURE

7.1. Author contribution statement

Conceptualization: K.S.-B., K.O.; Methodology: K.S.-B., K.O.; Software: K.S.-B., K.O.; Validation: K.S.-B., K.O.; Formal analysis: K.S.-B., K.O.; Investigation: K.S.-B., K.O.; Resources: K.S.-B., K.O.; Data Curation: K.S.-B., K.O.; Writing – rough preparation: K.S.-B., K.O.; Writing – review and editing: K.S.-B., K.O.; Visualization: K.S.-B., K.O.; Supervision: K.S.-B., K.O.; Project administration: K.S.-B., K.O.

All authors have read and agreed with the published version of the manuscript.

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7.3. Institutional review board statement

Not applicable.

7.4. Informed consent statement

Not applicable.

7.5. Data availability statement

Not applicable.

7.6. Conflict of interest

The authors declare no conflict of interest.

REFERENCES

[1] R. E. Wierzejska, "Dietary Supplements—For Whom? The Current State of Knowledge about the Health Effects of Selected Supplement Use," Int. J. Environ. Res. Public Health, vol. 18, no. 17, p. 8897, Sep. 2021, https://doi.org/10.3390/IJERPH18178897

[2] M. Starek, M. Błasiak, and M. Dąbrowska, "Insights into dietary supplements as popular product supporting the diet," Naunyn. Schmiedebergs. Arch. Pharmacol., Dec. 2025, https://doi.org/10.1007/s00210-025-04889-z

[3] E. M. Papatesta, A. Kanellou, E. Peppa, and A. Trichopoulou, "Is Dietary (Food) Supplement Intake Reported in European National Nutrition Surveys?," Nutrients, vol. 15, no. 24, p. 5090, Dec. 2023, https://doi.org/10.3390/NU15245090

[4] R. L. Bailey, J. J. Gahche, P. E. Miller, P. R. Thomas, and J. T. Dwyer, "Why US adults use dietary supplements," JAMA Intern. Med., vol. 173, no. 5, pp. 355–361, Mar. 2013, https://doi.org/10.1001/JAMAINTERNMED.2013.2299

[5] A. K. Koyande et al., "Microalgae: A potential alternative to health supplementation for humans," Food Science and Human Wellness, vol. 8, no. 1, pp. 16–24, Mar. 2019, https://doi.org/10.1016/J.FSHW.2019.03.001

[6] C. Safi, B. Zebib, O. Merah, P.-Y. Pontalier, and C. Vaca-Garcia, "Morphology, composition, production, processing and applications of Chlorella vulgaris: A review," Renewable and Sustainable Energy Reviews, vol. 35, pp. 265–278, Jul. 2014, https://doi.org/10.1016/j.rser.2014.04.007

[7] C. A. Wang, H. Onyeaka, T. Miri, and F. Soltani, "Chlorella vulgaris as a food substitute: Applications and benefits in the food industry," J. Food Sci., vol. 89, no. 12, p. 8231, Dec. 2024, https://doi.org/10.1111/1750-3841.17529

[8] Y. Panahi, B. Darvishi, N. Jowzi, F. Beiraghdar, and A. Sahebkar, "Chlorella vulgaris: A Multifunctional Dietary Supplement with Diverse Medicinal Properties," Curr. Pharm. Des., vol. 22, no. 2, pp. 164–173, Dec. 2016, https://doi.org/10.2174/1381612822666151112145226

[9] I. T. K. Ru et al., "Chlorella vulgaris: a perspective on its potential for combining high biomass with high value bioproducts," Applied Phycology, vol. 1, no. 1, pp. 2–11, Dec. 2020, https://doi.org/10.1080/26388081.2020.1715256

[10] F. J. Choix, L. E. de-Bashan, and Y. Bashan, "Enhanced accumulation of starch and total carbohydrates in alginate-immobilized Chlorella spp. induced by Azospirillum brasilense: II. Heterotrophic conditions," Enzyme Microb. Technol., vol. 51, no. 5, pp. 300–309, Oct. 2012, https://doi.org/10.1016/J.ENZMICTEC.2012.07.012

[11] A. D. Maysitha et al., "Determination of Minimum Inhibitory Concentration of Chromium and Salinity on Chlorella vulgaris," Journal of Ecological Engineering, vol. 25, no. 8, pp. 130–140, Aug. 2024, https://doi.org/10.12911/22998993/190039

[12] J. A. Coronado-Reyes et al., "Chlorella vulgaris, a microalgae important to be used in Biotechnology: a review," Food Science and Technology, vol. 42, p. e37320, 2022, https://doi.org/10.1590/FST.37320

[13] L. Xu, P. J. Weathers, X. R. Xiong, and C. Z. Liu, "Microalgal bioreactors: Challenges and opportunities," Eng. Life Sci., vol. 9, no. 3, pp. 178–189, Jun. 2009, https://doi.org/10.1002/ELSC.200800111

[14] H. Komaki et al., "The effect of processing of Chlorella vulgaris: K-5 on in vitro and in vivo digestibility in rats," Anim. Feed Sci. Technol., vol. 70, no. 4, pp. 363–366, Mar. 1998, https://doi.org/10.1016/S0377-8401(97)00089-8

[15] T. Bito, E. Okumura, M. Fujishima, and F. Watanabe, "Potential of Chlorella as a Dietary Supplement to Promote Human Health," Nutrients, vol. 12, no. 9, p. 2524, Sep. 2020, https://doi.org/10.3390/NU12092524

[16] Y. Heo, M. Y. Kim, and J. Y. Cho, "Chlorella vulgaris, a representative edible algae as integrative and alternative medicine," Integr. Med. Res., vol. 15, no. 1, p. 101228, Mar. 2025, https://doi.org/10.1016/J.IMR.2025.101228

[17] M. Tabarsa et al., "An immune-enhancing water-soluble α-glucan from Chlorella vulgaris and structural characteristics," Food Sci. Biotechnol., vol. 24, no. 6, pp. 1933–1941, Dec. 2015, https://doi.org/10.1007/s10068-015-0255-0

[18] M. Yu et al., "Preparation of Chlorella vulgaris polysaccharides and their antioxidant activity in vitro and in vivo," Int. J. Biol. Macromol., vol. 137, pp. 139–150, Sep. 2019, https://doi.org/10.1016/j.ijbiomac.2019.06.222

[19] Vitamin and mineral requirements in human nutrition: report of a joint FAO/WHO expert consultation, Bangkok, Thailand, 1998. WHO. FAO, 1998.

[20] T. Bito et al., "Characterization and Quantitation of Vitamin B12 Compounds in Various Chlorella Supplements," J. Agric. Food Chem., vol. 64, no. 45, pp. 8516–8524, Nov. 2016, https://doi.org/10.1021/ACS.JAFC.6B03550

[21] R. Green et al., "Vitamin B12 deficiency," Nat. Rev. Dis. Primers, vol. 3, no. 1, p. 17040, Jun. 2017, https://doi.org/10.1038/nrdp.2017.40

[22] A. L. Rauma, R. Torronen, O. Hanninen, and H. Mykkanen, "Vitamin B-12 status of long-term adherents of a strict uncooked vegan diet ('living food diet') is compromised," J. Nutr., vol. 125, no. 10, pp. 2511–2515, 1995, https://doi.org/10.1093/JN/125.10.2511

[23] M. Dey et al., "Folic acid: The key to a healthy pregnancy - A prospective study on fetomaternal outcome," Tzu Chi Med. J., vol. 36, no. 1, pp. 98–102, 2023, https://doi.org/10.4103/TCMJ.TCMJ_110_23

[24] E. H. Reynolds, "The neurology of folic acid deficiency," Handb. Clin. Neurol., vol. 120, pp. 927–943, 2014, https://doi.org/10.1016/B978-0-7020-4087-0.00061-9

[25] C. Camaschella, "Iron-deficiency anemia," N. Engl. J. Med., vol. 372, no. 19, pp. 1832–1843, May 2015, https://doi.org/10.1056/NEJMRA1401038

[26] W. Maret and H. H. Sandstead, "Zinc requirements and the risks and benefits of zinc supplementation," Journal of Trace Elements in Medicine and Biology, vol. 20, no. 1, pp. 3–18, May 2006, https://doi.org/10.1016/j.jtemb.2006.01.006

[27] R. S. Gibson, V. Raboy, and J. C. King, "Implications of phytate in plant-based foods for iron and zinc bioavailability, setting dietary requirements, and formulating programs and policies," Nutr. Rev., vol. 76, no. 11, pp. 793–804, Nov. 2018, https://doi.org/10.1093/NUTRIT/NUY028

[28] A. Lacurezeanu and D. C. Vodnar, "Arthrospira platensis and Chlorella vulgaris Consumption on Iron Status: A Systematic Review of In Vivo Studies," Mol. Nutr. Food Res., vol. 69, no. 24, Dec. 2025, https://doi.org/10.1002/mnfr.70318

[29] Y. Nishimoto et al., "The Nutritional Efficacy of Chlorella Supplementation Depends on the Individual Gut Environment: A Randomised Control Study," Front. Nutr., vol. 8, p. 648073, May 2021, https://doi.org/10.3389/FNUT.2021.648073/TEXT

[30] S. Oparil et al., "Hypertension," Nat. Rev. Dis. Primers, vol. 4, p. 18014, Mar. 2018, https://doi.org/10.1038/NRDP.2018.14

[31] T. Tsuchida et al., "Clinical Study of γ-Aminobutyric Acid-rich Chlorella for Subjects with High-normal Blood Pressure and Mild Hypertension," Nippon Eiyo Shokuryo Gakkaishi, vol. 56, no. 2, pp. 97–102, 2003, https://doi.org/10.4327/jsnfs.56.97

[32] M. Shimada et al., "Anti-Hypertensive Effect of γ-Aminobutyric Acid (GABA)-Rich Chlorella on High-Normal Blood Pressure and Borderline Hypertension in Placebo-Controlled Double Blind Study," Clin. Exp. Hypertens., vol. 31, no. 4, pp. 342–354, 2009, https://doi.org/10.1080/10641960902977908

[33] T. Otsuki, K. Shimizu, and S. Maeda, "Changes in arterial stiffness and nitric oxide production with Chlorella-derived multicomponent supplementation in middle-aged and older individuals," J. Clin. Biochem. Nutr., vol. 57, no. 3, pp. 228–232, 2015, https://doi.org/10.3164/JCBN.15-86

[34] Y. Panahi et al., "Investigation of the effects of Chlorella vulgaris supplementation in patients with non-alcoholic fatty liver disease: a randomized clinical trial," Hepatogastroenterology, vol. 59, no. 119, pp. 2099–2103, Oct. 2012, https://doi.org/10.5754/HGE10860

[35] A. A. Fallah et al., "Effect of Chlorella supplementation on cardiovascular risk factors: A meta-analysis of randomized controlled trials," Clin. Nutr., vol. 37, no. 6 Pt A, pp. 1892–1901, Dec. 2018, https://doi.org/10.1016/J.CLNU.2017.09.019

[36] A. Sahebkar et al., "Investigation of the effects of Chlorella vulgaris as an adjunctive therapy for dyslipidemia: Results of a randomized open-label clinical trial," Clin. Biochem., vol. 44, no. 13, pp. S338–S339, Sep. 2011, https://doi.org/10.1016/j.clinbiochem.2011.08.840

[37] S. Kim et al., "A dietary cholesterol challenge study to assess Chlorella supplementation in maintaining healthy lipid levels in adults: a double-blinded, randomized, placebo-controlled study," Nutr. J., vol. 15, no. 1, May 2016, https://doi.org/10.1186/S12937-016-0174-9

[38] J. H. Kwak et al., "Beneficial immunostimulatory effect of short-term Chlorella supplementation: enhancement of Natural Killer cell activity and early inflammatory response (Randomized, double-blinded, placebo-controlled trial)," Nutr. J., vol. 11, no. 1, p. 53, Dec. 2012, https://doi.org/10.1186/1475-2891-11-53

[39] M. Sanayei et al., "Chlorella vulgaris in combination with high intensity interval training in overweight and obese women: a randomized double-blind clinical trial," J. Diabetes Metab. Disord., vol. 20, no. 1, pp. 781–792, May 2021, https://doi.org/10.1007/s40200-021-00816-0

[40] A. Karbalamahdi, B. Abedi, H. Fatolahi, and A. Pazoki, "Effect of Aerobic Training and C. vulgaris Intake on Lipid Profile and Leptin in Obese Women," Hormozgan Medical Journal, vol. 23, no. 2, p. e91436, Jun. 2019, https://doi.org/10.5812/hmj.91436

[41] N. Sherafati et al., "Effect of supplementation with Chlorella vulgaris on lipid profile in adults: A systematic review and dose-response meta-analysis of randomized controlled trials," Complement. Ther. Med., vol. 66, p. 102822, Jun. 2022, https://doi.org/10.1016/J.CTIM.2022.102822

[42] M. Ebrahimi-Mameghani et al., "The Effect of Chlorella vulgaris Supplementation on Liver Enzymes, Serum Glucose and Lipid Profile in Patients with Non-Alcoholic Fatty Liver Disease," Health Promot. Perspect., vol. 4, no. 1, p. 107, 2014, https://doi.org/10.5681/HPP.2014.014

[43] N. H. Ryu et al., "Impact of daily Chlorella consumption on serum lipid and carotenoid profiles in mildly hypercholesterolemic adults: A double-blinded, randomized, placebo-controlled study," Nutr. J., vol. 13, no. 1, pp. 57-, Jun. 2014, https://doi.org/10.1186/1475-2891-13-57

[44] M. Ebrahimi-Mameghani et al., "Glucose homeostasis, insulin resistance and inflammatory biomarkers in patients with non-alcoholic fatty liver disease: Beneficial effects of supplementation with microalgae Chlorella vulgaris: A double-blind placebo-controlled randomized clinical trial," Clinical Nutrition, vol. 36, no. 4, pp. 1001–1006, Aug. 2017, https://doi.org/10.1016/J.CLNU.2016.07.004

[45] L. Ismail, H. Materwala, and J. Al Kaabi, "Association of risk factors with type 2 diabetes: A systematic review," Comput. Struct. Biotechnol. J., vol. 19, pp. 1759–1785, Jan. 2021, https://doi.org/10.1016/J.CSBJ.2021.03.003

[46] S. Shibata et al., "Antioxidant and anti-cataract effects of Chlorella on rats with streptozotocin-induced diabetes," J. Nutr. Sci. Vitaminol. (Tokyo)., vol. 49, no. 5, pp. 334–339, 2003, https://doi.org/10.3177/JNSV.49.334

[47] C. Jong-Yuh and S. Mei-Fen, "Potential hypoglycemic effects of Chlorella in streptozotocin-induced diabetic mice," Life Sci., vol. 77, no. 9, pp. 980–990, Jul. 2005, https://doi.org/10.1016/J.LFS.2004.12.036

[48] J. F. Vecina et al., "Chlorella modulates insulin signaling pathway and prevents high-fat diet-induced insulin resistance in mice," Life Sci., vol. 95, no. 1, pp. 45–52, Jan. 2014, https://doi.org/10.1016/J.LFS.2013.11.020

[49] H. Itakura, M. Kobayashi, and S. Nakamura, "Chlorella ingestion suppresses resistin gene expression in peripheral blood cells of borderline diabetics," Clin. Nutr. ESPEN, vol. 10, no. 3, pp. e95–e101, Jun. 2015, https://doi.org/10.1016/J.CLNESP.2015.04.002

[50] T. Miyazawa et al., "Ingestion of Chlorella reduced the oxidation of erythrocyte membrane lipids in senior Japanese subjects," J. Oleo Sci., vol. 62, no. 11, pp. 873–881, 2013, https://doi.org/10.5650/JOS.62.873

[51] J. J. Merino et al., "The Long-Term Algae Extract (Chlorella and Fucus sp) and Aminosulphurate Supplementation Modulate SOD-1 Activity and Decrease Heavy Metals (Hg++, Sn) Levels in Patients with Long-Term Dental Titanium Implants and Amalgam Fillings Restorations," Antioxidants (Basel), vol. 8, no. 4, Apr. 2019, https://doi.org/10.3390/ANTIOX8040101

[52] I. Lee et al., "Detoxification of chlorella supplement on heterocyclic amines in Korean young adults," Environ. Toxicol. Pharmacol., vol. 39, no. 1, pp. 441–446, Jan. 2015, https://doi.org/10.1016/J.ETAP.2014.11.015

[53] Y. Panahi et al., "A randomized controlled trial of 6-week Chlorella vulgaris supplementation in patients with major depressive disorder," Complement. Ther. Med., vol. 23, no. 4, pp. 598–602, Aug. 2015, https://doi.org/10.1016/J.CTIM.2015.06.010

[54] F. Haidari et al., "Effect of chlorella supplementation on systematic symptoms and serum levels of prostaglandins, inflammatory and oxidative markers in women with primary dysmenorrhea," Eur. J. Obstet. Gynecol. Reprod. Biol., vol. 229, pp. 185–189, Oct. 2018, https://doi.org/10.1016/J.EJOGRB.2018.08.578

[55] T. Gurney and O. Spendiff, "Algae Supplementation for Exercise Performance: Current Perspectives and Future Directions for Spirulina and Chlorella," Front. Nutr., vol. 9, p. 865741, 2022, https://doi.org/10.3389/fnut.2022.865741

[56] R. Milad et al., "Reduction of Muscle Damage Indices by Consuming Chlorella vulgaris Along With High-Intensity Interval Training in Men With Overweight: A Controlled Clinical Trial," Health Sci. Rep., vol. 8, no. 10, Oct. 2025, https://doi.org/10.1002/hsr2.71304

[57] M. Sanayei et al., "High-intensity interval training with or without chlorella vulgaris supplementation in obese and overweight women: effects on mitochondrial biogenesis, performance and body composition," British Journal of Nutrition, vol. 128, no. 2, pp. 200–210, Jul. 2022, https://doi.org/10.1017/S0007114521003287

[58] H. White and T. Gurney, "Chlorella Supplementation Reduces Blood Lactate Concentration and Increases O2 Pulse during Submaximal and Maximal Cycling in Young Healthy Adults," Nutrients, vol. 16, no. 5, p. 697, Feb. 2024, https://doi.org/10.3390/nu16050697

[59] T. Gurney, J. Brouner, and O. Spendiff, "The Efficacy of Chlorella Supplementation on Multiple Indices of Cycling Performance," J. Diet. Suppl., vol. 21, no. 1, pp. 99–115, Jan. 2024, https://doi.org/10.1080/19390211.2023.2186557

[60] P. Rzymski et al., "Essential and toxic elements in commercial microalgal food supplements," J. Appl. Phycol., vol. 31, no. 6, pp. 3567–3579, Dec. 2019, https://doi.org/10.1007/S10811-018-1681-1

[61] E. Tiberg, S. Dreborg, and B. Björkstén, "Allergy to green algae (Chlorella) among children," J. Allergy Clin. Immunol., vol. 96, no. 2, pp. 257–259, 1995, https://doi.org/10.1016/S0091-6749(95)70016-1

[62] P. Rzymski et al., "The multidisciplinary approach to safety and toxicity assessment of microalgae-based food supplements following clinical cases of poisoning," Harmful Algae, vol. 46, pp. 34–42, Jun. 2015, https://doi.org/10.1016/j.hal.2015.05.003

[63] H. E. Yim et al., "Acute tubulointerstitial nephritis following ingestion of Chlorella tablets," Pediatric Nephrology, vol. 22, no. 6, pp. 887–888, Jun. 2007, https://doi.org/10.1007/s00467-006-0420-z

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