Spirulina production in the ESA-IO region - The way forward

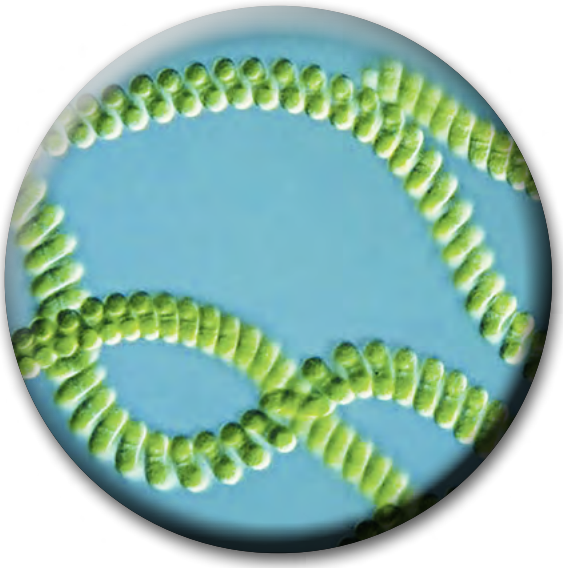
Smart Fiche 4

WHAT IS SPIRULINA?

Spirulina (Arthrospira platensis) is a micro-algae and one of the smallest, most ancient and robust organisms living on Earth and alone produces about 60% of the Earth's oxygen. They have survived some of Earth's harshest conditions for several billion years due to their robust cell wall.

There are more than 30,000 species of micro-algae and they come in a variety of strains (variants); each strain has different proportions of proteins, lipids (fats) and carbohydrates. Depending on the strain used micro-algae can produce :

- Food for high protein intake, used for malnourished children in developing countries as well as a food supplement and immune booster for the health conscious in industrialised countries like the U.S., Australia and the United Kingdom. (Arthrospira platensis).
- Oil for bio-crude if the lipid content is adequately high, strains such as (Botryococcus braunii) or (Chlorella ellipsoidea) can be used for this.
- Ethanol or biogas, through fermentation if the variant contains more carbohydrates; such as (Porphyridium cruentum) and (Spirogyra sp).



The focus for SmartFish is on the growth and production of one particular strain of micro-algae (Arthrospira platensis); commonly known as spirulina, which is very high in protein content (60-70%). Spirulina grows naturally in warm water alkaline lakes with high pH values it sustains the life of the flamingos in the area and the carotenoids contained in the spirulina is renowned for giving them their distinct pink/orange colouring. Spirulina is a single celled organism that turns sunlight into micronutrient life energy and is one of the earliest life forms originating more than 3.6 billion years ago, its spiral shape is what gives it the common name of spirulina.

All the essential vitamins and minerals required can be provided by this micro-algae Spirulina as well as antioxidants, carotenoids and is known to be a natural source of natural beta-carotene.

A BIT OF HISTORY

Spirulina dates as far back as the 16th Century when the Aztecs were harvesting it from the great soda lakes of Mexico. The conqueror Cortés travelled to Mexico in 1519 and was amazed at how the Aztecs used spirulina as a commodity. It was found in marketplaces together with jewlery, medicine, animals and pottery. The Aztecs made it into "tecuitlatl" or small cakes and sold it at the local markets to be used as an addition to sauces and mixed with grains. Cortés never really acquired a taste for the algae but they did report that the Aztec Indians found it delicious. It is said that the Aztec emperor Montezuma was a lover of fish and unfortunately the closest fresh fish available was in the Gulf of Mexico. It was the marathon runners who were given the task to provide the emperor with fresh fish on a daily basis – these runners would stop half way towards the sea and take spirulina to give them strength, energy and endurance.

Even further back in history there is evidence that the Mayas from about 300 to 900 A.D., cultivated spirulina in their waterways which were also used to irrigate their crops.

More recently the Kanembu, people living along the shores of Lake Chad use spirulina and it remains one of their main sources of protein. The spirulina is harvested from the lake by skimming the surface of the water with finely woven nets. The slushy watery substance is collected and the women dig round

holes in the warm sand to place the spirulina in, the water drains into the sand leaving behind a round "cake" like dry substance which is locally called dihé. The cake is then cut up in slices and sold at the local market where consumers purchase it and sprinkle it on food; it is their main source of protein.

HOW TO GROW SPIRULINA

Spirulina grows naturally in many parts of the world including the rift valley in Eastern Africa, Western Africa (see table 1), Mexico and Asia and can be harvested from these water resources as do the Kanembu people In Chad. The most productive and efficient way is to grow and harvest spirulina in man-made ponds. In these semi controlled environment spirulina can grow and can be harvested without too much effort. With some basic knowledge, essential requirements and the right conditions 4 small sized ponds measuring 6m x 20m each can yield as much as 5kg (10-12 grams per square metre) of dry spirulina a day.

Table 1 : African lakes which have natural Spirulina production

Name	Country	pH	Salinity
Wadi El Natrun lakes	Egypt	NA	NA
Malha Crater Lake	Sudan	9.5-10.3	NA
Lake Arenguadi (Green Lake)	Ethiopia	9.5-9.9	0.25%
Lake Basaka	Ethiopia	9.6	0.3%
Lake Shala	Ethiopia	9.8	1.8%
Lake Chitu	Ethiopia	10.3	5.8%
Lake Abijatta	Ethiopia	9.9	3.4%
Lake Magadi	Kenya	10	>10%
Lake Bogoria	Kenya	10.5	35%
Lake Turkana	Kenya	8.5-9.2	0.25%
Lake Nakuru	Kenya	10.5	NA
Lake Logipi	Kenya	9.5-10.5	2-5%
Lake Sonachi (Crater Lake)	Kenya	NA	NA
Lake Manyara	Tanzania	9.5-10	NA
Lake Natron	Tanzania	9-10.5	>10%
Lake Rukwa	Tanzania	8-9	NA
Lake Eyasi	Tanzania	9.3	0.5%
Lake Ngami	Botswana		
Rombou Lake	Chad	10.2	2%

The basic requirements for growing Spirulina in man-made ponds are the following :

- Basins in order to contain the water (about 50 to 60 cm high) and the culture (algae). Basins can be either made of polished cement or dug in the ground with a polythene cover to contain the water.
- Adequate sunlight (below 18oC growth is practically nil and the optimum temperature is between 35oC and 37oC, (higher temperatures will destroy the nutrients).
- A cover for the pond (to avoid contamination and cross-breeding)
- Salts to soften the water and to increase the pH value (more alkaline)

Fishermen are equipped with the expertise and the knowledge on how to better handle and manage fish and water products, the basic principles of pond grown and harvested spirulina are similar to growing tilapia or other fish in an aquaculture environment. Growing spirulina in a pond could also be an introduction to basic aquaculture for fishermen.

Shelf price of spirulina varies from 70 Euros/kg (local Kenya market) to 150 Euros/Kg (USA/Australia/UK). The protein content and quality of the spirulina are a determining factor in evaluating its market price, the higher the micro-nutrient/protein content the higher the selling price. Therefore growing spirulina could be a worthwhile investment for fishermen as an alternative or to complement fishing particularly in lake regions of central and southern Africa as well as the Indian Ocean region where water is available. With world fish stocks being depleted and highly competitive fish markets, spirulina production offers a way for fishermen to diversify from fishing.

Spirulina can also be grown in Photo Bio-Reactors (PBR) or man-made machines specifically built to grow micro-algae; the fully controlled environment of the PBRs ensures a higher quality product with less waste and higher nutritional value. However the downside is that these machines are very expensive to buy and generally require specialised staff to operate them.

BENEFITS OF SPIRULINA

Protein:

Spirulina is rich in proteins, minerals and vitamins, but on its own is not enough to satisfy the daily health needs of an individual especially a child. The rate of protein varies on the strain used between 60% and 70% of dry matter which is more than fish (25%) and soya at (35%). With this in mind 10grams of spirulina (1 heaped spoon) can yield about 6 to 7 gr of protein which represents almost 50% of the daily need.

Spirulina contains a large part of essential amino acids; however it cannot do all the work on its own and it must be associated with other protein sources rich in amino acids such as cereals, rice, mil or legumes such as sesame and peas.

Vitamins & Minerals:

Spirulina contains a large number of Vitamins and Minerals and covers all the requirements of Vitamins B1, B2, B3 and phosphorus as well as substantial quantities of brass, magnesium and calcium. Its real strength lies in the fact that it contains large amounts of Iron and Vitamin A which are 2 of the most deficient elements in malnutrition.

Table 2 : General Composition of Spirulina

General Composition of Spirulina	
Protein	53 – 62 %
Carbohydrates	17 – 25 %
Lipids	4 – 6 %
Minerals	8 – 13%
Moisture	3 – 6 %

Table 3 : Vitamins a nd Minerals contained in Spirulina

Vitamin and minerals (ug)	Need per day for a child between 6 and 23 months (ug)	Content in 10g of spirulina (ug)
Iron	7 - 11	5,8 - 18
V itamin A	300 - 500	1560 - 3780
Vitamin B1	0,2 - 0,5	0,35 - 0,5
Vitamin B2	0,4 - 0,6	0,3 - 0,5
Vitamin B3	1,5 - 8	13
Phosphorus	54 - 460	67 - 90
Magnesium	54 - 85	20 - 30
Brass	0,2 - 0,4	0,08 - 0,1
Calcium	270 - 525	13 - 140

Spirulina is considered a health food supplement and is widely used amongst the sport minded and health enthusiasts. A daily intake of 5-10gr of spirulina has been proven to be beneficial to :

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1. Increase the CD4 count – strengthens the immune system (particularly useful for HIV sufferers).
2. Increase RNA (Ribonucleic acid) in the brain for more energy.
3. Contains 10 times more beta carotene and is an excellent source of disease fighting antioxidants as well as healthy for eyes and vision.
4. Contains vegetable protein and amino acids to build muscle tissue
5. High concentration of B Vitamins; which breakdown carbohydrate and lipids and maintain cardiovascular health.
6. Excellent anti-inflammatory, which is an essential benefit to arthritis patients and prevents heart disease.
7. Contains anti-aging properties.
8. Improve digestive health.
9. Contains easy to absorb iron supplements ideal for women and children.
10. Reduces cancer with antioxidant protection.

SPIRULINA PRODUCTION IN THE ESA-IO REGION

As a follow up to an initial study on spirulina in March/April 2011, by Antonio Piccolo (SmartFish consultant) it was decided to move forward and assess the possibility of developing Spirulina in one of the project countries. From October 23-25 a mission took place in Ethiopia (by George Bonnin – SmartFish consultant) to assess the potential of Ethiopia's spirulina production. None of the lakes visited by the mission contained Spirulina production in visible amounts, however it was concluded that despite this there is still a great potential to grow Spirulina in the region.

From October 28 – 30 immediately following the Ethiopia mission the consultants went onto Kisumu, Kenya to conduct a 3 day Training Workshop on Spirulina Production. The workshop saw participants from Zambia, Kenya, Ethiopia and Uganda who were not only taught history and theory behind spirulina production but also hands on practical work which was undertaken at the Dunga Spirulina Farm in Dunga, Kisumu – Kenya.

WHAT IS THE FUTURE

In the future SmartFish hopes to engage in spirulina production through the establishment of a pilot project in the region. The pilot could include an array of PVC-lined culture ponds stirred by electrically drive paddle wheels along with some harvesting, drying and laboratory equipment.

Along with a pilot plant a demonstration unit could also be installed to demonstrate the effectiveness of the designed process and to train local inhabitants to this relatively new activity. A 100 m2 PVC-lined pond able to contain 20 m3 of water would be installed on flat ground where the spirulina could grow. Water would be pumped in from a nearby lake and the required chemicals added – the pond could be innoculated with the strains taken from other spirulina producers.

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