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Popular Article

CULTIVATING SPIRULINA IN LOW-COST CEMENT TANKS: A SUSTAINABLE APPROACH

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Spirulina is a type of multicellular and filamentous cyan bacteria that thrives in water and can be easily harvested and processed. It contains a high concentration of macronutrients, micronutrients, essential amino acids, proteins, lipids, vitamins, minerals, and antioxidants. It is widely considered a comprehensive dietary supplement for addressing malnutrition in developing nations.

INTRODUCTION

Algae are photosynthetic organisms that convert light energy from the sun into chemical energy by the process of photosynthesis. The Spirulina is Earth's oldest living plant approximately 3.6 billion years ago and the first photo-synthetic life form that has created our oxygen atmosphere so all life could evolve. Algae that is currently cultivated for its maximum protein content is the cyanobacterium species Athrospira, which is commonly known as Spirulina. Spirulina was first discovered by Spanish Scientist Hernando Cortez and Conquistadors in 1519. Spirulina is the most nutritious, concentrated food that is Known to mankind containing antioxidants, phytonutrients, probiotics, and nutraceuticals.

The two most important species of Spirulina are Spirulina maxima and Spirulina platensis. It has a considerably high content of micro and macronutrients. Its dry-weight chemical composition includes 60e70% proteins, carbohydrates, vitamins like provitaminA, vitamin C, and vitamin E, and minerals such as iron, calcium, chromium, copper, magnesium, manganese, phosphorus, potassium, sodium, and zinc. Essential fatty acids g-linolenic acid (GLA), pigments like chlorophyll a, phycocyanin, and carotenes are also present. Spirulinais also used in cosmetics, medicines, and wastewater treatment. Itscell wall consists of polysaccharides that have a digestibility of 86%and can be easily absorbed by the human body.

Technologies for Cultivating Spirulina

Algae can be cultivated in open systems such as ponds,lakes, or lagoons, as well as in closed systems. Currently, thecultivation of Spirulina primarily employs two major technologies:

closed photobioreactors (PBR) and openponds. Both methods are commercially utilized for the production of high-value products.

Open pond system

Open ponds can be grouped intonatural bodies of water such as lakes, lagoons, and ponds, as well as artificial ponds orcontainers. The most widely employed systems include large shallow ponds, circular ponds, tanks, and raceway ponds. Open systems aresimpler to build and operate, leading to lower production andoperating costs. However, openponds have some disadvantages, including inefficient use of light by the cells, loss of water due to evaporation, release of carbon dioxide into the atmosphere, and the need for large expanses of land.

Setting up of cement tank

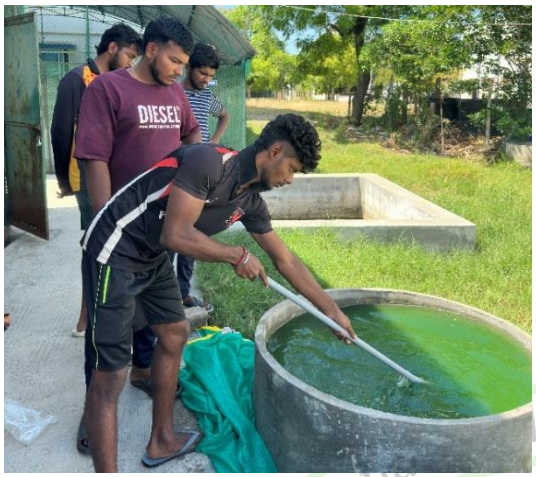
Selecting the Tank: Choose a cement tank that is clean, sturdy, and suitable for holding water. The size of the tank will depend on the scale of Spirulina production you aim for. It should have a smooth interior surface to prevent damage to Spirulina filaments during harvesting.

Location: Place the tank in a location where it can receive adequate sunlight, preferably in a sunny area with minimal shading. Spirulina requires plenty of sunlight for photosynthesis and growth.

Preparing the Tank: Clean the tank thoroughly to remove any residues or contaminants. Rinse it with clean water multiple times to ensure it is completely free of chemicals or debris that could harm Spirulina.

Filling with Water: Fill the tank with clean, preferably filtered, water. The water quality is crucial as Spirulina is sensitive to contaminants. Use water that is free from chlorine and heavy metals. Rainwater or well water can be suitable if it meets quality standards.

Nutrient Addition: Spirulina requires nutrients such as nitrogen, phosphorus, potassium, and trace elements for growth. Depending on the water quality and initial nutrient levels, you may need to supplement with appropriate nutrients. Common sources include urea, potassium nitrate, and sodium bicarbonate. The addition of nutrients should be carefully controlled to prevent overfeeding or underfeeding.



Growth parameters

Spirulina's growth requirements are akin to those of plants on land, butthey utilize resources efficiently to increase biomass productivity with less water. Temperature plays a crucial role in influencing Spirulina's growth. Growth is nearly non-existent below 17°C, butthe algae can survive. The best temperature for growth is35°C, but growth is hindered above 38°C. Light is also vital, but direct sunlight is not ideal. It's better to provide 30% offull sunlight, although more may be required towarm up the culture quickly in the morning. Growth occurs only in the presence of light, but constant 24-hour illumination is not recommended. During dark periods, chemical reactions occur within Spirulina, including protein synthesis and respiration.

Culture Media

Various cultural media are utilized to establish new cultures based on the water source. It is important to use clean or filtered water to prevent the growth of other algae. While water usually contains sufficient calcium, excessive hardness can result in muddy conditions. Portable water is convenient, but RO-treated water is the most suitable for cultivating Spirulina. The primary makeup media mainly comprises urea. Bicarbonate replaces carbonate. Urea and specific ions, such as sulfate, chloride,nitrate, and sodium, are more effective for nitrogen supply but can be highly toxic in high concentrations. Spirulina can thrive on eithernitrate or urea alone, but it is beneficial to use both simultaneously. Phosphate, magnesium, and calcium cannot besubstantially increased. Potassium concentration can be elevated as long as it does not exceed five times thesodium concentration. When cost reduction prompts the use of fertilizer grade chemicals, they should be of the soluble or crystallized type, rather than the slow-release, granulated type.

Mother culture

To prepare the inoculum and maintain the culture, a fully grownand concentrated Spirulina culture is necessary. The chosen Spirulinastrain should have predominantly coiled filaments (<25%straight filaments, or none) and contain at least 1% gamma-linolenic acid(GLA) based on dry weight. A concentrated Spirulina seed culture canbe obtained from the floating layer of a mixed culture orby diluting a freshly filtered biomass. The culture shouldexhibit a clear green color, and the growth rate should be approximately 30% per day under suitable temperatures and other environmental conditions. Since growth is directly related to the area of theculture

exposed to light, it is recommended to maximize this area at all times. It is crucial to ensure that the Spirulina culture has a minimum cell population to initiate and sustain its growth.

Mixing and aeration

It is essential to agitate the culture to ensure uniform distribution of light among all Spirulina filaments. Mixing is crucial for high-density cultures. Aeration is also important for the quality and yield of Spirulina. This can be achieved using rotators to keep the cells suspended and gently agitated. Spirulina yields high biomass when the growth medium is aerated. Aerationensures even distribution of Spirulina filamentsfor adequate exposure to light and helps maintain uniform carbon dioxidelevels while removing inhibitory substances.

Temperature and pH

Spirulina can thrive within a temperature range of 20°C to 37°C, with the most favorable temperature forits growth being between 29°C and 35°C. Spirulina's growth is minimal or nearly nonexistent during the night. The pH level directly influences the growth, pigment production, and protein content ofSpirulina species, thus affecting the antioxidant system. Adjust the pH of the water to around 10-11 using sodium bicarbonate to create a suitable environment for spirulina growth.

There are two primary ways in which Spirulina's growth can be affected:

1. Changes in available carbon, which can disrupt photosynthesis.

2. Disruption of cell membrane processes.

Harvesting system

The optimal time for harvesting Spirulina is in the early morning due to severalreasons:

1. The protein concentration in Spirulina is highest during this time.

2. The cooler temperature facilitates the harvesting process.

3. There are more hours of sunshine available for drying the product.

The harvesting process involves two main steps:

Filtration: This step results in a biomass with roughly 10% dry matterand 50% residual culture medium.

Removal of residual culture medium: This step produces freshSpirulina biomass with about 20% dry matter.

Harvesting of microalgae Spirulina involves using a filter or meshcloth with a minimum pore size of 50 microns to effectively collect Spirulina from itsmedium.

Benefits

Nutritional composition of Spirulina

Spirulina, a microalga with high nutritional value and reported health benefits, has been consumed for decades. Today, it is recognized

as a potent superfood and a natural marvel that thrives in oceans and salty lakes in subtropical climates. Spirulina contains almost all the components of an ideal complete food, including a significant amount of proteins, vitamins, mineral salts, carbohydrates, pigments, trace elements, and essential fatty acids. Unlike other algae, Spirulina is easier to consume.

Protein

Spirulina is incredibly rich in proteins, with plant protein accounting for 60%-70% of its weight, compared to about 35% in soya flour. Qualitatively, Spirulina offers complete proteins as it encompasses the full range of essential amino acids, making up 47% of the total protein weight.

Vitamins

The natural vitamins in Spirulina include beta-carotene, B1, B2,B12, and E. Its beta-carotene content is exceptionally high, about 30times higher than that found in a carrot. Spirulina is also notably rich in vitamin B12 (cobalamin), a nutrient difficult to obtain from a vegetarian diet. Additionally, it is an excellent source of vitamin E, comparable to levels found in wheat germ. The primary antioxidant vitamins in Spirulina are beta-carotene, carotenoids, and vitamin E.

Minerals

Spirulina contains iron, magnesium, calcium, and phosphorus. It is a splendid source of iron, containing 20 times more iron than wheat germ. This makes it advantageous for athletes, vegetarians, pregnant women, and teenagers, as iron is mainly found in animal-based foods such as meat and fish. The average nutritional analysis of Spirulina per 100 grams indicates its beneficial nutritional content for those seeking these essential vitamins and minerals.

Spirulina health benefits:

- Enhances long-lasting energy and vitalityfor athletes

- Supports digestion, assimilation, and elimination processes

- Helps in the prevention of diabetes

- Aids in stress reduction and prevention of depression

- Contains concentrated nutrients that aid in weight loss

- Improves memory and mental clarity

- Stimulates the immune system to combat diseases and carcinogens

- Enhances the immune system through antiviral, anti-tumor, and interferon-inducing effects

- Promotes tissue repair in wounds and burns and possesses anti-infectious properties

- Assists in lowering cholesterol levels and decreasing the risk of cardiovascular disease

- Acts as an anti-inflammatory agent, reducing inflammation often associated with arthritis

- Regulates appetite and stimulates metabolism"

Future outlook

Spirulina is a highly promising food source, containing a protein content of approximately 65-70%. Although the maximum reported protein content is currently 59%, there are

opportunities to increase this through the implementation of proper cultivation system design, efficient growth techniques, and the use of organic fertilizer.

Proper food processing, including the drying of Spirulina biomass, is a critical step in preserving its nutritional value and active compounds. It is essential to continue efforts to improve protein content and biomass yield.

Although open raceway pond cultivation is cost-effective, it only yields approximately 0.8 grams per liter per day. Additionally, this cultivation system has drawbacks, including insufficient light intensity, susceptibility to contamination, and a large land requirement.

Adequate aeration is crucial for obtaining high-quality spirulina and improved yields. Aeration should be performed every 4 hours to prevent clumping.).