



**INTERNATIONAL JOURNAL OF
PHARMACEUTICAL SCIENCES**
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: <https://www.ijpsjournal.com>



Review Article

Arthrospira Platensis: A Comprehensive Review on Recent Advances in the Biological Activities of Spirulina

Prabha Hullatti, Abhishek Ramapur, Aftab Makandar, Mallinath Patil*, Manikanta N., Varshitha M. S.

Department of Pharmacology, Bapuji Pharmacy College, S S layout, Davangere-577004, Karnataka, India.

ARTICLE INFO

Published: 15 Oct 2026

Keywords:

Arthrospira platensis, Spirulina, C-phycocyanin, Phycocyanobilin, Antioxidant activity, Pharmacological activities, Nutraceutical, Phytochemicals, Immunomodulatory activity, Aquaculture

DOI:

10.5281/zenodo.23393700

ABSTRACT

Spirulina, scientifically classified as *Arthrospira platensis*, is a filamentous cyanobacterium widely recognized for its exceptional nutritional value and diverse biological properties. It is a rich source of proteins, essential amino acids, polyunsaturated fatty acids, vitamins, minerals, carotenoids, phenolic compounds, polysaccharides, and phycobiliproteins, particularly C-phycocyanin. The present review provides a comprehensive overview of the taxonomy, morphology, geographical distribution, cultivation systems, phytochemical composition, nutritional properties, pharmacological activities, and potential applications of *Spirulina*. Several bioactive constituents of *Spirulina* contribute to its antioxidant, anti-inflammatory, immunomodulatory, anticancer, antiviral, antimicrobial, antidiabetic, hypolipidemic, anti-obesity, hepatoprotective, nephroprotective, neuroprotective, and radioprotective activities. C-phycocyanin and phycocyanobilin play important roles in scavenging reactive oxygen species and modulating oxidative and inflammatory pathways, while other bioactive compounds contribute to metabolic regulation and cellular protection. Evidence from preclinical and clinical studies indicates the potential of *Spirulina* as a nutraceutical and functional food for supporting human health and preventing various chronic disorders. In addition, its high protein content and digestibility make it a promising alternative protein source in aquaculture, where it can partially replace fishmeal and improve growth, feed utilization, and disease resistance. *Spirulina* also has emerging applications in food technology, environmental bioremediation, bioplastics, biofuels, and other biotechnological fields. Overall, the diverse nutritional, pharmacological, environmental, and industrial properties of *Arthrospira platensis* highlight its potential as a multifunctional natural resource with promising applications in health, food, feed, and biotechnology.

***Corresponding Author:** Mallinath Patil

Address: Department of Pharmacology, Bapuji Pharmacy College, S S layout, Davangere-577004, Karnataka, India

Email ✉: mallinathpatil378@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



INTRODUCTION

Currently, world public health suffers from serious issues emerging due to extensive environmental pollution, various types of stress, unhealthy lifestyle, quick urbanization, and dietary changes. These complex risk factors have increased the development of non-infectious lifestyle diseases (NCDs), such as heart diseases, type 2 diabetes, metabolic syndrome, obesity, and cancer diseases. Additionally, neurodegenerative and neurological disorders, primarily consisting of Alzheimer's disease (AD), Parkinson's disease (PD), and Multiple Sclerosis (MS), grow very quickly and cause serious motor and cognitive impairments of the elderly people all over the world [1,2,3].

To cope with these growing threats to health, current modern pharmacology, biotechnology, and preventive

medicine pay much attention to non-toxic natural products, nutraceuticals, and microalgae-based medicines. Out of various agents used for preventive purposes, photosynthesizing microalgae and cyanobacteria can be regarded as unique products because of their highly nutritious content and rich secondary metabolites. Particularly, *Spirulina* (genus *Arthrospira*) has become one of the most cultivated microalgae in the world, making about 30% of the entire amount of commercial microalgae biomass produced in the world [4,5].

Officially recognized as a “Superfood” and called “the ideal food for humanity” by the FDA and FAO of the United States, *Spirulina* is extensively used as a compact and highly nutritious supplement by international agencies such as NASA during long-term space missions [6].

Biochemical Composition of Spirulina Biomass (% Dry Weight)

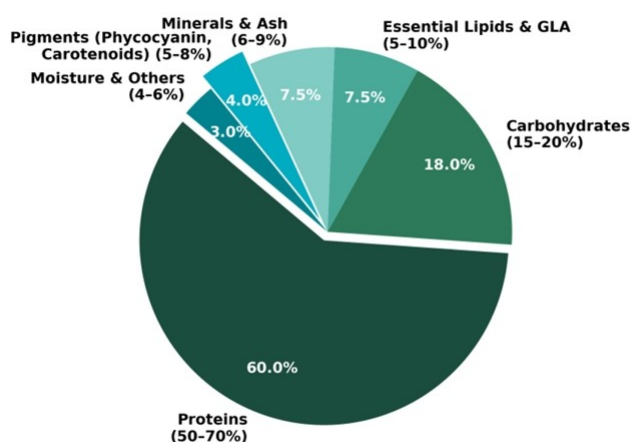


Figure 1: Comprehensive biochemical composition breakdown of dry *Spirulina* biomass, highlighting its dominant protein fraction, essential fatty acids, carbohydrates, and vital pigments [3, 11, 28].

Taxonomy, Scientific Classification, and Historical Nomenclature

Taxonomically, the classification of *Spirulina* has seen numerous advancements since it was first isolated in 1827. For instance, in 1844, the spirally arranged, septate, and blue-green algae was given the name *Spirulina jenneri* f. *platensis*. The genus *Arthrospira* was created by Stizenberger in 1852 based on the visible multicellular septa and the spiral trichome formation. On the other hand, in 1892, Gomont reclassified the two genera under *Spirulina*. It was only in 1989 that

modern microbiology criteria separated the organisms into two genera, namely *Spirulina* and *Arthrospira*. Nonetheless, despite the separation, the term “*Spirulina*” is still widely used in commerce, medicine, and science [7,8].

Based on taxonomic classification, the commercial *Spirulina* falls under the domains Bacteria and Kingdom Eubacteria, Phylum Cyanobacteria, Class Cyanophyceae, Subclass Oscillatorioophycideae, Order Oscillatoriales, Family Oscillatoriaceae (Microcoleaceae), and Genus *Arthrospira*. *Arthrospira*



platensis and *Arthrospira maxima* are the two major economically and clinically important species ^[9].

SCIENTIFIC CLASSIFICATION:

Arthrospira maxima/*Arthrospira platensis* ^[10]

- **Domain** : Bacteria
- **Kingdom** : Eubacteria
- **Phylum** : Cyanobacteria
- **Class** : Cyanophyceae
- **Sub-class** : Oscillatoriophycideae
- **Order** : Oscillatoriales
- **Family** : Oscillatoriaceae / Microcoleaceae
- **Genus** : *Arthrospira*
- **Species** : *Arthrospira platensis*/ *Arthrospira maxima*

SCIENTIFIC SYNONYMS & TAXA

Taxonomically, the major commercial and research species belong to the genus *Arthrospira*, though they are universally referred to by the historical genus name *Spirulina* in commercial and mainstream scientific literature ^[11,12]

Accepted Botanical Taxonomy	Major Scientific Synonym(s)
<i>Arthrospira maxima</i>	<i>Spirulina maxima</i>
<i>Arthrospira platensis</i>	<i>Spirulina platensis</i>
<i>Arthrospira fusiformis</i>	<i>Spirulina fusiformis</i>
<i>Limnospira platensis</i>	<i>Arthrospira platensis</i> / <i>Spirulina platensis</i>

VERNACULAR & CULTURAL NAMES

Spirulina is recognized across various regions, cultures, and commercial sectors under several historical and contemporary designations;

- Dihe / Kanembu: Traditional dried algal cakes harvested and produced by the Kanembu people along the shores of Lake Chad in Africa.

- Tecuitlatl: Historical Aztec name for harvested blue-green algal biomass gathered from Lake Texcoco in ancient Mexico.
- Blue-Green Algae / Microalgae: Common international, agricultural, and commercial designations used in global health and dietary supplement markets. ^[13]

MORPHOLOGICAL CHARACTERISTICS

Spirulina (*Arthrospira*) belongs to the kingdom Cyanobacteria, order Oscillatoriales, and family Oscillatoriaceae. It is a multicellular oxygenic photosynthesizing organism. As concerns its morphology, *Spirulina* is known to have regular, spiral-shaped, cylindrical, unbranched filaments called trichomes, about 0.5 mm in length. It is the spiral structure of the filaments that makes up the name of the genus. Conventional methods for the identification of species of *Spirulina* are mainly based on the spiralization characteristics (tightness and configuration of spirals, as well as trichome width) ^[14].

During laboratory or industrial mass cultivation, *Spirulina* demonstrates structural flexibility and sometimes develops morphologically abnormal strains, including irregularly coiled or fully straight, non-spiral trichomes. The blue-green pigmentation of *Spirulina* cells is provided by a unique two-layer pigment composition including green chlorophyll-and blue phycobiliproteins, especially C-phycocyanin and allophycocyanin. It should be noted that in contrast to typical eukaryotic microalgae like Chlorella, *Spirulina* does not possess a firm cellulose cell wall. Its cell membrane is composed of soft peptidoglycan complex with mucopolysaccharides and that is what makes it extremely digestible in animal and human organisms without any thermal or chemical treatment of the cells ^[13,14].





Spirulina plant



Spirulina powder

Morphological and Microscopic Differentiation Between *Arthrospira maxima* and *Arthrospira platensis* ^[15]

Microscopic /Morphological feature	<i>Arthrospira maxima</i>	<i>Arthrospira platensis</i>
Trichome Constriction	Not or slightly constricted at cross walls	Clearly constricted at cross-walls.
Trichome Diameter	Wider trichome diameter	Narrower trichome diameter.
Terminal Cells	Attenuated (6–7 cells); terminal cell capitate/calyptrate	Less attenuated; terminal cell less specialized.
Coil Diameter	Slight attenuation toward apices	Constant coil diameter throughout.
Gas Vacuoles & Granulation	Densely granulated with regular gas vacuole distribution	Densely granulated but less regular distribution.
Cell Wall / Sheath (SEM)	Thicker sheath; deep surface ribs	Thinner sheath; shallow, anastomosed ribs.
Trichome Length / Coils	Longer trichomes with multiple spiral coils	Shorter trichomes (typically 5–7 coils).
Gliding Motility	Higher gliding motility in liquid media	Lower gliding motility.

GEOGRAPHICAL CHARACTERISTICS

Spirulina normally exists in highly alkaline aquatic ecosystems, having higher pH values (pH 9 – 11), very high carbonate/bicarbonate ions concentration, and hot tropical/subtropical conditions. Natural blooms of *Spirulina* have been reported in highly alkaline lakes of volcanic origin, such as the Great Rift Valley lakes of East Africa (Lake Nakuru, Lake Bogoria), Lake Chad in Central Africa, and Lake Texcoco in Mexico. The other natural ecosystems where *Spirulina* grows are hot marine and tropical freshwater ecosystems of the Pacific region in Hawaii and Japan.

Because of its high socio-economic importance, *Spirulina* mass culture is practiced all over the world in North America, South America, Europe, Asia (China, India), and Africa. For commercial purposes, *Spirulina* cultivation involves two major types of cultures:

- **Open Raceway Ponds:** Shallow raceway ditches of unlined/lined type, equipped with paddlewheels. It uses inexpensive continuous harvesting system in highly alkaline waters for inhibition of competing organisms.
- **Closed Photobioreactor (PBR) System:** Closed transparent tubular systems used mainly in hatcheries and pharmaceutical applications to avoid environmental contamination and growth control.

After biomass reaches an exponential level, mature trichomes are collected using fine cloth filters and vibrating sieves, washed and dried by solar/spray drying into fine, shelf-stable dark green powder ^[16].

Natural Habitat, Ecological Adaptation, and Ultrastructure

The *Spirulina* species are characterized by a remarkable ability to survive in a variety of aquatic and terrestrial ecosystems, including freshwater, brackish

water, and seawater, marshes, tropic soils, and hot springs. By nature, *Spirulina* inhabits hypersaline, highly alkaline soda lakes in tropical and subtropical zones with pH 8.5-11.0 and salt content over 30 g/L^[17].

Some natural habitats for *Spirulina* are Lake Texcoco in Mexico (cultivated as Tecuitlatl by the Aztecs) and the alkaline lakes of Rift Valley in East Africa (Lake Chad, cultivated as Dihe). The dominance of *Spirulina* in such extreme environments is related to its ability to tolerate high cytoplasmic pH (4.2-8.5) and utilize bicarbonate and ammonia as carbon and nitrogen sources in carbonate-alkaline environments when competing microflora is inhibited^[18].

Transmission electron microscopy revealed ultrastructure of *Arthrospira* species with typical prokaryotic cell structure without membrane-enclosed nucleus and chloroplasts. Cell wall includes four layers (L-I, L-II, L-III, L-IV) and has a thick electron dense layer^[19].

The peripheral cytoplasm of the cells contains numerous parallel arrays of thylakoid membranes with electron opaque phycobilisomes, main photosynthetic protein complexes. The cytoplasm also has polyglucan

granules, gas vacuoles which provide buoyancy of the cells, protein fibrils and lipid bodies^[20,21].

Cultivation Systems, Bioprocess Engineering, and Processing

The industrial-scale production of *Spirulina* biomass takes place using either the open raceway ponds or the closed photobioreactor (PBR) approach. The open raceway ponds are cheap and easy-to-maintain structures stirred by paddlewheel mixers and can be run under alkaline conditions where there is no contamination.

On the other hand, closed photobioreactors have the advantage of accurate climate control, increased volumetric light utilization, optimal CO₂ dissolution, and sterility, which results in increased biomass density and improved metabolite formation.



Fig. 4 Spirulina cultivation and its application as feedstock for biodiesel production and adsorbent for wastewater remediation

Bioprocess Flow Chart: From Cultivation to Multi-Sectorial Applications

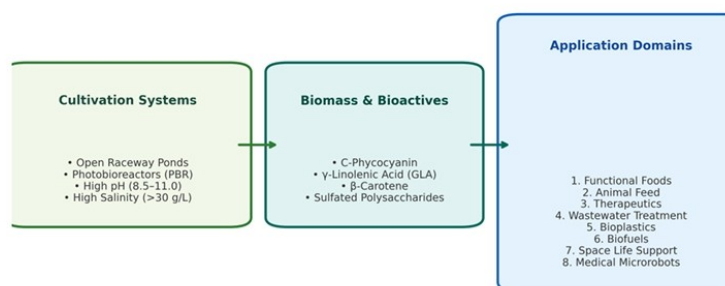


Figure 3: Integrated bioprocess flow chart depicting *Spirulina* cultivation modalities, bioactive fraction extraction, and primary application sectors [7, 10, 11, 27].

Production is controlled by eight environmental parameters, including: irradiance, temperature, inoculum density, stirring rate, total dissolved solids, pH, water quality and macro/micro-nutrient ratios. Harvest includes filtration, washing to remove the extra sodium salts, cell dehydration, drying and powdered preparation [22].

Molecular Pathways of Antioxidant, Anti-Inflammatory, and Immunomodulatory Activity

The cellular basis of dysfunction and inflammation involves an imbalance in the production of ROS and RNS, relative to endogenous antioxidant defenses. Excess ROS (H_2O_2 , $O_2^{\bullet-}$, $HO^{\bullet}$) triggers lipid peroxidation, alterations to membrane integrity, and degradation of nucleic acids. This oxidative chain reaction stimulates the phosphorylation and degradation of the nuclear factor kappa B (NF- κ B) inhibitor protein I κ B,

allowing for the translocation of NF- κ B transcription factors into the nucleus. NF- κ B transactivation increases the expression of pro-inflammatory cytokines, such as TNF- α , IL-6, inducible nitric oxide synthase (iNOS), and COX-2 [23,24].

Spirulina-derived compounds, such as C-PC, phycocyanobilin, GLA, and beta-carotene, disrupt this pathophysiological chain at various molecular checkpoints. The antioxidant C-PC serves as an inhibitor of NADPH oxidase, thus inhibiting ROS formation [25].

In addition, clinical meta-analysis of *Spirulina* supplementation shows that it increases serum IL-2 levels (SMD = 2.69 pg/mL, $p = 0.03$), resulting in increased cytotoxic effects of NK cells and T-cells, as well as decreased levels of IL-6 and TBARS in non-obese patients (BMI < 25 kg/m²). Furthermore, *Spirulina* increases the activity of endogenous antioxidant enzyme systems, SOD, CAT, and GPx [26].

Molecular Pathways of Spirulina Anti-Inflammatory and Antioxidant Mechanisms

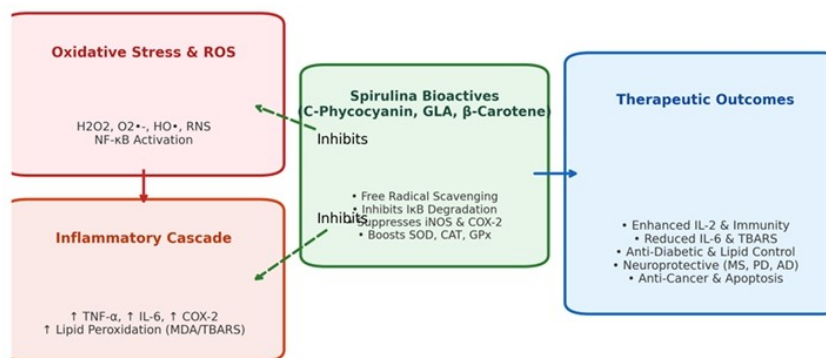


Figure 4: Molecular pathway diagram illustrating how *Spirulina* bioactive components (C-phycocyanin, GLA, β-carotene) attenuate ROS-induced NF-κB activation, downregulate pro-inflammatory cytokines (IL-6, TNF-α), and restore systemic antioxidant equilibrium [11, 16, 32, 34].

Multi-Sectorial Therapeutic, Environmental, and Biotechnological Applications

1. **Neuroprotective Potential:** In MS, C-PC induces remyelination, gliogenesis, and increases the expression of axon-glia repair gene and down-regulates the markers of demyelination (CD44, PPAR). In PD, *Spirulina* polysaccharides maintain tyrosine hydroxylase and DAT mRNA expression, whereas it inhibits MAOB. In AD, C-PC decreases Aβ aggregation and hyperphosphorylation of tau protein.
2. **Metabolic & Cardiovascular Function:** From clinical studies, it is evident that *Spirulina* decreases serum fasting blood glucose level, HbA1c, total cholesterol, and LDL-C, a decrease of 4.5% in total serum cholesterol has been reported.
3. **Antiviral and Antimicrobial Potential:** The Ca-SP inhibits viral attachment and penetration against enveloped viruses such as HIV-1, HSV-1, Influenza A, Mumps, and Measles.
4. **Industrial Applications & Environmental & Engineering:** *Spirulina* is used in the synthesis of bioplastics by blending it with polyethylene to increase its tensile strength. It is used in bioremediation of wastewater space closed-loop life support systems. Its use is increasing in biohybrid magnetic microrobots for targeted [27].

PHYTOCHEMICAL CONSTITUENTS AND TRADITIONAL USE OF *SPIRULINA*:

BIOACTIVE PROPERTIES OF *SPIRULINA*:

Amir Ali Anvar et.al have conducted a study on the bioactive properties of *Spirulina* which have the chemical constituents such as 70-55% of proteins, 20-25% of carbohydrates, 18% of essential fatty acids, vitamins, minerals, and pigments such as carotene, chlorophyll A and phycocyanin.

Spirulina consists of some of the essential anti-oxidants such as santos, Freitas, Moreira, zanfonato, and costa. It consists of some of the essential; fatty acids such as linoleic acid, linolenic acid, phycobiliproteins and also consists of phycocyanin, allophycocyanin and consists of some essential amino acids such as leucine (10.9% of total amino acids), valine isoleucine and minerals like iron.

Spirulina consists of immunological properties such as anti-cancer, probiotic property, neuroprotective property, hypoglycaemic, hypolipidemic, antinephrotoxicity, anti-genotoxicity, anti-viral activity, anti-inflammatory and antiobesity activities [28].

SPIRULINA PLATENSIS- FOOD FOR FUTURE:

Saranraj. P et.al have a conducted the study on active constituents of *Spirulina*. *Spirulina* consists of some active constituents such as rhamnose, ribose, mannose, fructose, galactose, xylose, glucose, glucuronic acid, galacturonic acid and calcium sulphate.

Spirulina is active against viruses such as HIV, Herpes Simplex Virus, Human Cytomegalovirus, Influenza A Virus, Mumps Virus and Measles Virus. Cell extract of *Spirulina maxima* has shown antimicrobial activity against *Bacillus Subtilis*, *Streptococcus aureus*, *Saccharomyces cerevisiae* and *Candida albicans*. *Spirulina* reduces hepatic damage due to drug abuse and heavy metal exposure, inflammatory response, cell degradation, anaphylactic reaction. *Spirulina* contains vitamin A, important in preventing eye diseases, iron and vitamin B12, useful in treating hypoferric anaemia and pernicious anaemia, respectively γ -linolenic acid, appropriate in treatment of atopic child eczema therapy, to alleviate premenstrual syndrome, and immune stimulation [29].

SPIRULINA IN CLINICAL PRACTICE, EVIDENCE-BASED HUMAN APPLICATIONS:

P.D. Karkos, S.C. Leong et.al have conducted a study on *Spirulina* in clinical practice. The study suggested that *Spirulina* consists of high content that is 70% of protein, vitamins especially vitamin-B12, provitamins like β -carotenes and minerals like iron. *Spirulina* is also rich in phenolic acids, tocopherols and γ -linolenic acid. *Spirulina* is active against Herpes simplex type1, human cytomegalovirus, measles and mumps virus, influenza A virus and human immune-deficiency virus-1 (HIV-1). It is used for the treatment of cancer and chronic arsenic poisoning. It also acts as an antioxidant [30].

CHEMICAL COMPOSITION, BIOACTIVITIES and APPLICATIONS

OF *SPIRULINA (LIMNOSPIRA PLATENSIS)* IN FOOD, FEED AND MEDICINE:

Maria P Spinola, Ana R Mendes et.al have conducted a study on the chemical constituents, bioactivities and applications of *Spirulina* in food, feed and medicine. The study suggested that *Spirulina* is rich in proteins, essential fatty acids, vitamins, minerals and bioactive compounds such as phycocyanin pigment, polysaccharides and carotenoids. The *Spirulina* exhibit some of the biological activities such as anti-oxidant, anti-inflammatory, immunomodulatory, antiviral, anti-cancer and lipid lowering effects.

Spirulina have potential effect in reducing the oxidative stress, enhancing immune function, inhibits tumour growth and also prevents chronic diseases. It also consists of some of the phytoconstituents such as phenolic compounds, flavonoids and phycocyanin which helps in preventing some of the chronic diseases such as cancer and diabetes [31].

FUNCTIONAL PROPERTIES OF BIOACTIVE COMPOUNDS FROM *SPIRULINA SPP*: CURRENT STATUS AND FUTURE TRENDS:

D.G. Bortolini, G.S. Maciel et.al have conducted a study to evaluate the functional properties of *Spirulina*. Functional foods non-toxic biocompounds that offer health benefits beyond their nutritional value and beneficially modulate one or more target functions in the body. It also contains macronutrients such as carbohydrates, lipids, proteins, vitamins and minerals.

It also contains some of the essential amino acids, unsaturated fatty acids, carotenoids and phenolic compounds. It also contains saturated fatty acids, mono-unsaturated fatty acids, poly-unsaturated fatty acids. It also contains essential amino acids such as tryptophan, threonine, leucine, lysine, methionine, phenylalanine, histidine and valine which are not normally produced in the human body [32].

SPIRULINA: A SPOTLIGHT ON ITS NUTRACEUTICAL / PROPERTIES AND FOOD PROCESSING APPLICATIONS:

S. Priyanka, R. Varsha et.al have conducted a study on the nutraceutical properties of *Spirulina*. They found to know that *Spirulina* is a blue-green algae which is now world-wide used as a dietary supplement which consists of 50-60% of proteins, antioxidants, essential fatty acids etc which are important for the body immunological functions.

It consist of 373kcal, sugar (1.30g), lactose (<0.10g), dietary fibre (7.70g), carbohydrate (17.80g), protein (63g), total fat (5.60g), vitamins (A, C, E, K, B1, B2, B3, B6, B12, biotin and folic acid), minerals (calcium, iron, phosphorous, magnesium, sodium, potassium, iodine, zinc, copper, manganese, boron, chromium, molybdenum, selenium) [33].



EXPLORING THE NUTRITIONAL AND MEDICINAL POTENTIAL OF *SPIRULINA*.

Khushboo Gaur, Ankita Wal et.al have conducted a study on the nutritional value and medicinal potential of *Spirulina*. *Spirulina*, a polyphyletic group of algae, is known for its economically significant products and is widely used as a dietary supplement. It is rich in essential compounds, including proteins, antioxidants, vitamins and minerals.

It consists of proteins (60-90%), carbohydrates (16-20%), lipids (5-7%), minerals (6-9%), moisture content (2.56.0%). It also consists of vitamins like vit-B1 (0.15-0.30mg), vit-B2 (4.07.0mg), vit-B3 (10.0-25.0mg), vit-B6 (0.5-1.5mg), vit-B12 (0.1-0.3mg), folic acid (0.05-0.30mg), inositol (70-90mg), vit-K (0.90-1.05). it also contains some of the minerals such as iron (0.55-1.5g/kg), calcium (1.2-15g/kg), phosphorous (6.5-9.2g/kg), potassium (6.8-15.7g/kg) ^[34].

BENEFICIAL EFFECTS OF *SPIRULINA* CONSUMPTION ON BRAIN HEALTH:

Teresa Trotta, Chiara Porro et.al have conducted a study on *Spirulina* to know the beneficial effects of *Spirulina* consumption on brain health. *Spirulina* consists of high levels of functional compounds such as phycocyanin, phenols and polysaccharides with anti-inflammatory, antioxidant, immunomodulatory effects. It has some positive effects in various pathologies such as cardiovascular diseases, hypercholesterolemia, hyperglycaemia, obesity, hypertension, tumours and inflammatory diseases. It helps in prevention and progression of neurodegenerative diseases such as Parkinson's disease, Alzheimer's disease and multiple sclerosis ^[35].

SPIRULINA AS A SUSTAINABLE FUNCTIONAL INGREDIENT: NUTRIENT DENSITY, BIOACTIVES, AND FOOD APPLICATIONS:

Marwa Ezz El-Din Ibrahim, Selinay Demirel et.al have conducted a study on *Spirulina* to assess its functional ingredients, nutrient density, bioactives. *Spirulina* is characterized by a rich content of protein, complex carbohydrates, polyunsaturated fatty acids, vitamins and minerals, while compounds such as C- phycocyanin, chlorophyll, β -carotene and phenolic

compounds. *Spirulina* consists of 15%-25% of carbohydrates and 5-8% of lipids. It consists of essential fatty acids such as palmitic acid, palmitoleic acid, stearic acid, oleic acid, linoleic acid, alpha-linoleic acid, gamma-linoleic acid and arachidic acid. It also consists of vitamins such as vitamin-B1, vitamin-B2, vitamin-B3, vitamin-B6, vitamin-B12, folic acid, vitamin-A, vitamin-E, vitamin-C and vitamin-K. It includes some of the essential minerals that are important for the human body, such as calcium (Ca), potassium (K), magnesium (Mg), phosphorous (P), sodium (Na), chromium (Cr), iron (Fe), copper (Cu), selenium (Se), zinc (Zn), boron (B) and manganese (Mn) ^[36].

ANTICANCER PROPERTIES OF BLUE GREEN ALGAE *SPIRULINA* PLATENSIS:

Ranjani Ramakrishnan et.al have conducted a study on the anticancer properties of blue green algae *Spirulina platensis*. *Spirulina* is helpful in curing and prevention of some of the most dreadful diseases like tuberculosis, diabetes, many viral infections, heart diseases and cancer are causing human deaths worldwide. Cancer is a complex, multistep process and multi-factorial in origin. Cancer causing agents called carcinogens transform a normal cell to tumour or cancerous cell. Life style, food habits, job factors, environmental factors and hereditary mutations play major role in carcinogenesis.

Consumption of Tobacco products, chewing of betel nut, Alcohol, high dietary fat, red meat, imbalanced diet, canned and preserved food, deep fried and junk food, Cigar smoking, exposure to smoke contents of cigarette, radiation for a longer period, lack of adequate physical activity, are main causes of tumorigenesis and increase in rate of cancer incidence. It consists of approximately 65% of proteins, 20% of carbohydrates, 7% of minerals, 5% of lipids and 3% of moisture. It consists of some of the active biomolecules such as glycolipids, polysaccharides, pigment proteins and amino acids ^[37].

PHARMACOLOGICAL ACTIVITY

The extensive range of preclinical and clinical studies reveal that *Spirulina* contains a wide range of biological activity and therapeutic effects due to the presence of biologically active phytochemicals in it, including



C-phycoerythrin, beta-carotene, gamma-linolenic acid (GLA), Ca-spirulina, and phenolic fractions [38].

Antioxidant Activity and ROS Scavenging

Spirulina is effective as a ROS scavenger and oxidative damage protector. The major antioxidant effect of *Spirulina* is exerted through C-phycoerythrin, a pigment-protein complex that includes phycoerythrin (PCB) pigment. PCB acts as an effective inhibitor of NADPH oxidase, which is an important enzyme responsible for oxidative stress under pathological conditions in mammalian cells. C-phycoerythrin is capable of scavenging hydroxyl, alkoxyl, peroxy, and superoxide free radicals, thus preventing lipid peroxidation and DNA degradation. In addition, *Spirulina* supplementation leads to strong activation of intracellular antioxidant enzymes in terms of SOD, CAT, GPx, and glutathione reductase activities [39].

Immunomodulatory and Anti-Inflammatory Effects

Spirulina has pronounced immunomodulatory activity in both the innate and adaptive immune system. Its oral or dietary intake induces bone marrow hematopoiesis, thymus and spleen enlargement, and accelerated synthesis of white blood cells, antibodies (IgA, IgM), and cytokines (interleukin-1, IL-1; interferon). It potentiates the activity of macrophages for their ability to phagocytose particles and destroy tumor cells, and also NK cell cytotoxicity.

Regarding its anti-inflammatory activity, C-phycoerythrin inhibits histamine liberation by mast cells, thus counteracting allergic reactions such as rhinitis. Moreover, sulfated polysaccharides like Calcium *Spirulina* (Ca-SP) inhibit inflammation [39].

Anti-Cancer and Antitumor Properties

Various scientific investigations have proven the antineoplastic and chemopreventive potential of *Spirulina*. These active constituents such as Se-SE (Selenium enriched *Spirulina* extract), C-Phycoerythrin, and Canthaxanthin have the ability to induce mitochondrial cell apoptosis (caspase-induced cell death) in various types of cancer cells. G1 cell cycle arrest is attained through up regulation of tumor suppressor genes like p53, p21, p57 and pro-apoptotic proteins Bax, while down

regulating anti-apoptotic proteins Bcl-2 and Bcl-xl. In human trials conducted in Kerala, India, oral consumption of *Spirulina* fusiformis for 12 months led to complete regression of oral leukoplakia lesions in 45% patients who were chronic tobacco chewers in comparison to 7% placebo patients. Moreover, Ca-SP blocks cell adhesion and migration to laminin basement membranes and thus reduces lung metastasis of melanoma cells [39,40].

Metabolic Regulation: Hypolipidemic, Antidiabetic, and Anti-Obesity Effects

Spirulina supplementation significantly improves metabolic parameters in cardiovascular and endocrine disorders [41]:

- **Hypolipidemic Action:** Extracts in aqueous solutions from *Spirulina* exhibit inhibitory actions on pancreatic lipase activity and reduce the absorption of fats through the intestines. Scientific clinical studies reveal marked reductions in the concentration of blood cholesterol, triacylglycerols, LDL cholesterol, and increased HDL cholesterol levels.
- **Antidiabetic Action:** Soluble fractions reduce the concentration of blood glucose while insoluble fractions prevent hyperglycemia following carbohydrate loading.
- Clinical studies involving diabetics indicate remarkable reductions in blood glucose levels in human patients with 21 days supplementation with 2 g/day of *Spirulina*.
- **Anti-Obesity and Antihypertensive Activities:** Controlled crossover studies prove the reduction in body weight in obese outpatients with 2.8 g of *Spirulina* taken three times daily for four weeks. The vasodilator effect of nitric oxide production facilitates the suppression of hypertension.

Hepatoprotection, Nephroprotection, and Radiation Protection

The extracts of *Spirulina* efficiently neutralize the toxicity caused due to the effects of heavy metals such as lead, cadmium, and arsenic, chemotherapeutic drugs such as doxorubicin, and hepatotoxicants such as galactosamine.



The protection of hepatic cells, regulation of serum enzyme balance, and reduction in nephrotoxicity are some of its functions. Moreover, *Spirulina* phytopigments and polysaccharides provide protection against radiations ^[42].

Aquaculture Applications: Fishmeal Replacement and Growth Promotion

For present-day aquaculture farms, feeding represents about 50% of operational variable costs, mainly because of increasing prices of fish-meals from the sea. *Spirulina* meal is now recognized as one of the best, yet unusual, sources of proteins used for finfish and shellfish farming ^[33].

Nutrient Component	<i>Spirulina platensis</i> (% Dry Weight)	Brown Fishmeal (% Dry Weight)
Crude Protein	41.2% - 61.3%	67.4%
Crude Lipid / Fat	5.5% - 13.7%	10.5%
Carbohydrates	18.9% - 23.1%	N/A
Ash Content	6.9% - 9.9%	12.8%
Crude Fiber	3.0%	1.5%

Inclusion Levels and Growth Performance

From an extensive review of the literature on aquaculture, it has been established that low to moderate inclusion of *Spirulina* meal (0.5% to 15–20%) ensures maximum growth performance higher FCRs, higher PERs, and increased resistance to diseases caused by pathogens like *Aeromonas hydrophila* ^[43].

- **Finfish Culture:** Inclusion of 1% to 10% *Spirulina* leads to better growth and survival of Nile tilapia, Rainbow trout (*Oncorhynchus mykiss*), Parrotfish (*Oplegnathus fasciatus*), and Indian major carps.
- **Reproductive & Fillet Quality:** *Spirulina* carotenoids improve egg quality, seed production, and fillet texture/coloration, which in turn makes the products more commercially acceptable.
- **Excessive High Inclusion Levels:** Above 30–40%, inclusion often results in slower growth or decreased feed consumption owing to changes in taste and amino acid balance (for example, low methionine and lysine). Hence, an ideal inclusion level is 1% to 20%.

Nutrient Profile and digestibility

Spirulina provides from 41% up to 63% of crude proteins on dry matter, having an excellent composition of essential amino acids, similar to that in high-quality brown fishmeal. Because there is no cellulosic membrane, *Spirulina* protein and fat fractions have very high levels of digestibility, especially in omnivorous and herbivorous species like Nile tilapia (*Oreochromis niloticus*), because of low stomach pH ^[43].

Nutrient Profile Comparison between *Spirulina platensis* and Fishmeal

CONCLUSION

The microalgae *Spirulina* (*Arthrospira platensis*) constitutes a very versatile, eco-resilient algae with superior structural, nutritional, and pharmacological features. It is due to its distinctive helical shape, readily digestible non-cellulosic peptidoglycan cell wall and ability to grow in high pH, alkaline conditions that make these algae highly feasible as a biological crop. Pharmacologically, the therapeutic efficacy of *Spirulina* is rather impressive, as it is demonstrated by its effective ROS scavenging action, immunomodulatory, anti-tumor activity via inducing apoptosis in tumor cell lines, lipid lowering and anti-diabetic actions and organ protective effects from various toxins and radiation. In agriculture, *Spirulina* works well as a partial substitute for costly fish meal and the addition of just 1% to 20% of this algae results in increased productivity, improved feed conversion, enhanced immune reactions and better carcass quality of cultured fishes.



REFERENCES

1. Deshmukh DV, Deshmukh PM, editors. Integrative Approaches in Modern Life Science Volume II. Integration. 2025 Jun.
2. GBD 2021 Stroke Risk Factor Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. The Lancet. Neurology. 2024 Oct;23
3. Rahman MA, Aziz MA, Al-Khulaidi RA, Sakib N, Islam M. Biodiesel production from microalgae *Spirulina* maxima by two step process: Optimization of process variable. Journal of Radiation Research and Applied Sciences. 2017 Apr 1;10 (2):140-7.
4. Saranraj P, Stella D, Usharani G, Sivasakthi S. Effective recycling of lignite fly ash for the laboratory cultivation of Blue Green Algae-*Spirulina* platensis
5. AlFadhly NK, Alhelfi N, Altemimi AB, Verma DK, Cacciola F, Narayanankutty A. Trends and technological advancements in the possible food applications of *Spirulina* and their health benefits: A Review. Molecules. 2022 Jan;27 (17):5584.
6. Ciferri O. *Spirulina*, the edible microorganism. Microbiological reviews. 1983 Dec;47 (4):551-78.
7. Jan S, Abbas N. Himalayan phytochemicals: sustainable options for sourcing and developing bioactive compounds. Elsevier; 2018 Apr 10.
8. Grosshagauer S, Kraemer K, Somoza V. The true value of *Spirulina*. Journal of agricultural and food chemistry. 2020 Mar 5;68 (14):4109-15.
9. Jacuinde-Ruíz JC, González-Hernández JC. Exploring the biotechnological applications of *Spirulina* maxima: a comprehensive review. Brazilian Journal of Biology. 2024;84:e287134.
10. Sinetova MA, Kupriyanova EV, Los DA. *Spirulina*/Arthrospira/Limnospira—Three names of the single organism. Foods. 2024 Aug 30;13 (17):2762.
11. Panda KC, Das R, Kumar BR, Sruti J. Neuroprotective and Antioxidant Study of Cyanobacteria Arthrospira. Current Aging Science. 2025.
12. Patel JS, Patel MR, Adiveshwara Reddy B, Raghunandan BL. *SPIRULINA*: NUTRITIONAL AND THERAPEUTIC REVIEW. International Journal. 2023;1 (1):11-5.
13. Mosha SS. The significance of *Spirulina* meal on fishmeal replacement in aquaculture: A review. J. Fish Aqua. Dev. 2019;145 (10.29011):2577-1493.
14. Manogar M, Devaraj N, Mahalingam P. A review on medical properties on *Spirulina* and their futuristic applications. Asian Journal of Biotechnology and Bioresource Technology. 2020 Nov 30;6 (4):1-1.
15. Tomaselli L, Palandri MR, Tani G. Advances in preparative techniques for observation of the fine structure of Arthrospira maxima Setch. et Gardner (syn. *Spirulina* maxima Geitler). Algological Studies/Archiv für Hydrobiologie, Supplement Volumes. 1993 Jan 1:43-55.
16. Ghaeni M, Roomiani L. Review for application and medicine effects of *Spirulina*, microalgae. Journal of Advanced Agricultural Technologies. 2016 Jun;3 (2).
17. National Research Council, Subcommittee on Fish Nutrition. Nutrient requirements of fish. National Academies Press; 1993 Feb 1.
18. Sarker PK, Gamble MM, Kelson S, Kapuscinski AR. Nile tilapia (*O. reochromis niloticus*) show high digestibility of lipid and fatty acids from marine *S. chizochytrium* sp. and of protein and essential amino acids from freshwater *Spirulina* sp. feed ingredients. Aquaculture nutrition. 2016 Feb;22 (1):109-19.
19. Van Eykelburg C. The ultrastructure of *Spirulina* platensis in relation to temperature and light intensity. Antonie Van Leeuwenhoek. 1979 Sep;45 (3):369-90.
20. Belay A, Kato T, Ota Y. *Spirulina* (Arthrospira): potential application as an animal feed supplement. Journal of Applied Phycology. 1996 Jul;8 (4):303-11.
21. Kim J, Lee HJ, Lee KW. Naturally occurring phytochemicals for the prevention of Alzheimer's disease. Journal of neurochemistry. 2010 Mar;112 (6):1415-30.



22. Olvera-Novoa MA, Domínguez-Cen LJ, Olivera-Castillo L, Martínez-Palacios CA. Effect of the use of the microalga *Spirulina* maxima as fish meal replacement in diets for tilapia, *Oreochromis mossambicus* (Peters), fry. *Aquaculture research*. 1998 Oct;29 (10):709-15.
23. Park HJ, Lee YJ, Ryu HK, Kim MH, Chung HW, Kim WY. A randomized double-blind, placebo-controlled study to establish the effects of *Spirulina* in elderly Koreans. *Annals of Nutrition and Metabolism*. 2008 Aug 19;52 (4):322-8.
24. Mao TK, Water JV, Gershwin ME. Effects of a *Spirulina*-based dietary supplement on cytokine production from allergic rhinitis patients. *Journal of Medicinal Food*. 2005 Mar;8 (1):27-30.
25. Spínola MP, Mendes AR, Prates JA. Chemical composition, bioactivities, and applications of *Spirulina* (*Limnospira platensis*) in food, feed, and medicine. *Foods*. 2024 Nov 17;13 (22):3656.
26. Chojnacka K, Chojnacki A, Gorecka H. Biosorption of Cr³⁺, Cd²⁺ and Cu²⁺ ions by blue-green algae *Spirulina* sp.: kinetics, equilibrium and the mechanism of the process. *Chemosphere*. 2005 Mar 1;59 (1):75-84
27. Subramaiam H, Chu WL, Radhakrishnan AK, Chakravarthi S, Selvaduray KR, Kok YY. Evaluating anticancer and immunomodulatory effects of *Spirulina* (*Arthrospira*) *platensis* and gamma-tocotrienol supplementation in a syngeneic mouse model of breast cancer. *Nutrients*. 2021 Jul 6;13 (7):2320
28. Priyanka S, Varsha R. *Spirulina*: A spotlight on its nutraceutical properties and food processing applications. *Journal of microbiology, biotechnology and food sciences*. 2023 Mar 7;12 (6):e4785-
29. Trotta T, Porro C, Cianciulli A, Panaro MA. Beneficial effects of *Spirulina* consumption on brain health. *Nutrients*. 2022 Feb 5;14 (3):676.
30. Ibrahim ME, Demirel S, Yıkımsı S, Tokatlı Demirok N, Ahmed MB, Amin AK. *Spirulina* as a sustainable functional ingredient: nutrient density, bioactives, and food applications. *Frontiers in Nutrition*. 2026 Apr 15;13:1810841.
31. Al-Hussaniy HA, Al-Tameemi Z, Al-Zubaidi B, Oraibi AI, Naji FA, Kilani S. Pharmacological properties of *Spirulina* species: Hepatoprotective, antioxidant and anticancer effects. *Farmacia*. 2023 Jul 1;71 (4):670-8.
32. Clement G, Giddey C, Menzi R. Amino acid composition and nutritive value of the alga *Spirulina* maxima. *Journal of the Food and Agriculture*. 1967 Nov;18 (11):497-501.
33. Pekamwar SS, Kalyankar TM, Kokate SS. Pharmacological activities of *Coccinia grandis*. *Journal of Applied Pharmaceutical Science*. 2013 May;3 (05):114-9.
34. Kinnunen T, Chamberlain N, Morbach H, Cantart T, Lynch M, Preston-Hurlburt P, Herold KC, Hafler DA, O'Connor KC, Meffre E. Specific peripheral B cell tolerance defects in patients with multiple sclerosis. *The Journal of clinical investigation*. 2013 Jun 3;123 (6):2737-41.
35. Elbaz AC, Kab L. S. & Moisan, F.(2016). Epidemiology of Parkinson's disease. *Revue neurologique*.;172 (1):14-26
36. Anvar SA, Nowruzi B, Afshari G. A review of the application of nanoparticles biosynthesized by microalgae and cyanobacteria in medical and veterinary sciences. *Iranian Journal of Veterinary Medicine*. 2023 Sep 8;17 (1):1-8.
37. Parikh P, Mani U, Iyer U. Role of *Spirulina* in the control of glycemia and lipidemia in type 2 diabetes mellitus. *Journal of medicinal food*. 2001 Dec;4 (4):193-9
38. Zhang DM, Luo Y, Yishake D, Liu ZY, He TT, Luo Y, Zhang YJ, Fang AP, Zhu HL. Prediagnostic dietary intakes of vitamin A and β -carotene are associated with hepatocellular-carcinoma survival. *Food & function*. 2020 Jan 1;11 (1):759-67.
39. Dwivedi S. Bioremediation of heavy metal by algae: current and future perspective. *J Adv Lab Res Biol*. 2012 Jul 1;3 (3):195-9.
40. Evans AM, Smith DL, Moritz JS. Effects of algae incorporation into broiler starter diet formulations on nutrient digestibility and 3 to 21 d bird performance. *Journal of applied poultry research*. 2015 Jun 1;24 (2):206-14.

41. Karkos PD, Leong SC, Karkos CD, Sivaji N, Assimakopoulos DA. *Spirulina* in clinical practice: evidence-based human applications. Evidence-based complementary and alternative medicine. 2011;2011 (1):531053.
42. Spínola MP, Mendes AR, Prates JA. Chemical composition, bioactivities, and applications of *Spirulina* (*Limnospira platensis*) in food, feed, and medicine. Foods. 2024 Nov 17;13 (22):3656.
43. Bortolini DG, Maciel GM, Fernandes ID, Pedro AC, Rubio FT, Branco IG, Haminiuk CW. Functional properties of bioactive compounds from *Spirulina* spp.: Current status and future trends. Food Chemistry: Molecular Sciences. 2022 Dec 30;5:100134.

HOW TO CITE: Prabha Hullatti, Abhishek Ramapur, Aftab Makandar, Mallinath Patil, Manikanta N., Varshitha M. S., *Arthrospira Platensis: A Comprehensive Review on Recent Advances in the Biological Activities of Spirulina*, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 10, 2401-2414. <https://doi.org/10.5281/zenodo.23393700>

