ISSN No:-2456-2165

Applications of Arthrospira Platensis

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Abstract:- ***Arthrospira platensis*** **is also known as spirulina, which is a blue-green algae. It grows rapidly & easily without much supply of external nutrients. In today's world, rapidly changing needs of human beings are not getting satisfied with existing material resources and we need to have an alternative source for it. There are problems like depletion of fossil fuels, pollution caused by synthetic dye, lack of nutrient-rich food, lack of efficient fertilizers, etc. To overcome these problems, spirulina can be a satisfactory alternative. In this review paper, different applications of** ***Arthrospira platensis*** **are discussed. Still, a lot of research has to be done but spirulina has a strong potential as a solution to the above listed problems.**

Keyword*:- Spirulina, application of spirulina.*

I. INTRODUCTION

Spirulina is a type of blue-green algae that is multicellular & filamentous in nature, found in both freshwater habitats & altwater habitats. It belongs to the phylum *cyanobacteria*. Recently, this algae is being widely because of its high protein content, macro & micronutrients. Growing & harvesting spirulina is facile. It has been used as a dietary supplement for centuries. Spirulina naturally grows in the alkaline lakes, so settlements around these lakes have been consuming it for a very long time [1].

Spirulina was first discovered in the valley of Mexico in the sixteenth century by the Spanish invaders. It was then rediscovered by French phycologist Dangeard in 1940, near Lake Chad. It has a high production rate so it can produce 20 times more protein per unit area than soybean, 40 times more than corn & 400 times more than beef [5].

Spirulina contains about 60-65% of dry weight proteins. It also contains essential amino acids, polyunsaturated fatty acids, vitamins like B12 & E, polysaccharides, minerals, pigments like chlorophyll, C-phycocyanin, allophycocyanin and β-carotene. The C-phycocyanin content was determined to be 12.6% in dried spirulina [6]. NASA uses spirulina as a space travel nutrient supplement because of its high protein, vitamin rich content as well as high phycocyanin content which is associated with antioxidants [4]. The biomass produced by the genus *Arthrospira*is sometimescalled spirulina. Most commonly, *Arthrospira platensis* is utilized [2]. Over 30 % of biomass is produced globally from this spirulina species because of its high protein content (60 % of dry weight) as well as photosynthetic pigments like carotenoid [3]. It is used in a variety of applications like medical, aquaculture, food, textile, cosmetics, biofertilizers, biofuels, and biomaterials.

II. CHARACTERISTICS OF ARTHROSPIRA PLATENSIS

It is believed that cyanobacteria evolved 3.5 billion years ago & they were the first organisms to fix atmospheric carbon dioxide into inorganic carbon with the help of water. Spirulina grows in warm & alkaline water (pH = 10-11). Years ago, Mexican settlements started using this blue-green alga as human food. Currently, it is majorly consumed by the African Kanembou tribe near Chad Lake. And it is grown all over the world because of its high protein content & health benefits [18].

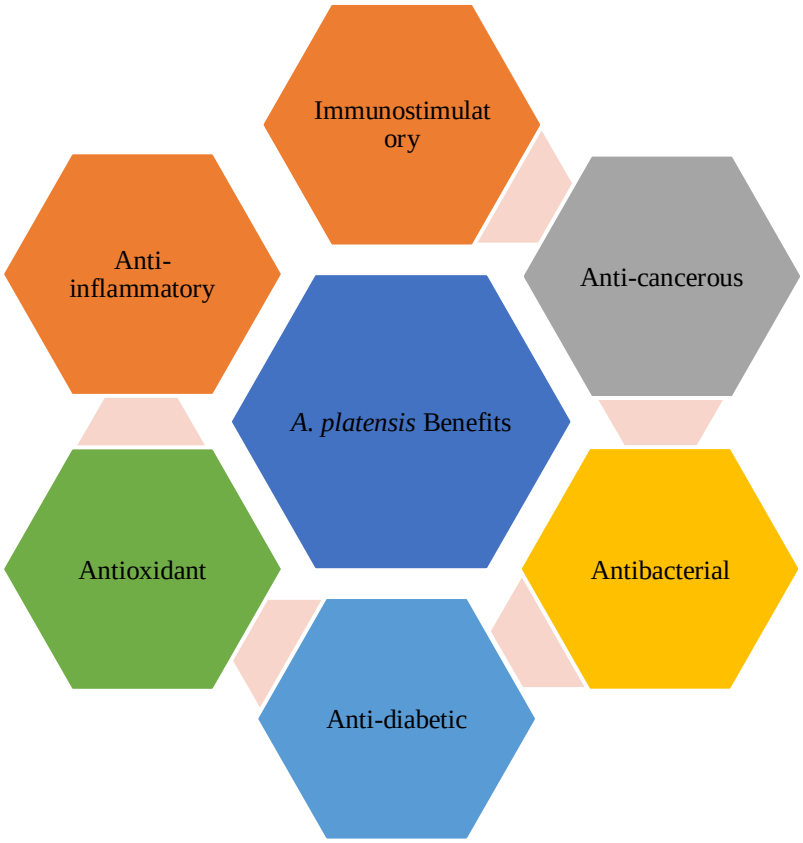
A. platensis belongs to the kingdom Monera. Kingdom Monera contains bacteria (prokaryotic organisms). Prokaryotic organisms do not have membrane-bound cell organelles. It belongs to the phylum cyanobacteria, which encompasses photosynthetic filamentous eubacteria. *A. platensis* is called blue-green algae but it is not true algae. The name is given in such manner because it is a photosynthetic organism & grows in water & when a considerable amount of *A. platensis* grows in water, the water looks green or blue-green. True algae belong to kingdom plantae because algae have defined cell organelle structure i.e. eukaryotic, but that is not the case with *A. platensis*.

A variety of products can be obtained from spirulina, main advantages of these products are that they are eco-friendly, sustainable and renewable.

ISSN No:-2456-2165

III. APPLICATIONS

A. *Health*



Spirulina has lots of health benefits which includes antioxidant, antimicrobial, anti-inflammatory, anti-cancerous, anti-diabetic, immunostimulatory properties. Spirulina alone is a healthy option because of the presence of vitamins, pigments, proteins, amino acids, polysaccharides and minerals in a single type of biomass. Along with this, consumption of coco & spirulina powder together will promote antioxidant formation as well as promote vascular health [7]. Coco is flavonol rich, which has health benefits like decreasing blood pressure in case of high blood pressure, improves blood flow to the heart and brain and also fights cell damage. Spirulina is phycocyanin rich which helps in blood cell regeneration and enhances the disease resistance of body. When both coco & spirulina are consumed together, endothelial production of nitric oxide is increased and NADPH oxidase is inhibited. NADPH oxidase is the main source of pathogenic oxidant stress in many health diseases [8]. Spirulina is used in food as a texturing and gelling agent, as prebiotic and colourant which also results in the enhancement of nutritional content of the food.

B. *Aquaculture*

The growth rate & quality of fish in aquaculture have a negative impact due to the limited availability of fish feed & clean water. The prices of fish food are increasing day by day so a good alternative is in demand. Fish meal can be partially replaced by *Arthrospira platensis* species. The use of spirulina as feed in aquaculture increases growth rate as well as reproductive ability of the fish. Fish species like *Tilapia* (*O. niloticus* and *O. mossambicus*) show an increase in growth rate by 60 % till it reaches 75% where it starts to decrease. The percentage of spirulina varies from species to species. With the increase in growth rate, the fat content will also increase and that is an important parameter according to the consumer's perspective. In reproduction, the quality of the egg is also affected because of some fatty acids like ascorbic acid [11].

Microalgae contain an active pigment that has antioxidant and anti-inflammatory effects. It was observed that in catfish (*C. batrachus*), 7.5 to 10% consumption of spirulina decreases the severity of apoptosis, micronuclei formation which is caused due to arsenic toxicity and protects the liver [17].

Spirulina not only helps fishes to grow but also helps maintain clean water by absorbing heavy metals and pollutants in aquaculture. Heavy metals present in water are not only harmful to fishes but human beings as well. Metals like cadmium, copper and zinc accumulate into fish muscles and when humans consume the fish, it affects the human health. It may cause mutations or carcinogenic effects. Cadmium, chromium, lead and cerium can be absorbed by *A.platensis*efficiently [11]..

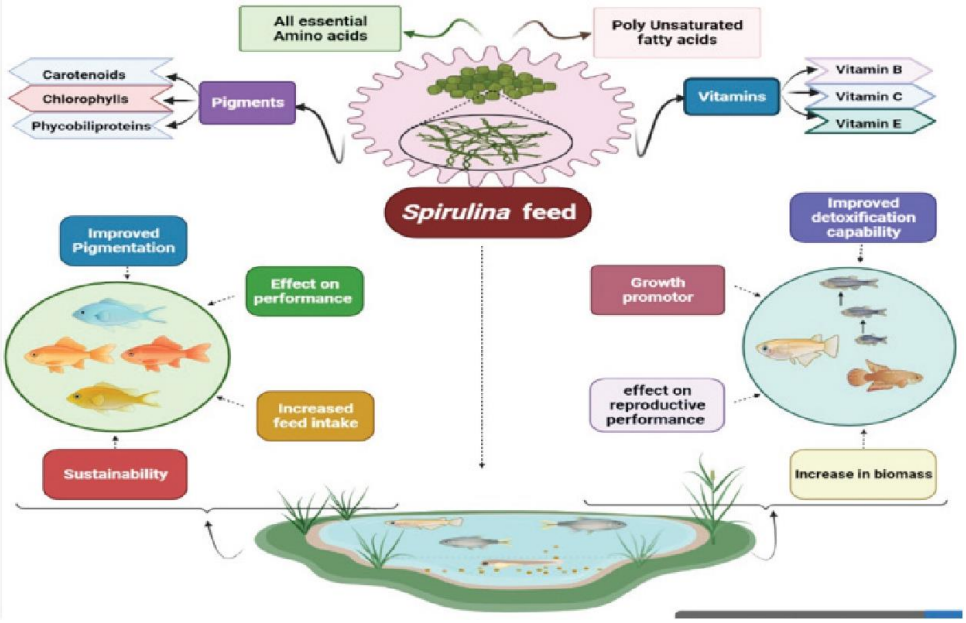


Fig 1: Effect of spirulina on fish [16]

C. Food

Spirulina has been used as a food source for centuries. People living near alkaline lakes have consumed it for a very long time. The mid-1900s research on spirulina gave an insight into its nutritional content.

It is used in cheese and ice-creams. Because of the addition of *A.platnesis* in cheese & ice creams, protein content increases significantly. After the addition of *A.platnesis* in cheese, the amount of β carotene also increases, which is a natural antioxidant. The addition of spirulina increases the softness & creamy consistency of ice cream because of the addition of protein, also the melting point of ice cream increases [9].

Up to 20 % of spirulina biomass can be used in cookies, without a change in taste. These vegan spirulina cookies will increase the protein quantity by 40% [15].

D. Biodiesel

Conventional sources, fossil fuels are non-renewable forms of fuels, so the search for another alternative continues to this date. Biodiesel will be another option for it. Biodiesel is a diesel obtained from biological materials like vegetable oil, soybean oil, peanut seed oil, jatropha biodiesel, cottonseed oil and many more. But if we use these oils for making biodiesel it will affect the supply of oil for human consumption. Microalgae is seen as a potential source for biodiesel because of the presence of high protein content & less land requirement for their growth.

Microalgae produce biodiesel 5.87 L/m2 to 13.69 L/m2 which is 10 – 20 times more than other vegetable or seed oil [12]. Also, it does not affect human consumption.

But one of the crucial factors to take into consideration is its cost. Compared to diesel, the cost of algae biodiesel is more as harvesting and cultivation must also be considered. And this is also a limitation for scaling up algae production. Cost can be optimized by using suitable technological alternatives and by direct methods such as using dry biomass. Along with this, direct extraction of biodiesel from biomass without using other chemicals can also be done so that cost of chemicals will decrease. To overcome every limitation, further research is needed [22].

Parameter	Biodiesel	Base diesel
Carbon monoxide	1.20 g/kWh	3.10 g/kWh
Hydrocarbon	0.04-0.13 g/kWh	0.06-0.13 g/kWh
Nitrogen oxides	16.19 g/kWh	13.13 g/kWh
Smoke	0.70%	0.60%

Table1: Emission comparison (for B100)

E. For wastewater treatment

Rapid industrialization causes great pollution, affecting the environment. Wastewater may contain heavy metals and dyes as the main pollutants. Methods like membrane filtration, ion exchange irradiation, precipitation etc. are available to combat this pollution. But these methods are expensive as well as less adaptive over a large range of wastewater. In this case, biosorption is used. It is a process of removing pollutants by using dead microbial mass and at the end environmental disposable pollutants are formed. For

ISSN No:-2456-2165

dye-binding, many functional groups like carboxylic, hydroxyl, phosphate & other charged molecules are also present [14]. So, we can consider spirulina for dye removal.

Spirulina removes synthetic dyes like FD&C red no. 40 and acid blue 9. After the process 75.5% FD&C red no. 40 and 15% acid blue 9 dye removed. The rate of biosorption is high in microparticles compared to nanoparticles. Physical interaction between spirulina microparticles and dye takes place. That is why it is more efficient. [14]

F. Dyes

After synthetic dying, a large amount of wastewater is generated in the industry which contains a high percentage of heavy metals. These heavy metals are non-biodegradable so, they accumulate in water bodies & remain in living tissue. It causes serious diseases & discords. [13]

Spirulina can be a good alternative for synthetic dye. But only 1% of natural dyes are used in industry because of issues like limited colours, unavailability of dye, limited quantity, etc. So, research is going on worldwide to overcome these limitations. Spirulina contains blue phycocyanin pigment which is used in cosmetics as well as food to give natural colour. There are major limitations to using spirulina as a natural dye in the industry. No doubt the growth of spirulina is very fast and also, we can grow it easily and anywhere. The challenge is that the dye produced from it will fade out after certain washes. So future coating processing is necessary [10].

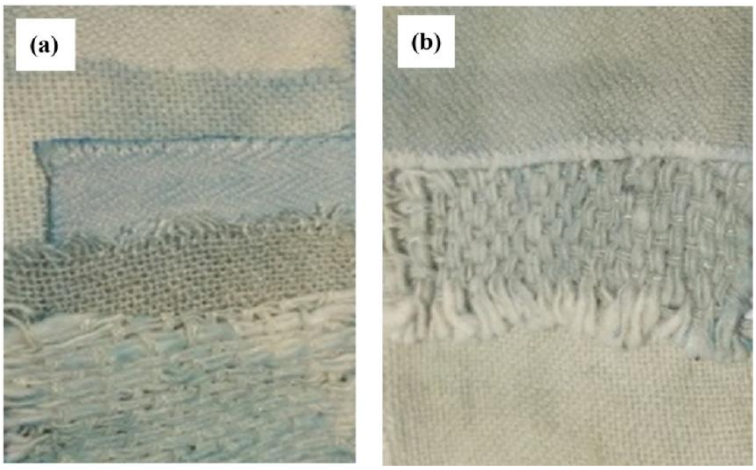


Fig 2: Final result after dyeing (a) cold dye, (b) hot dye. [10]

G. Biofertilizer

In the rice fields, one of the major factors which affect plant growth is nitrogen in the soil. If a sufficient amount of nitrogen is not present naturally, we have to give it externally with the help of fertilizer but at the same time, we have to consider that using chemical fertilizers has side effects. Cyanobacteria is the major component in fixing atmospheric nitrogen in paddy fields. Rice fields are favourable for the growth of cyanobacteria [23].

H. Cosmetics

Water molecules play a very important role in maintaining skin structure and thickness. Water molecules bind to dermal proteins, like collagen, and maintain tissue thickness. But in aged skin, the water network is weak, so water does nott bind to protein properly. That is why aged skin is less firm & glowy.

Spirulina improves the structure of the epidermis, also boosts water in the skin & also controls oil which ultimately reduces ageing. While doing this experiment two groups were selected, one young group (age 18-39) & other mature (40-65). A 28 days trial was carried out. It was observed that the oily appearance of the skin increases because of the presence of fatty acids of spirulina like α & γ linolenic acid. It further improves skin hydration as well as stimulates cell division & improves keratinization [19].

Spirulina also has pigments like chlorophyll, phycocyanin that can be used in make-up products like lipstick, eyeliner for long-lasting colouration. Antioxidants present in it will help to protect skin from UV- light [21].

Hypersecretion of sebum causes acne. Sebum helps to lubricate & moisturize the skin. Because of hypersecretion of sebum, lipid anaerobic environment is formed which promotes the growth of bacteria like *Cutibacterium* acnes. It was observed that synthetic drugs may show some side effects & also acne-induced bacteria may show resistance to these drugs. To avoid this, mostly natural active ingredients are used [20]. The antioxidant activity of spirulina is dependent on pigment phycocyanin & its concentration should be in the range 0.05 and 0.3 mg-1mL-1. Also, the water-based formation of the cream is more effective in inhibiting microbial proliferation. So, it is confirmed that spirulina shows anti-acne properties [21].

IV. CONCLUSION

Cyanobacteria, spirulina, and blue-green algae have a lot of potential uses. The rich nutritional content of spirulina makes it exceptional from other algae. A variety of applications of *A. platnesis* are mentioned in this review paper. Which includes pharmaceuticals too. It was observed

that the use of spirulina in aquaculture has a lot of benefits. It can be used as a feed in aquaculture as well as in wastewater treatment. The presence of high protein in it makes it a good alternative to protein in the diet. Also, it is used in biodiesel as it contains lipids. The natural pigments present in it give colour which can be used as a natural dye, which will be a great alternative for synthetic dye. Cyanobacteria fix atmospheric nitrogen in the soil so it makes the land more fertile. *A. platnesis* improves the structure of the epidermis that's why it can be used in cosmetics as well.

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