# Spirulina Platensis an "Ultimate Food": A Review

[1]Akshita Sharma, [2] Kamalpreet Kaur, [3] Manjri, [4] Deepti Marwaha

[1,4]Assistant Professor, [2,3]Research Scholar

[1]Department of Biotechnology,

[1]Guru Nanak Girls College, Model town, Ludhiana, India.

## Introduction:

*Spirulina platensis* is non toxic blue green algae which is filamentous cyanobacteria taken by the human as dietary supplement and use it as a food. *Spirulina platensis* is a biomass which is dried form of Arthrospira platensis .This blue green algae is the primary diet in humans, animals and aquatic life. *Spirulina platensis* is easily digested due to absence of cell wall .This blue green algae is an important diet in humans and in animals. In humans it is used as a source of protein and vitamin without causes any harmful effect. It is rich in phenolic acids, tocopherol and y-linolenic acids [1]. *Spirulina platensis* is most commonly available and widely used genus which has been extensively studied in different fields specially food and medicine [2]. *Spirulina platensis* was originally discovered in ponds and lakes. *Spirulina platensis* has been proven to boost the immune system, bolster the energy and reduce the risk of many cancers and infection. The nutritional quantity of the Blue-green algae *Spirulina platensis* has been evaluated on the basis of its chemical and amino acid composition and feeding trails with rats [3]. Due to high content of highly valuable proteins, indispensable amino acids, vitamins, beta carotene and other pigments, mineral substances, indispensable fatty acids and polysaccharides, *Spirulina platensis* has been found suitable for use as bioactive additives [4].

*Spirulina platensis* after the first isolation by Turpin in 1827 from a fresh water stream (159), species of *Spirulina platensis* have been found in a variety of environments; soil, sand, marshes, brackish water, seawater and freshwater [5]. Different *Spirulina platensis* preparations influences immune system viz., increase phagocytic activity of macrophages, stimulating the production of antibodies and cytokines, increase accumulation of NK cells into tissue and activation and mobilization of T and B cells [6].

It was also suggested that supplementation of *Spirulina platensis* reduce the blood cholesterol, LDL (Low Density Lipoprotein), Triglyceride and Induction in HDL (High Density lipoprotein) cholesterol which is quite useful for the heart disease patients [7]. In year 1970, the German federal republic supported the investigation on human consumption of *Spirulina platensis* in India, Peru, Thailand .The daily meal is in the form of solid which consume *Spirulina platensis* and it is beneficial for the physical and mental health of the population [8]. *Spirulina platensis* or Arthrospira became famous after it was successful used by NASA as a Dietary supplement for astronauts on space missions [9]. Numerous strains of *Spirulina platensis* are easily cultured and harvested and are rich in carotenoids and other valuable products [10]. Whether the *Spirulina platensis* come from a natural medium

or synthetic culture basin, harvesting includes the successive stages of concentration, filtration and washing followed by drying in conventional manner [11]. Chemical analyses of microalgae indicate that it is the excellent source of macro and micronutrients. Biological properties of *Spirulina platensis* include Anticancer, Antimicrobial, Antioxidant and immuno-stimulant effects [2].

## History:

*Spirulina platensis* are multicellular and filamentous cyanobacteria which contain high amount of carbonate and bicarbonate. It grows in water, can be harvested and processed easily and has very high content of micronutrients and macronutrients. *Spirulina platensis* is found at Lake Texcoco in Mexico, around Lake Chad in Africa, Asia and South America while *Spirulina platensis* Maxima found in Central America [12]. It is one of the oldest inhabitants of the planet. Its scientific name is Arthrospira platensis. Five years ago, a huge amount of money was invested by the government and private sector in the development of the blue green algae for the extraction of biodiesel, as it is 20 times more productive [13].

In year 1940, a French scientist discovered the harvesting of *Spirulina platensis* near the shallow Lake Chad in Africa .But not enough launch *Spirulina platensis* as food. It would take many years to rediscovered Spirulina health benefits. In 1967, *Spirulina platensis* established as the "Ultimate source of food" in the International Association of applied Microbiology while analysis its nutritional properties it was observe that *Spirulina platensis* contain high amount of protein. This data was sufficient to establish research projects to produce inexpensive amount of protein. Microorganisms like bacteria, yeast, *Spirulina platensis*, are the direct route for the production of single cell protein. After some time no microorganism was fulfill to produce enough amount of protein. *Spirulina platensis* was continuously increased the yield of protein as the dietary supplement to human, animals and aquatic animals [14] [15].

**Figure: 3** Kanenbu Ladies harvesting Spirulina from Lake Boudou Andja. Photo: Marzio Marzot, FAO Report the future is an Ancient Lake, 2004.

## Dihe in Chad:

In 1940, a French physiologist Dangered on material Dihe eaten by the Kanembu people near Lake Chad which is hardened cake of dried blue green algae collected from the small ponds near the Lake Chad. This report was unnoticed. After two decades, in 1994 the botanist reported that the blue green algae which was growing in the small ponds that form to the Lake Chad after rainy season. Leonard recognized the connection between the algal blooms and the dried cake which is sold in the market [14] [16].

The technique of Kanembu people living along the Lake Chad for harvesting and drying have been passed from generation to generation. Kanembu ladies collects the micro algae in the clay pots , drainage the water from the algae and spread it around the shore of the lake for sun drying .after drying women cut the algae in the square pieces and then sell into the local market for the money to fulfill their needs. Dihe is mixed with the tomato sauce and pepper and poured into the meat and fish. First large scale production of *Spirulina platensis* was established in 1970 [13].

**Figure: 4** Ladies harvesting and traditionally drying *Spirulina platensis* dihe in a sand filter. Photo: Marzio Marzot, FAO Report the future is an Ancient Lake, 2004.

Now days, *Spirulina platensis* is available in the market and consumed by the people of different countries like Germany, Brazil, Spain, Canada, Egypt, Ireland, Argentina, India, and also different associations approved it for consumption.

Best companies for the production of *Spirulina platensis* in the worldwide are Earthrise Farm (USA), Cyanotech (USA), Genix (Cuba) and Solarium biotechnology (Chile).

## Morphology:

*Spirulina platensis* is symbiotic, multicellular and filamentous blue green microalgae with symbiotic bacteria which fix the nitrogen from air. The shape of *Spirulina platensis* can be like rod or disk. The main morphological feature of *Spirulina platensis* genes would be the arrangement of the multicellular cylindrical trichome. The photosynthetic pigment of *Spirulina platensis* is phycocyanin, its colour is blue. This type of bacteria contains chlorophyll a and carotenoids. Some of the bacteria contain pigments like phycothrin which bacteria red and pink

colour. *Spirulina platensis* are photosynthetic, so therefore it is autotrophic in nature. The reproduction of *Spirulina platensis* is due to binary fission. *Spirulina platensis* have a crew like trichome which have generally closed, uniform, and narrow diameter from 0.5-3um. Cells with cross walls are visible under light microscope, without gas vacuoles and with prominent granules. The trichomes have a length of 50 to 500um and its width is up to 4um. Gram negative bacteria have similar cell wall to cyanobacteria which contain peptidoglycan, lysozyme sensitive heteropolymer [17].

Environmental factors those affect the helix geometry are temperature, physical and chemical condition. One of the drastic alteration is the geometry is the reversible transition from helix to spiral shape while transferring the filaments from liquid to solid media [18].

## Taxonomy:

| | |
|---|---|
| CLASS | MYXOPHYCEAE |
| ORDER | HORMOGONALES |
| FAMILY | OSCILLATORIACEAE |
| GENUS | *SPIRULINA PLATENSIS* |

In year 1827, *Spirulina platensis* was isolated from fresh water sample. In 1844, according to the report wittrock and noidstedt *Spirulina platensis* jennerif platensis present near the city of Montevideo. But it was not proved until the first taxonomic report written by Stizenberger in 1852 was appeared. According to the presence of septa, helical form and multicellular structure, he gave this genus name Arthrospira. The investigation of the blue green algae is carried out under the name of *Spirulina platensis*. It was difficult to change this common identification by the scientists and the consumers [19] [20].

As Arthrospira and *Spirulina platensis* are the two separate genera has been shared by the authors for many times and has been accepted officially by the Bergey's Manual of systematic bacteriology. The separation between two genera is on the basis of many characteristics such as helicity, trichome size, cell wall structure, pore pattern, gas vesicles, and trichome motility fragmentation. The cyanobacteria systematic position has been the serious discussion matter, as these photosynthetic organisms were first considered algae. In 1962, a difference between prokaryote and eukaryotes was clearly established. The main contrast is based on the presence of cell organelles blue green algae into the prokaryote kingdom and proposed to call these microorganisms' cyanobacteria [12].

## Natural habitat and Source:

After Lake Texcoco, the largest *Spirulina platensis* lakes are in central Africa and also in east Africa. The stable monoculture of *Spirulina platensis* found in Lake Chad. *Spirulina platensis* survive in alkaline lakes where it is most difficult or impossible for the other microorganisms to survive [21]. In lakes, the supply of nutrients is limited to regulate the growth cycle. *Spirulina platensis* dies off when nutrients are exhausted. *Spirulina platensis* is found in lakes, soil, marshes, seawater, brackish water etc. Alkaline saline water is favorable for the good production of *Spirulina platensis*. *Spirulina platensis* cannot grow in dark on media which contain organic carbon compounds and reduce carbon dioxide in light. The main product of *Spirulina platensis* photosynthesis is glycogen. *Spirulina platensis* shows optimum growth 35 and $37^0$C under laboratory conditions. The minimum temperatures at which *Spirulina platensis* growth take place is $15^0$C during day and tolerate low temperature at night [22].

## Biochemical composition of *Spirulina platensis*:

The basic biochemical composition of *Spirulina platensis* can be summarized as follows:

**Protein**: *Spirulina platensis* contain high amount of protein between 55-70% by the dry weight. Protein contains all the essential amino acids which are very useful for the better yield of the biomass from *Spirulina platensis*.

**Essential fatty acids:** *Spirulina platensis* has a high amount of polyunsaturated fatty acids 1.5-2.0% of 5-6% total lipid. *Spirulina platensis* is rich in linolenic acid, stearidonic acid, eicosapentaenoic acid and arachidonic acid.

**Vitamins**: *Spirulina platensis* contains vitamin B1, B2, B3, B6, B12, Vitamin C, Vitamin D and Vitamin E.

**Minerals**: *Spirulina platensis* is a rich source of potassium, calcium, chromium, copper, iron, magnesium, manganese, phosphorus, sodium and zinc.

**Phytopigments:** *Spirulina platensis* contain many pigments including chlorophyll-a, xanthophylls, echinenone, myxoxanthophyll, beta carotene, chlorophyll etc [2].

**TABLE 1: General composition of *Spirulina platensis*: (Thomas SS, 2010)**

| | |
|---|---|
| Carbohydrates | 16%-20% |
| Protein | 60%-69% |
| Lipids | 5%-7% |
| Minerals | 6%-9% |
| Moisture | 2.5%-6% |

## Environmental factors influencing growth of *Spirulina platensis*:

*Spirulina platensis* plants for the mass cultivation are done in the suitable environmental conditions. But it is difficult to have a proper ideal growth of the *Spirulina platensis* due to different environmental factors like temperature, ph, light, salinity, nutrients etc.

**Temperature:** Temperature in the range of 30-35C is well suited for the maximum growth of *Spirulina platensis*. Temperature above than 35C leads to the bleaching of the culture. Rafiqul Islam reported that, the maximum growth rate of *Spirulina platensis* which was 0.141 was found at 32C and 0.144 was found at 37C for *Spirulina platensis* fusiformis. Maximum production of biomass of 2.4g and chlorophyll a production of 16.6mg were observed at 32C for *Spirulina platensis*. Maximum production of biomass of 2.3g and chlorophyll a production of 14.2mg were observed at 37C for *Spirulina platensis* fusiformis. Luciane Maria found that the temperature is most important environmental factor for the optimum growth of *Spirulina platensis* [23].

**pH:** pH is the important environmental factor which influences the *Spirulina platensis* cultivation for most. pH determines directly or indirectly the solubility of mineral and carbon source in the culture. *Spirulina platensis* well suited growing ph value ranges between9-11. During the mass cultivation of the medium of *Spirulina platensis* was shifted from 8.4 to 9.5 due to the composition of bicarbonate and sodium ions [24].

**Light:** During the growth phase of *Spirulina platensis* light intensities required. The optimum light intensity was between 20 and 30K lux [25]. The light was provided to the culture for 10 hours at 2K LUX intensity by using lamp or fluorescent bulb. Yellow, white, red and green light yield less protein content than the blue light. According to the Dubey, had reported moderate light intensity in the cultivation of *Spirulina platensis*, suggesting low light intensity was provided at the beginning to avoid photolysis. Also noted that the high light intensity photolysis them [26].

It is also studied, that the *Spirulina platensis* is the important source of pharmaceuticals and nutraceuticals like g-linolenic acid (GLnA). The yield of the GLnA from the culture medium is obtained at the highest light intensity of 5.0klx [27].

**Water quality:** The quality of water plays an important role in the algal mass production of *Spirulina platensis*. It had two influences, firstly by affecting the solubility of nutrients added in the medium and secondly by the accumulation of certain heavy metals by algae during the growth phase of *Spirulina platensis* [28].

**Nutrient medium:** *Spirulina platensis* required high amount of nutrients and salt concentration. Because of this salt concentration *Spirulina platensis* naturally grows in the salt lakes. The difficult media currently in use in various areas of production were small alternations of the medium first developed by Zarrouk's for the *Spirulina platensis* culture. *Spirulina platensis* required a medium of high alkalinity and continuous supply of bicarbonates ions [29].

**Inoculum size:** According to the report of Fatma, that the synchronous growth of *Spirulina platensis* was failed to grow both in liquid and solid media. It was also observed that minimum population of cell is necessary to initiate and sustain *Spirulina platensis* culture [30].

**Agitation:** The advantages of uniform distribution of carbon dioxide and prevention of thermal stratification due to the agitation of algal culture. So many devices of agitation had been introduced which range from motor driven paddles, pumps, and gravity flow and air light systems. The aeration to *Spirulina platensis* is achieved by rotators and also provides agitation to growing cells and maintained these cells in suspension and it is very necessary for the better yield of *Spirulina platensis* species [31].

**Contamination:** According to the report of Venkatraman and Sindhukanya, about the insect contamination in *Spirulina platensis* culture. The larvae of mosquito fed on the algal biomass for 2-3 days before entering into purple stage and the decrease in biomass yield was up to 10 percent. By using fine wire mesh removed all extraneous material. The forms of bacterial and pathogenic occurred in the culture were identified as aerobic spore formers [32].

***Spirulina platensis* as a single cell protein:** The increasing population in the world increases the demand of necessary food sources among the people. In particular, protein supply generates a problem since essential amino acids cannot be replaced. The deficiency of protein increasing in the world becomes a major problem for mankind. So many efforts have been made to produce new, alternate and unconventional protein. In the year 1996, Bacteria, yeast, fungi and algae were used to produce protein biomass which is known as Single Cell Protein. In 1966, Single Cell Protein was invented by Carol L. Wilson. Single Cell Protein is used as a protein supplement in human food and animal feeds [33].

Single Cell Protein is the dried cells of microorganisms like yeast, algae, bacteria and fungi. As a source of single cell protein, Cyanobacterium has certain advantages over microorganism because of its quality, quantity and rapid growth [34]. In particular, the microalgae *Spirulina platensis* contains about 60 to 70% of protein. *Spirulina platensis* was cultured near Lake Chad in Africa. After drying use it as food Supplement. *Spirulina platensis* is most widely used algae, during space travel astronauts take it to space also as supplement. Alga is used as foods in many different ways with its advantages include simple cultivation, faster growth and high protein content. The algae *Spirulina platensis* use as a supplementary protein. It is a blue green algae having strong antioxidant activity. *Spirulina platensis* should be encouraged in patients suffering from malnutrition, immune suppression and hepatic [35].

## *Spirulina platensis* – Market:

As per the survey conducted by **Spirulina.Company**, *Spirulina platensis* is now available in the form of tablets or powder. In 1970, at which *Spirulina platensis* was launched in the market, the market for food supplements

was not well organized. In 1981, the marketing of *Spirulina platensis* as the supplement was started. The consumption of *Spirulina platensis* was increased due to the front page article which was publish in a US daily newspaper, that the "*Spirulina platensis* as a hunger reducer for people on a diet". Media took up the subject and demand of *Spirulina platensis* exploded in the USA. Hundered and thousands of companies entered the market to offer their *Spirulina platensis*.

Now today, companies produce high quality *Spirulina platensis* and at the same time, they are developing products with higher added value. The main producer of *Spirulina platensis* is located in Asia and the USA. The companies produce around 350 tons of *Spirulina platensis* per year.

**Market value**: As per the survey conducted by **Spirulina.Company**, the annual production of *Spirulina platensis* is 5000 tons. It is difficult to determine the exact production because of the many relatively small producers in Asia, but the capacity exists to expand production of *Spirulina platensis* to meet any growing market demand.

Now, the market price of *Spirulina platensis* is around Rs 1200-1500 for 1kg.

## References:

1. J.C Dillon, A.P. Phuc and J.P. Dubocq (1995), Nutritional value of algae spirulina world : Review of Nutrition and Dietetics, 77: 32-46.

2. SM Hoseini, K Khosravi-Darani and M.R. Mozafari (2013), Nutritional and Medical Applications of Spirulina Microalgae,13:1231-1237.

3. D.L.R. Narasimha, G.S. Venkataraman, Surinder K.Duggal, Bjorn O. Eggum (1988) Nutritional quality of the blue green alga spirulina platensis geitler.

4. L.P Beineova, O.B. Gorobets, A.P.Baturo (2001) Biological activity of Spirulina,2: 114-118.

5. O. Ciferri (1983) Spirulina, the edible microorganism, 47(4): 551-578.

6. Khan Z, Bhadourial, Bisen PS. (2005) Nutritional and therapeutic potential of spirulina, 6(5): 373-9

7. Aram Heidarpour, Amir-Davar Fourouzandeh-Shahraki and shahin Eghbalsaied (2011) Effect of Spirulina platensis on performance, digestibility and serum biochemical parameters of Holstein calves, 6(22): 5061-5065.

8. Archana Kulshreshtha, Anish Zacharia J., Urmila Jarouliya, Pratiksha Bhadauriya, G.B.K.S. Prasad and P.S. Bisen (2008) Spirulina in health care management, 9:400-405.

9. P.D. Karkos, S.C. Leong, C.D. Karkos, N. Sivaji and D.A. Assimakopoulos (2011) Spirulina in clinical practice: Evidence-Based human applications, Article 1D 531053.

10. Miguel Olaizola, Eirik O. Duerr (1990) Effect of light intensity and quality on the growth rate and photosynthetic pigment content of spirulina platensis, 2(2): 97-104.

11. Clement G (1975) Production and characteristic constituents of the algal spirulina platensis and maxima, 29(6): 477-88.

12. Avigad Vonshak (2002), Spirulina platensis (Arthrospira), Physiology, Cell Biology and Biotechnology.

13. Robert Henrikson (2011), Spirulina world food: How this micro alga can transform your health and our planet.

14. Leonard, J. (1966), the 1964-65 Belgian Trans-Saharan expedition. Nature, 209: 126-128.

15. Sasson, A. (1997), Micro Biotechnologies: Recent Developments and Prospects for Developing Countries, BIOTEC Publication 1/2542. pp. 11-31.

16. Dangeard, P. (1940), Sur une algue bleue alimentaire pour I'homme: Arthrospira platensis Gomont, Actes Soc. Linn. Boreaux Extr. Proces- verbaux, 91: 39-41.

17. M.Ahsan, B.Habib, Mashuda Parvin (2008), A Review on Culture, Production and use of Spirulina as food for humans and feeds for domestic animals and fish, ISSN 2070-6065.

18. Van Eykelnburg, C., Fuchs, A. and Schmidt, G.H. (1989), Anatomie Van Leewenbokek, 45: 369.

19. Tomaselli, L, Palandri, M. and Tredici, M. (1996), on the correct use of Spirulina designation, Algal.Stu. 83: 539-548.

20. Tomaselli, L, (1997) Morphology, Ultrastructure and Taxonomy of Arthrospira (Spirulina) maxima and Arthrospira (Spirulina) platensis. In Vonshak, A, ed. Spirulina platensis (Arthrospira): Physiology, cell- biology and biotechnology, pp. 1-16.

21. Kebebe, E. & Ahlgren, G. (1996) Optimum growth conditions and light utilization efficiency of Spirulina platensis (Cyanophyta) from Lake Chitu, Ethiopia. Hydrobiol, 332:99-109.

22. Richmond, A.E. (1986) Microalgae, CRC Critical Review in Biotechnology, USA, Vol. 4, pp. 349-438.

23. Rafiqul Islam, M., Hassan, A, Sulebele, G.,Orosco C and Roustaian, P. (2003) Influence of Temperature on Growth and Biochemical Composition of Spirulina Platensis and Spirulina fusiformis. Iranian International Journal of Science, 4(2): 97-106.

24. Vincent, W.F and W.B Silvester (1979) Waste water as a source of algae. Water Research, 13:717-719.

25. Ogawa, T and G. Teuri (1970) Blue green algae Spirulina. Journal of Fermentation Technology, 48:361.

26. Dubey, R.C. (2006) A textbook of Biotechnology. Fourth revised and enlarge edition, S. chand and company limited, 419-421.

27. Mohammad-Taghi, Golmakani, Karamatollah Rezaei, Sara Mazidi and Seyyed Hadi Razavi (2012) g-Linolenic acid production by Arthrospira platensis using different carbon sources. European Journal of Lipid Science Technology, 114:306-314.

28. Argaman, Y. and E. Spivak (1974) Wastewater as source of algae. Water Resources, 8:317.

29. Cifferi, O. (1983) Spirulina: The edible microorganism. Microbial Reviews, 47(4); 551-578.

30. Tanseem Fatma (1990) Effect of culture filtrate on growth of Spirulina platensis. Current Science, 59(6):797-798.

31. G.Usharani, P.Saranraj and D.Kanchana (2012) Spirulina Cultivation: A Review, 3(6): 1327-1341.

32. Venkataraman, L.V and T.C Sindukanya (1981) Insect contamination in the mass outdoor culture of green alga Spirulina platensis Proc., Indian Academy of Science, 90:665-672.

33. Gour Suman, Mathur Nupur, Singh Anuradha and Bhatnagar Pradeep (2015) Single cell protein production: A Review, international journal of current microbiology and applied sciences, 4: 251-262.

34. Molina GE, Belarbi EH, Acien- Fernandez FG (2002), Recovery of microalgal biomass and metabolites: process option and economics. Biotechnol. Advan. 20: 491-515.

35. Raja, R., Kumar, N.A., Sridhar, S. (2008) a perspective on biotechnological potential of microalgae, 34: 77-88.