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Nutritional and Health Benefits of Spirulina and its Cultivation Methods

Dr. Swati Chaurasia

Associate Professor, Department of Botany, DDU Government PG College, Saidabad, Prayagraj, UP - 221508, India
Email: *swati17j[at]gmail.com*
Mob: 9451181542

Abstract: ***With increase in population, there are worrying global trends in malnutrition. Arthrospira, commercially known as Spirulina could be a better solution to this problem. Spirulina is an autotrophic fresh water blue green alga belonging to class cyanophyceae. It appears as a mass of intertwined filaments that are multicellular, motile and gliding along the axis. The alga is rich in proteins, vitamins and minerals that boost the immune system in fighting infection. Other biological activities include antiallergic, antioxidant, anti - inflammatory, anticancer, antiobesity, antidiabetic, antibacterial, antiviral, anti - neurodegenerative and hepatoprotective qualities. Due to its nutritional benefits and easily digestible nature its production and consumption is encouraged in developing countries with population suffering from malnutrition. This review presents a brief overview of the general characteristics of* Spirulina*, as well as its biochemical components and health benefits. It also mentions some common cultivation methods of Spirulina.***

Keywords: Spirulina, *Arthrospira*, health benefits

1. Introduction

The term “Spirulina” is commonly used to refer to two particular species of *Arthrospira*, i. e., *Arthrospira maxima* and *A. platensis* (Berden Zrimec *et al.*, 2024). Spirulina is an autotrophic, multicellular and filamentous fresh water blue green alga belonging to class cyanophyceae. It is a rich nutrient source due to the presence of high protein content, vitamins, minerals, natural fibres, beta - carotene and phytopigments (Liestianty *et al.*, 2019). Due to its nutritional quality, its production is encouraged at domestic levels especially in developing countries that are suffering from malnutrition and other deficiency diseases. Prokaryotic nature of Spirulina makes them readily digestable due to the absence of cellulose in its cell walls and is helpful for people suffering from intestinal malabsorption (Sharoba, 2014). The bioactive components of Spirulina exhibit therapeutic properties, like, blood pressure regulation, immune regulation, anti - cancer effects, antioxidation and anti - inflammatory effects. Besides this Spirulina has unique property of detoxifying heavy metals and toxic minerals, a property not found in other algae (Monteiro and Castro, 2012; Rangsayatorn *et al.*, 2002). Thus, it is commercially cultivated on large scale for its use in medicine and cosmetic industries. This review provides information about structure, biochemical composition, health benefits and cultivation methods of Spirulina.

2. Literature Survey

Spanish Scientist Hernando Cortez and Conquistadors discovered Spirulina in 1519. The health benefits of Spirulina were revealed by Pierre Dangeard (Soni et al., 2017). Spirulina being rich in protein (50 - 60%), antioxidants, essential fatty acids, vitamins and minerals, is used as a dietary supplement worldwide. It is also a well-known space food (Campanella *et al.*, 1999). Chlorella based food was first produced by Japan (Sanchez *et al.*, 2003). Various researches emphasize its anti - inflammatory, anti - microbial, antioxidant, immuno - stimulatory, anti - diabetic, anti - obesity, anti - aging, nourishing and detoxifying effects (Priyanka *et al.*, 2023). Latest findings indicate the neuroprotective role of Spirulina (Trotta, 2022).

Structure of Spirulina

Botanists classify Spirulina in class cyanophyceae on the criterion of presence of chlorophyll a, carotenoids, myxoxanthophyll and c - phycocyanin while bacteriologists called them bacteria due to their prokaryotic structure. Spirulina has a multicellular, non - heterocystous, unbranched trichome with an open left - hand helix along the entire length (Vo *et al.*, 2015). Trichomes enveloped by a thin sheath show easily - visible transverse cross - walls with slight constrictions and have apices either slightly or not at all attenuated. Flagella and heterocysts which are generally present in many blue green algae are absent. Gas filled vacuoles along with helical filaments help in buoyancy of the mats. Cell wall is made of four layers: L - I, L - II, L - III, and L - IV. Layers L - I and L - III are fibrillar molecule while L - II layer is made up of peptidoglycan. The membranous layer L - IV is covered with acidic polysaccharides sheath (Chen *et al.*, 2020). The genus is characterized by the helical shape of filament (trichome) that often variates according to the environmental factors (van Eykelenburg, 1979, Jeeji Bai, 1985).

3. Biochemical composition and health benefits of Spirulina

Protein

Spirulina has both essential and non essential amino acids. These amino acids build wide variety of proteins required for repair, growth and maintenance of cells. Phycobilin is the chief protein in Spirulina made up of three components phycocyanin, allophycocyanin, and phycoglobin. Spirulina protein is superior to all standard plant proteins including legumes (AlFadhly, 2022).

Polysaccharides

The polysaccharides of Spirulina is water soluble and are primarily composed of D - mannose, L - rhamnose, D - glucose, D - galactose and glucuronic acid along with small amount of xylose, fucose, arabinose, ribose, galacturonic acid and other monosaccharides. Polysaccharide in Spirulina have antioxidant, antitumor, antiaging, antivirus, antiradiation, antifatigue, anti - inflammatory, antimutation and immune regulation activities (Wang *et al.,* 2018).

Fatty acids

Unsaturated fatty acids in Spirulina include docosahexaenoic acid, eicosapentaenoic acid, stearidonic acid, arachidonic acid and γ - linolenic acid. Among autotrophs Spirulina is the richest source of γ - linolenic acid that reduces inflammation and blood pressure. It is also used in the treatment of premenstrual syndrome, rheumatoid arthritis and eczema (Nascimento Sassano *et al.,* 2014; Ronda and Lele, 2008). The myristic and palmitic acids are the lowest and the highest content of fatty acids respectively in Spirulina (Liestianty *et al.,* 2019).

Pigment

Chlorophyll a, phycobiliproteins (phycoerythrin, phycocyanin and allophycocyanin) and carotenoids are the important group of pigments found in Spirulina. Chlorophyll a is a natural fat soluble pigment consisting of four pyroll rings with magnesium and nitrogen. Phycocyanin has one alpha (α) and one beta (β) polypeptide sub - units covalently linked with phycocyanobilin. Phycocyanin is reported to have antioxidant, antimicrobial, anti - inflammatory, anti - neurodegenerative, antidiabetic, hepatoprotective, anticancer, anti - obesity, and wound healing activities (Grover *et al.,* 2021; Fernandes *et al.,* 2023). C - phycocyanin is reported as the main antioxidant in Spirulina. (Finamore *et al.,* 2017). β - carotene as a potent antioxidant in Spirulina has anti - carcinogenic and radio - protective effects (Krinsky *et al.,* 2005). Carotenoids, besides being the source of pro - vitamin A, protects human body from serious health disorders (Rao and Rao, 2007).

Vitamins

Spirulina contains Vitamin B1 (thiamine), Vitamin B2 (riboflavin), Vitamin B3 (nicotinamide), Vitamin B6 (pyridoxine), Vitamin B9 (folic acid), Vitamin B12 (cyanocobalamin), Vitamin C, Vitamin D, and Vitamin E (tocopherol). These vitamins along with minerals (K, Ca, Mg, Fe, Cu, Se, and Zn) present in Spirulina promote metabolism of carbohydrate, protein and fats along with maintaining a healthy immune system. The presence of Vit B12 in Spirulina is a boon to vegetarians as this vitamin is usually part of animal origin food (Khan *et al.,* 2005).

Vitamins and minerals along with β - carotene, chlorophyll, provitamin A, and phycocyanin present in Spirulina acts as antioxidants that neutralize free radicals which the body encounters in daily life either from internal metabolic processes or from external sources, like, pollutants, radiations, tobacco smoking and industrial chemicals (Asghari *et al.,* 2016).

4. Cultivation of Spirulina

Domestic cultivation method

It is a 'mud pot Spirulina cultivation method' in which a pot is burried in ground under the sunlight and poured with water and biogas - slurry medium containing potassium di - hydrogen phosphate, sea - salt, cooking soda and sodium chloride along with pure Spirulina culture. After three to four days it is filtered and washed with pure water for immediate consumption or dried to powdered form (Dergist, 2012).

A simplified method of Spirulina cultivation for domestic use was suggested by Srivani *et al., (*2017). In this method the mother culture of *Spirulina maxima* was mixed with designed culture medium (NaCl: 2.0 g., NaHCO3: 16.0 g., NaNO3: 2.0 g., K2SO4: 1.0 g., KH2PO4: 0.5 g., FeSO4: 100 mg per litre of water) with pH value of 10.5. This is kept in an orbital shaker with natural illumination for 7 days. When the OD value is reached to 0.8 initial culture was transferred to plastic tubs for mass culture under direct sunlight for 7 days. After this Spirulina was harvested through muslin cloth.

Photobioreactors

A photobioreactor (PBR) is a closed system that uses light to grow organisms like cyanobacteria in culture medium. One of the crutial requirement in photobioreactoer cultivation is the supply of appropriate light requirement as both high and low light intensities are not suitable for cyanobacterial culture. Vertical, Horizontal and Flat Plane photobioreactors are used to cultivate Spirulina. A photobioreactor can provide a better control of culture conditions and fresh alga for consumption. It also minimizes the nutrient loss after drying process (Jamal Uddin *et al.,* 2020).

Raceway ponds

In raceway ponds, alga is cultivated outdoors. These ponds are in the form of a closed loop recirculation channel built of concrete or compacted earth in which water, algae and nutrients circulate around a race track. It has a paddle wheel to circulate the algal biomass and to prevent sedimentation (Choong - Jae *et al.,* 2007).

Green house method using vertical aeroponic substrates

This method is a technical innovation in algal cultivation that enhanced biomass production compared to the traditional hydroponic system at same culture conditions. In this method substrates composed of cotton soaked in inoculum are placed 5cm apart and suspended from a scaffolding system using hooks placed. This system is placed in a green house and the substrates on the scaffolding system are continuously irrigated with a nutrient solution (water and nutrients). The algal biomass is harvested by gently washing the substrates (Lien *et al.,* 2016).

5. Conclusion

Spirulina has well been recognised as a super food with high protein content and other nutrients along with the ability to fight various health disorders. In developing countries, like India, its consumption can be promoted to overcome the challenge of social malnutrition. Spirulina cultivation can be

encouraged as an opportunity of agri - entrepreneurship for youths.

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