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Spirulina as a Functional Food: A Review of Nutraceutical Properties

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ABSTRACT : -

Nutraceutical is "a food or part of food" that provides nutrition or health advantages, such as illness prevention and treatment. Spirulina, a blue-green algae that is a member of the Oscillatoriaceae family, is derived from Spirulina maxima or Spirulina platensis. There are several different ways to cultivate spirulina, including open ponds, hybrid systems, vertical column PBR, flat plate PBR, tubular PBR, and internally illuminated PBR. Spirulina, an algae rich in nutrients, is becoming more and more well-liked. Indian companies have started producing spirulina for human consumption and aquaculture improvement. India is producing spirulina, a nutrient-rich algae, for human consumption and to help with fish farming. The hybrid system is the simplest culture method. can also use it in the space. Scientists are searching for a stem transplant in nutraceuticals to be found in spirulina in the future. In an effort to improve the quality and quantity of Spirulina biomass production, the key growth parameters have been investigated. Spirulina is able to offer more oxygen than other plants in space stations, therefore cultivate it correctly using the above-mentioned cultivation procedure, we can cultivate the maximum quantity of nutrients in spirulina.

KEY WORDS: -

Spirulina, Nutrition, PBR (photobioreactor), Nutraceutical, Prebiotic, Probiotic.

1.INTRODUCTION: -

Nutraceutical is defined as the 'a food or part of food' provided nutrition or health benefits including then precaution & treatment of diseases. The Stephen Defelice, founder and chairman of the foundation for innovation in medicine, location Crandall New Jersey, created the term in 1979.

The dietary supplements health and education act of 1992, the concept of a nutraceutical has been expanded to include dietary supplements like vitamins, minerals, and herbs. Phytochemicals, also known as functional group of phytoc

chemicals, are naturally occurring bioactive chemical compounds with_therapeutic, disease-preventive or health-promoting qualities.

In addition to their basic nutrition, the following functional foods are proven to have health advantages.

1. Green tea contains antioxidant qualities and is well known for being a good source of vitamin C.

2.Alfalfa is recognized as a food rich in minerals, having calcium, iron, magnesium, potassium, vitamins A and C, thiamine, riboflavin, and niacin [(1)].

Fig. No.1: Nutraceutical

Types of Nutraceutical product available in market like Functional Food, Functional, Beverage, Dietary supplement. Nutraceutical play an important role in therapeutic areas such Arthritis, cancer, diabetes, digestion, cholesterol, blood pressure, Painkiller, depression and various other disorders. Nutraceutical are classified according to their chemical nature and Therapeutic properties as follows:

MINERALS, ANTIOXIDANTS, PUFAs, PROBIOTICS, PREBIOTICS [2].

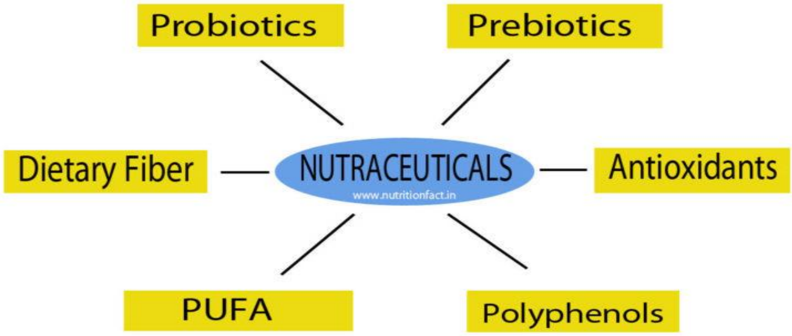

Fig.No.2: - Classification of nutraceutical

1.1: -Market Trend of Nutraceutical

The three primary segments of the nutraceutical market are functional foods, dietary supplements, and herbal/natural goods. In 1995, the Nutrition Business Journal (NBJ) estimated an $80 billion nutraceuticals market based on natural and organic foods ($6.2 billion), functional foods ($13.4 billion), certain lesser-evil foods with reduced or no unhealthy ingredients ($23 billion), dietary supplements ($8.9 billion), and selected market standard foods ($28.3 billion) [3-4].

NBJ has begun following the expansion of the nutraceuticals industry. According to NBJ, the industry has risen at a rate of 7.1 percent per year on average since 1995. Industry sales totalled $91.7 billion in 1997 (NBJ 1998). Dietary supplements (19.5 percent per year) and natural/herbal goods (11.6 percent per year) were the fastest expanding segments of the business [5].

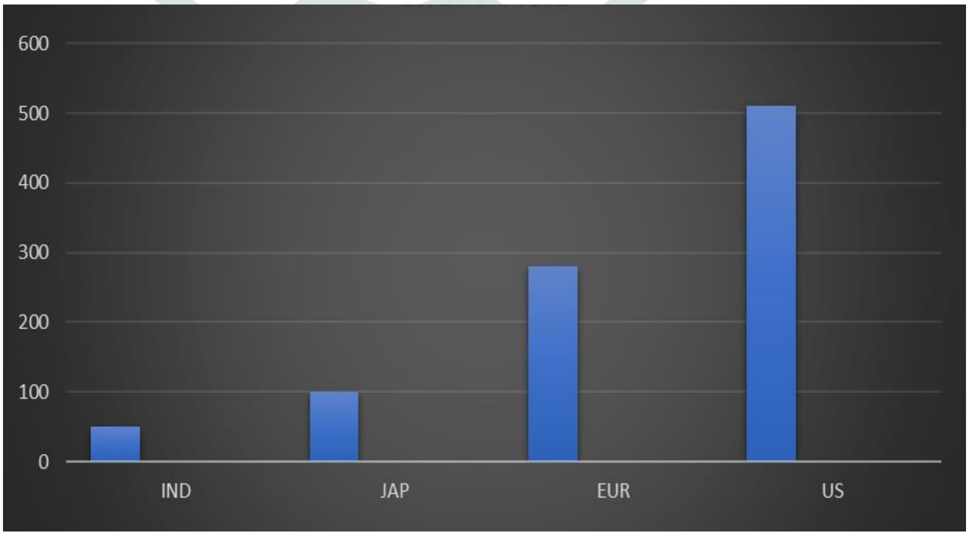

Fig. No.3: Nutraceutical market in different countries.

1.2: - Spirulina

SPIRULINA it is blue green algae obtained from Spirulina maxima or Spirulina platensis, belonging to the family: Oscillatoriaceae. It contains It contains 50–70% proteins and 5–6% fats. Essential fatty acids including linoleic acid, oleic acid, and palmitic acid are found in Lipids. Additionally, it contains glycolipids, sulpholipids, and several Vitamins, including Vitamins B1, B2, and B3. It contains the enzyme Superoxide dismutase, which is useful in atherosclerosis and Contains iron, Spirulina is use in Immune stimulant, Anticancer- antiviral, Hypocholesterolaemia, appetite stimulant. A Planktonic Photosynthesizing film-forming cyanobacteria called Spirulina Platensis has a very high population in the upper and lower Skin layers. Which have a high carbonate and bicarbonate content, As well as an alkaline pH value of up to 11. The chemical makeup of Spirulina indicates that it has a high nutritional value due to its Abundance in a variety of nutrients, including provitamins, minerals, Protein.

Polyunsaturated fatty acids like gamma-linoleic acid. Spirulina is derived from at in word 'helix' or 'spiral', spirulina natural Growth in alkaline water reservoir in subtopic & tropical area (America, Mexico, Belay) [4].

Spirulina, which is gathered from naturally growing populations and used as food, has gained fame for being used by the populace in Lake Chad.

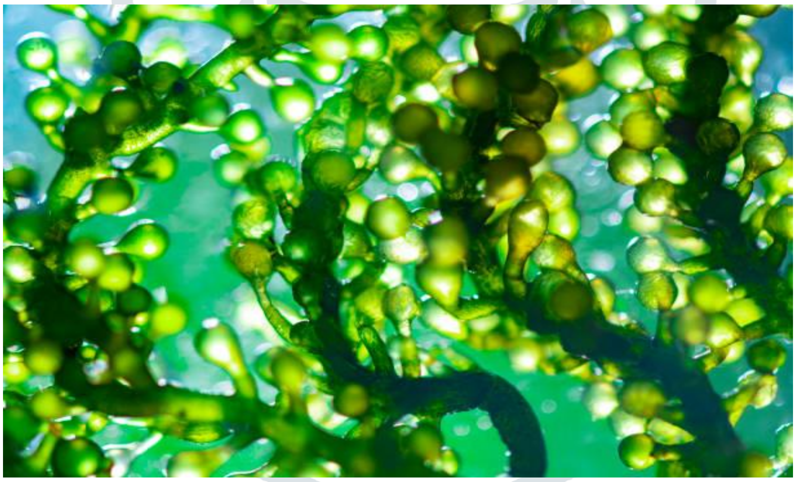

Fig. No.4: -Microscopical diagram of Spirulina.

Spirulina, which is gathered from naturally growing populations and used as food, has gained fame for being used by the populace in Lake Chad Furthermore, spirulina has been shown to boost the population beneficia intestinal lactobacillus, minimise nephrotoxicity induced by heavy metals and drugs, and provide radiation production. The ability of spirulina to prevent cancer and lessen damage to particular organs is influenced by its antioxidant qualities. Recent research has shown that spirulina has a good impact on immunity, gastrointestinal health, and growth performance [6].

1.3: - Spirulina example of cyanobacteria.

Spirulina, which is harvested from naturally growing populations and used as food, has made Lake Chad famous.[7] .There is consensus that "Arthrosporic is a distinct genus consisting of over 30 different species, including A. Platensis, A. Maxima, and A. Fusiformis," and that the word "spirulina" should be used for strains used as food supplements. Arthrosporic platensis has distinct psychological traits, and a thorough book has been written about its biology.

A. platensis exhibits robust filament (trichome) gliding motility with rotation along their long axis. It was certified to treat radiation sickness symptoms following the Chernobyl tragedy in Russia [4].

1.4 Drug Profile of Spirulina: -

Biological source: SPIRULINA it is blue green algae obtained from Spirulina maxima or Spirulina platensis.

Family: Oscillatoriaceae.

Chemical constituent: It contains 50–70% proteins and 5–6% fats. Essential fatty Acids including linoleic acid, oleic acid, and palmitic acid are found in Lipids. Additionally, it contains glycolipids, sulpholipids, and several vitamins, including vitamins B1, B2, and B3. It contains the enzyme Superoxide dismutase.

Uses: It is use in Atherosclerosis and Contains iron, Spirulina is use in Immune stimulant, Anticancer-antiviral, Hypocholesterolaemia, Appetite stimulan [2].

2. Ecology of spirulina: -

Spirulina also has qualities that are advantageous to the environment. On the edges of alkaline lakes (pH 9–11), it develops mats. Additionally, it has salt tolerance, thriving in conditions 1.5 times saltier than sea water [8] As a result, it frequently predominates in lakes with high pH and carbonate/bicarbonate concentrations. Spirulina also tolerates temperatures up to 60 ^{0}C and grows best in seas between 32^{0}C and 45^{0}C [9]

Some Spirulina species that have evolved to desert environments may persist even after their pond habitats dry up and become dormant on rocks that are up to 70°C in temperature. In this inactive state, the cyanobacterium's blue-green hue changes to a frosted white and takes on a sweet flavour. Speculative research suggests that the "manna" of the Israelites' wanderings, which magically emerged on rocks after a severe dry season and was described as taste "like wafers made with honey," may have really been a dried version of dormant Spirulina [6].

2.1. Nutritional values of Spirulina: -

Spirulina is currently anticipated to be a “food of the future” due to its exceptional capacity to produce high-quality concentrated nutrients more quickly than any other alga. In comparison to beef, which has just 22% protein, spirulina has a high protein content (almost 60% of the dry weight).

In addition, compared to agricultural plants like soybeans, which only have a 3% photosynthetic conversion rate, spirulina has an 8–10% rate. Spirulina also offers substantial amounts of several other nutrients in absorbable forms. S. platensis has trichrome that may reach a length of 0.5 mm, which is nearly 100 times longer than those of the majority of other filamentous cyanobacteria. Spirulina is simple to harvest due to the organism’s prolific reproductive ability and propensity to collect in colonies. It is desirable for biotechnological applications because to these characteristics [6] .

Table No.1: Nutrient data for spirulina [6]

Nutrient	Unit	Value(/100g)
Proximate		
Energy	Kcal	290
Protein	G	57.47
Total lipid (fat)	g	7.72
Carbohydrate, by differences	g	23.9
MINERAL		
Calcium, Ca	mg	120
Iron, Fe	mg	28.5
Magnesium, Mg	mg	195
Phosphorus, p	mg	118
Potassium, K	mg	1363
Sodium, Na	mg	1048
Zinc, Zn	mg	2
Copper, Cu	mg	6.1
Manganese, Se	mg	1.9
VITAMIN		
Vitamins c	Mg	10.1
Thiamine	Mg	2.38
Riboflavin	Mg	3.67

Niacin	Mg	12.82
Pantothenic acid	mg	3.48
LIPIDS		
Fatty acids	g	2.65
14:0	g	0.075
16:0	g	2.496

3. Cultivation & production of Spirulina: -

3.1: - Open Pond

Algae cultivation on open ponds has been widely researched [10] .Lakes, lagoons, ponds, and manmade ponds or containers are all examples of open ponds. Shallow huge ponds, circular ponds, tanks, and raceway ponds are the most widely utilised systems. Open systems are simpler to build and operate, resulting in lower manufacturing and operational costs. The main disadvantage of open ponds is inadequate light utilisation by the cells, evaporative losses, carbon dioxide diffusion to the atmosphere, and the demand of enormous acres of land. Furthermore, because of insufficient aeration in open cultivation systems, mass transfer rates are relatively low, leading in lower biomass output. Location, season, temperature, pH level, nutrition and carbon - dioxide supply all influence growth. The contamination of open pond systems by animals and other fast developing heterotrophs is another key disadvantage. Researchers have attempted closed systems to eliminate the difficulties inherent with open systems. Algae may be cultivated in large quantities; however, they are difficult to grow outside since they are readily polluted. This may be fixed by producing algae in greenhouses, which shield them from airborne contaminants. When compared to outside growing, a properly built algal greenhouse with controlled environment systems may boost production tenfold [11] .

Fig.No.5: - Open Pond

3.2: -Vertical-column PBR

Vertical-column photo bioreactors are simple to operate, small, and inexpensive**.** Vertical column photo bioreactors of various designs and scales have been reported for the culture of algae, and they are particularly promising for large-scale production. It has been observed that bubble-column and airlift photo bioreactors (up to 0.19 m in diameter) may achieve final biomass concentrations and specific growth rates equivalent to tubular photo bioreactors. Some bubble column photo bioreactors have draft tubes or are built as split cylinder (11) .

Fig.No.6: - Vertical-column PBR

3.3: -Flat plate PBR

Flat-plate photo bioreactors have attracted a lot of attention for cultivating photosynthetic microorganisms due to their enormous light surface area. The described study cleared the door for the production of algae in flat culture containers. A flat reactor with fluorescent bulbs was designed. Following that, an outdoor flat panel reactor made of thick transparent PVC materials was created. Later, substantial research on several designs of flat plate reactors and vertical panels for bulk production of diverse algae was published.

Flat plate photo bioreactors are made of transparent materials to maximise the use of sunlight. Dissolved oxygen concentrations accumulate in horizontal tubular When compared to flat-plate photo bioreactors, the efficiency of photo bioreactors is rather high. Flat-plate photo bioreactors have been shown to produce significant photosynthetic efficiency. Raceway ponds have the highest output of Spirulina platensis of any culture system. A one-hectare ground surface area is often used to calculate aerial production (11) .

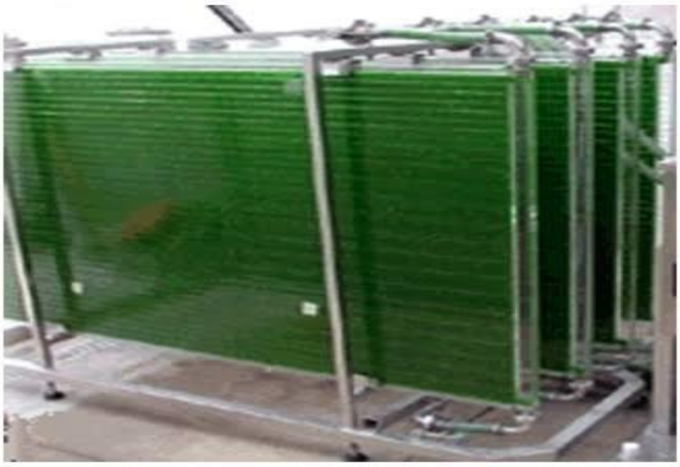

Fig.No.7: - Flat plate PBR

3.4: -Tubular PBR

The most appropriate form of bioreactor for outdoor mass production is a tubular photo bioreactor.Outdoor tubular photo bioreactors are often made of glass or plastic tubes. They might be horizontal, serpentine, vertical, or conical in shape. Air-pump or airlift devices are commonly used to mix and aerate cultures in tubular photo bioreactors. When tubular photo bioreactors are built up, mass transfer becomes an issue.

Many people have claimed that tubular photo bioreactors can readily achieve very high dissolved oxygen (DO) values. Most tubular photo bioreactors make it difficult to regulate culture temperatures. They can be outfitted with a thermostat to maintain the correct culture temperature, although this might be quite expensive and difficult to accomplish (11)

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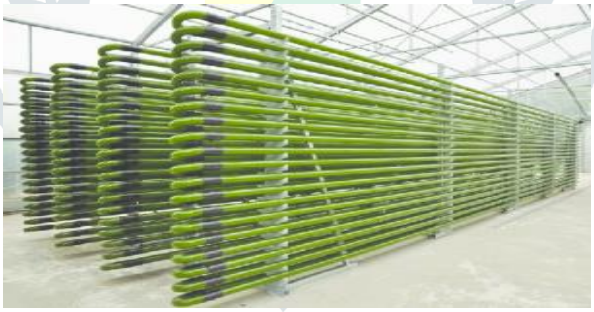

Fig.No.8: - Tubular PBR

3.5: - Hybrid system

A hybrid photo bioreactor is most commonly utilised to take use of the advantages of two different types of reactors while overcoming the limitations of others. A thermostatic pond of water with an integrated airlift system and an exterior tube loop has been reported. The reactor's entire volume was 200 L. The external loop functions as a light-harvesting.

device, providing a high surface area to volume ratio and controlling the culture's temperature. The airlift system functions as a degassing system, and probes may be added to control additional culture factors. It offers the benefit of providing more control over culture factors, allowing for increased production while lowering power usage [11].

Fig.No.9: - Hybrid system

3.6. Internally-illuminated PBR

These photobioreactors can be internally illuminated with fluorescent lamps. Air and CO2 are supplied to the cultures through the spargers with continuous agitation by impellers. This photo bioreactor can also be modified in such a way that it can utilize both solar and artificial light system [12]. The artificial light source is used whenever the solar light intensity decreases below a set value as during cloudy weather or at night. It has been reported, on the use of optic fibres to collect and distribute solar light in cylindrical PBR). A major advantage of internally-illuminated photobioreactor is that it can be heat-sterilized under pressure and by this contamination can be minimized [11].

Fig.No.10: - Internally-illuminated PBR

3.7: -Polybags

It is simple to grow algae in natural ponds, but it is quite challenging to convert it into a useful feedstock. Therefore, this technology may be used to provide larger production levels, the lowest capital and operational costs, increased biomass density, better climatically regulated conditions, and industrial scalability. Multi-compartment, thin, floating, flexible photo bioreactors (PBR) can be placed in freshwater or saltwater ponds, ditches, or any other body of water. The bag floats because the water within it has a lower density than the liquid it is submerged in. Different methods of controlling density enable the bags to be vertical to ease harvesting. The productivity studies have shown that cultivating algae in floating bags can be significantly more productive than other techniques. Poly Bags float in a cushion of water to get the most possible light exposure and optimum productivity outcomes.

However, as compared to cultures with internal illumination, they are ineffective. Polyethylene bag cultures have a short lifespan because bacteria and detritus from the culture environment stick to the interior surface, reducing light penetration and increasing contamination [11].

Fig.No.11: - Polybags

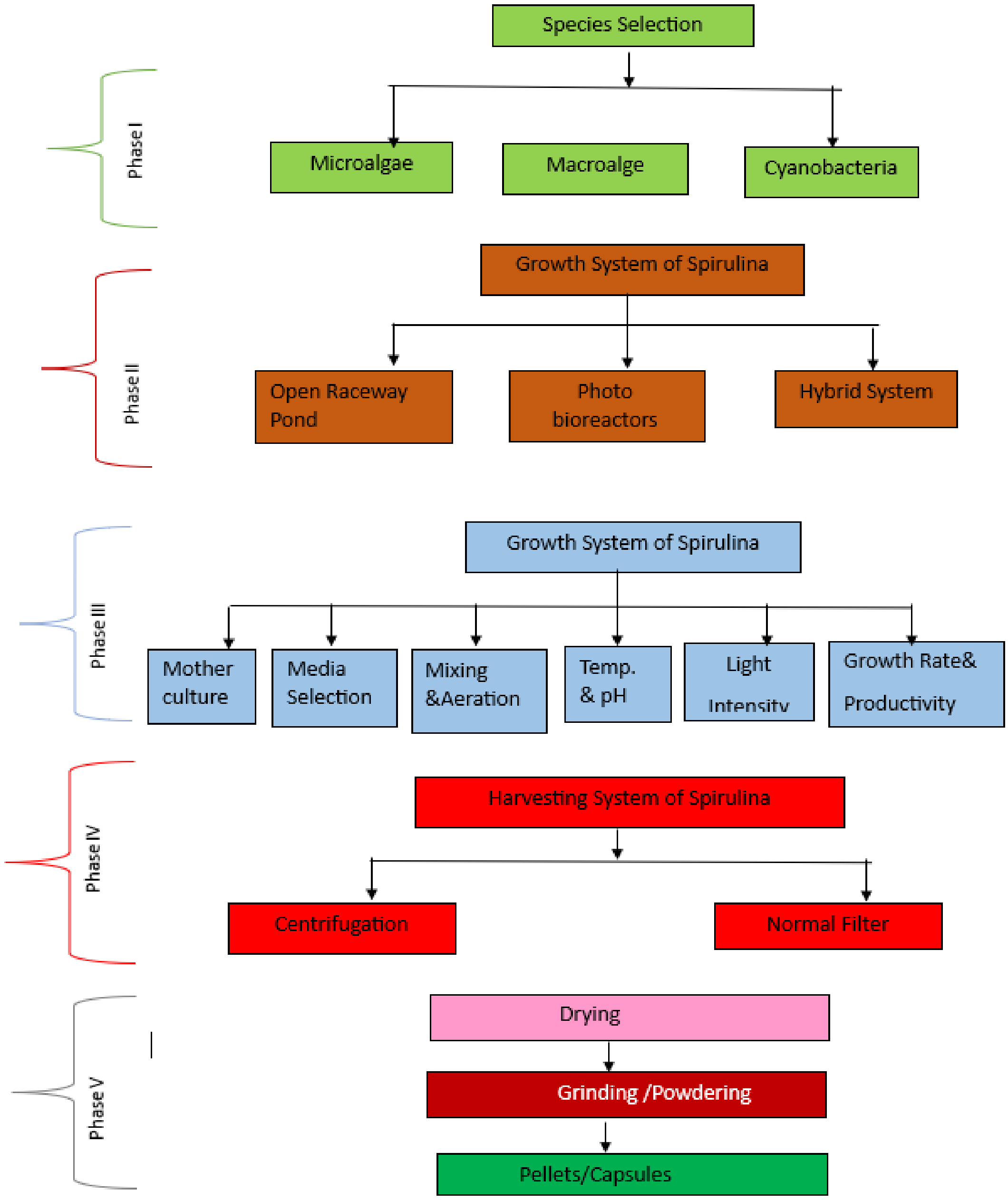

Fig.no 5: - Different phases of Spirulina cultivation system (a) strain selection (b) Growth systems (c) growth parameters (d) Harvesting system (e) Final product as capsules or pellets (13) .

Table No2: -prospect and limitation of various cultivation system [14].

SR. N0	Culture system	Dimensions	Specific growth rate	rate Prospects	Limitation
1	Open systems	Variable	0.30day	Relatively economical, easy to clean up after cultivation, good for mass cultivation of algae	Little control of culture conditions, difficulty in growing algal culturesforlong periods, poor productivity, occupy large land mass, limited to few strains of algae, cultures are easily contaminated
2	Vertical Column PBR	0.2 m diameter and 4 m column height	0.015 ± 0.002 h	High mass transfer, good mixing with low shear stress, low energy consumption, high potentials for scalability, easy to sterilize, good for immobilization of algae, reduced photo inhibition and photo-oxidation	Small illumination surface area, construction require sophisticated materials, shear stress to algal cultures, the decrease of illumination surface area upon scale-up
3	Flat plate PBR	0.07 m wide, 1.5 m height, 2.5 m length Volume 250lts Productivity - 1.0 g/L Day		Large illumination surface area, suitable for outdoor cultures, good for immobilization of algae, good light path, good biomass productivities, relatively cheap, easy to clean up, readily tempered, low oxygen builup	Scale-up require many compartments and support materials, difficulty in controlling culture temperature, some degree of wall growth, the possibility of hydrodynamic stress to some algal strains
4	Tubular PBR	D ¼ 3e10 cm	0.055 h	Large illumination surface area, suitable for outdoor cultures, fairly good biomass	Gradients of pH, dissolved oxygen and CO_2 along the tubes, fouling, some degree of wall growth, requires large land space

				productivities, relatively cheap	
5	Internally Illuminated PBR	Not Specified		Large illumination surface area, can utilize both solar and artificial light system, contamination can be	Outdoor mass cultivation of algae requires some technical efforts.
6	Hybrid System	Not Specified		Minimize microbial contamination, maximizebiomassproduct yield, Maximize CO2 supply	Requires large areas of land and some technical efforts
7	Poly Bags	D < 30 cm	0.20day	site flexibility, Low-cost materials, easy scalability, optimal light exposure, isolation of the crop from predators, very high biomass concentration, low energy consumption effective weather protection	Polyethylene bag cultures have a relatively short life because the internal surface attracts culture debris and bacteria, which collectively reduce light penetration and are a source of contamination

4. Review of growth parameters.

4.1: -Climatic factors

The rate of development of Spirulina is significantly influenced by temperature, a key climatic component. Growth is nearly non-existent below 17^0C, but spirulina doesn't perish. Spirulina grows best at a temperature of 35^0C, however over 38^0C, growth is hindered. Light is crucial, but it's not advisable to expose yourself to direct sunshine. In fact, 30% of full sunshinse is preferable, however more could be needed in the morning to quickly heat up the culture. [(15)] . Growth can only occur in the light, but it's also not advisable to have lights on all the time. Spirulina undergoes chemical processes like protein synthesis and respiration during the night [(11)].

4.2: -Media

Depending on the water supply, several culture mediums are employed to establish new cultures. To prevent the formation of more algae, the water utilised should be pure or filtered. Although water frequently has enough calcium, if it is excessively hard, muds will form. While RO-treated water is the ideal for growing spirulina, portable water is more practical. Urea makes up the majority of the cosmetics medium. Bicarbonate is used to replace carbonate. In urea, specific ions such as sodium, sulphate, chloride, and nitrate may be present.

These ions are more effective nitrogen suppliers, but in high quantities, they are exceedingly hazardous. Although spirulina may grow on either nitrate or urea by themselves, utilising both at once is preferable. Magnesium, calcium, and phosphorus cannot be significantly increased. As long as the potassium concentration does not exceed five times the sodium concentration, it can be raised correspondingly. If chemicals of the fertiliser grade are employed to cut costs, they should be of the soluble or crystallised kind rather than the delayed release, granular variety. Various media preparations are available depending on the growth circumstances where you are. The most popular medium is zarrouk's [(11)].

4.3: -Mother culture

Fully developed concentrated Spirulina culture is necessary for the production of inoculums and culture maintenance. The selected Spirulina strain needs to have at least 1% dry weight of gamma-linolenic acid (GLA) and a high percentage of coiled filaments (25% straight filaments, or none). You can make concentrated Spirulina seed cultures by dilution of newly filtered biomass or by using the floating layer of a constructed culture. The culture should be distinctly green in colour. When the temperature and other environmental circumstances are favourable, the growth rate is around 30% each day. Because development is proportional to the area of the culture exposed to light, it is best to keep this area as large as possible at all times [16] .It has been found that a low cell population is required to commence and sustain Spirulina cultures [11].

4.4: -Temperature and pH

Spirulina can grow at temperatures ranging from 20^{0}C to 37^{0}C. The ideal temperature for Spirulina development is between 29 and 35 degrees Celsius. Spirulina growth is minimal or non-existent at night. The influence of pH on algal growth, pigment synthesis, and protein content of Spirulina species has been shown to have a direct effect on the antioxidant system.**(17)** Growth may be impacted in two ways. Alteration of available carbon, which may Photosynthesis is disrupted. By interfering with cell membrane functions. This might have a direct influence on antioxidant accumulation. Furthermore, nutritional availability, ionisation, and heavy metal toxicity all have a significant influence on algal metabolism.

The key element influencing biomass production rates in outdoor Spirulina culture is temperature variability. During the rainy season, rainfall might contaminate the culture, resulting in the lowest dry mass. Physical elements that are unfavourable during the monsoon can be managed utilising locally accessible strategies. Bacterial contamination is caused by the warm, humid atmosphere. The primary pollutants of the Spirulina culture were protozoans such as amoeba and paramecium, which eventually ruined the cultures. During the rainy season, insects infest the culture, rendering it unsuitable for human consumption. Spirulina cultures can be housed in a housing composed of a plastic sheet to lessen the effect of low temperatures. A healthy culture has a pH level between 9 and 11. It also ensures that other strains do not contaminate the tank since they cannot exist in the alkaline environment in which Spirulina flourishes [11].

5. Benefits of Nutraceutical: -

From the consumer point of view functional food and nutraceutical may offer many benefits

1. May improve the nutritional value of our diet.
2. This could help us live longer lives.
3. It may help us avoid some medical disorders.
4. Doing something for oneself may have physiological benefits.
5. It may be perceived as more natural than traditional medicine, yet it is likely to induce unpleasant side effects.
6. Food for the population with specific needs may be presented [1].

5.1. Revolution of nutraceutical: -

Bing in the early 1980s sprang off when clinical research published in prestigious medical journals showed the real or potential therapeutic value of calcium fibres and fish oil. And when doctors use the media to educate their colleagues and raise attention to the drug, Factor for revolution.

5.1.1. Physician

Increased physician acknowledgment of nutritional protein's medicinal advantages drives up market demand for nutraceuticals.

5.1.2. Media

The media has emerged as the principal source of medical claims. Mass Media has now established itself as a formidable and respectable promoter of nutraceutical goods. Increasing fitness and health knowledge, suppressed by media coverage, is encouraging the majority of people to live healthier lifestyles, exercise more, and eat healthier.

Enzymes, according to many experts, constitute a new and intriguing future in Nutraceuticals. 'Enzymes have been underutilised... they will be a hot sector in the future. 'Fermentation technology that uses bacteria to make novel food items also has promise. This trend, in turn, is driving growth in the worldwide nutraceutical markets. The nascent neutrophils business appears to be set for expansion, with implications for the food, pharmaceutical, healthcare, and agricultural industries.

Global tendencies toward healthy products are not to be underestimated. Companies who take the lead by conducting strategic research in science, product development, marketing, and consumer education will be rewarded [1].

6. Benefits of Spirulina: -

6.1. Nutritional composition of Spirulina.

Spirulina is a microalga that has long been consumed for its high nutritional content and reputed health benefits. Spirulina is now recognized as a hidden, strong superfood that grows naturally in seas and saline lakes in subtropical climes.

Spirulina includes nearly all of the components present in a complete diet. Proteins, vitamins, mineral salts, carbs, colours, trace elements, and vital fatty acids are abundant. Spirulina is simpler to ingest than other algae.

6.1.1. Protein

Spirulina is the richest protein source. Spirulina is high in plant protein, which accounts for 60% to 70% of its weight. Soy flour has around 35% protein. Spirulina supplies complete proteins because it includes the whole range of essential amino acids, accounting for 47% of total protein weight.

6.1.2. Vitamins

Spirulina naturally contains the vitamins b-carotene, B1, B2, B12, and E. It has an extremely high b-carotene concentration, roughly 30 times that of a carrot. Spirulina is also quite high in vitamin B12 cobalamin. This vitamin is the most difficult to obtain. From a vegetarian diet because it is not found in any fruit, vegetable, grain, or legume. Spirulina contains four times the amount of vitamin B12 as raw liver, which was previously thought to be the finest source of this mineral. Spirulina is also known to be a great source of vitamin E, equivalent to wheat gram. Spirulina's principal antioxidant vitamins include b-carotene, carotenoids, and vitamin E.

6.1.3. Minerals Spirulina

Iron, magnesium, calcium, and phosphorus are among the minerals found. Spirulina is an excellent source of iron, containing 20 times more iron than wheat gram. Iron is a mineral found mostly in animal foods such as meat and fish. Spirulina is extremely beneficial to athletes, vegetarians, pregnant women, and youngsters [18].

6.2. Pharmaceuticals and Nutraceutical Applications.

Spirulina is the finest complete nutritious dietary supply of protein, beta carotene, GLA, B Vitamins, minerals, chlorophyll, sulfolipids, glycolipids, superoxide dismutase, phycocyanin, enzymes, RNA, and DNA. Nutraceutical foods enrich the diet while also assisting in the prevention or treatment of disease or disorder. There are several commercially available Nutraceutical and Functional food items with researched and approved health benefits. The present worldwide market size for nutraceuticals goods is projected to be between $30 and $60 billion, with the majority of sales occurring in the United States, Japan, and Europe. Spirulina goods have a potential market demand of over 197 billion dollars in the short term. As the need for nutraceuticals and dietary supplements grow, organisms that can manufacture nutritious compounds quickly are in high demand. Spirulina's propensity to be a strong antiviral, anti-cancer, hypocholesterolaemia, and health-improving agent is gaining interest as a nutraceutical and pharmaceutical.

Spirulina has the following health benefits.

- Long-lasting energy and energy for athletes.
- Helps with digestion, assimilation, and evacuation.
- Diabetes prevention.
- Aids in stress reduction.
- Depression is avoided.
- Weight loss with concentrated outstanding nutrients.
- It enhances memory and mental clarity.
- Stimulates the immune system to eliminate invading pathogens and carcinogens. Its antiviral, anti-tumour, and interferon-inducing properties boost the immune system.
- Promotes tissue healing in wounds and burns while also being anti-infectious.
- Lowers cholesterol levels and reduces the risk of cardiovascular disease. It acts as an anti-inflammatory agent. Reduce the inflammation associated with arthriti [19].

7. Future Aspect of Spirulina: -

Stem cell research's potential and promising uses have been a hot issue in medicine. Many disorders are thought to be curable with stem cell transplantation. (20)

Since indigenous stem cells can be stimulated to promote healing and regeneration as an alternative to stem cell transplantation, several researchers have also looked into the effects of certain nutraceuticals on stem cell development and proliferation. **(21)**

Spirulina use on Mars and the International Space Station is under consideration. This cyanobacterium may be cultivated without contamination because of its excellent alkali and salt tolerance (6) .

8.Conclusion: -

We came to the conclusion that spirulina is an affordable and helpful nutraceutical.

Many techniques for cultivating spirulina are reported. Open ponds, flat plate photobioreactors, tubular photobioreactors, vertical-column photobioreactors, and hybrid systems are a few of the methods. The sequencing of the Spirulina genome will present new possibilities for the development of advantageous nutraceuticals.

The nutrient-rich algae known as spirulina is gaining popularity. Spirulina has been produced by Indian businesses for human consumption and aquaculture enhancement. We have a lot of room to improve the way we cultivate and harvest this superfood, especially given its high export value. Spirulina presents a profitable potential because of its anticipated economic benefits. To put it simply, it means that spirulina, an algae rich in nutrients, is being produced in India for human consumption and to support fish aquaculture.

In Future spirulina is Scientific are looking for the stem transplant in the nutraceuticals so the fine it in the spirullina. If we cultivated spirulina properly by the cultivation process as mentioned above so we can cultivate maximum amount of nutrition in spirulina .spirulina is able to provide more amount of Oxygen s as compared to other plant in space station , so we can used it in the space as well .

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