Spirulina and Malnutrition

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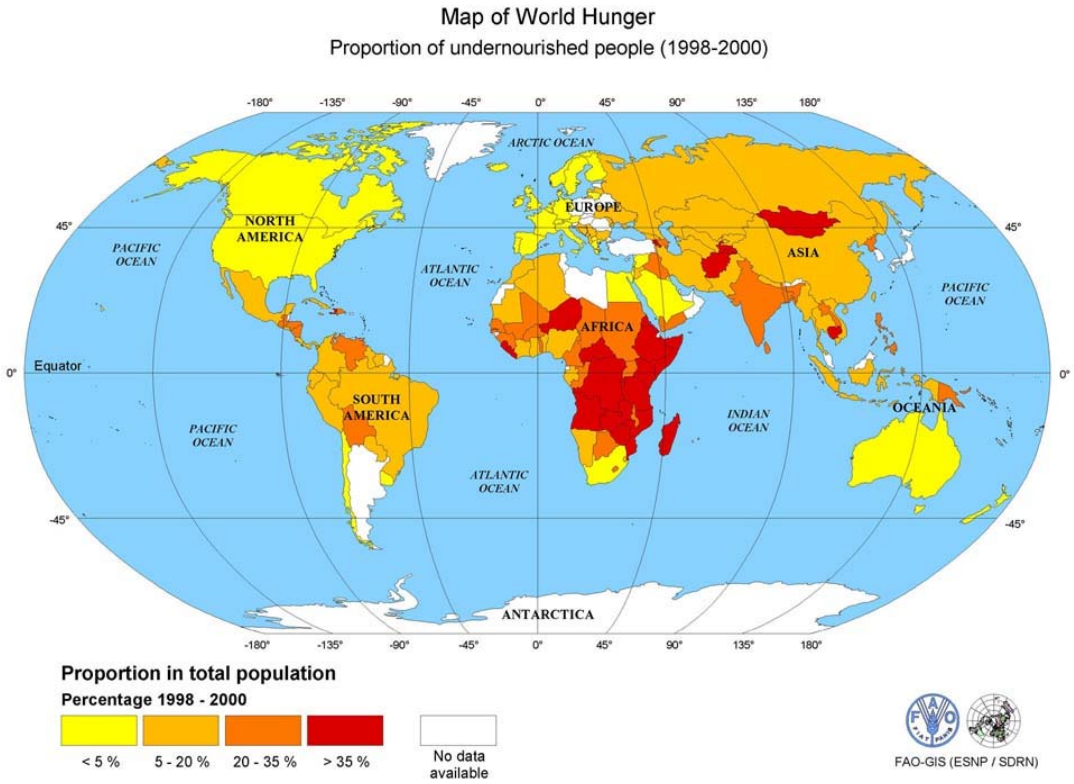
I. Introduction

At the age where feeding the world becomes a real challenge, Africa is the area which is the most affected by malnutrition. Indeed, today, 95% (798 million) of the undernourished are in developing countries and almost one quarter (198 millions) of them are in the Sub-Saharan Africa. Besides, the quantity of food, people suffer from malnutrition; a deficiencies in nutrients due to prolonged consummation of a single nutrient.



FAO and the FMFH Partners, 2006

The main deficiencies are essential vitamins and minerals which mostly affect pregnant women and children between 3 months and 6 years when the growth needs are the highest. These deficiencies can cause diseases like kwashiorkor (physical troubles: pale face, members oedemas...), and other troubles with particular lacks.

Today, more than 3.5 billion people are affected by iron deficiency which can result in growth retardation, low resistance to disease, long-term impairment in mental and motor development and impaired reproductive functions; it contributes to approximately 20 percent of pregnancy-related deathscauses. It also causes anaemia by diminution of the hemoglobine rate. 2 billion people are at risk of iodine deficiency which causes intellectual retardations. Finally, 200 million pre-school children are affected by insufficient vitamin A which can result in blindness or death among children. It contributes to decreased physical growth and impaired resistance to infections, with increased mortality in young children as a consequence.

In these conditions, the intellectual and the economical development of these countries are affected and unable any reaction.

Indeed, 200 millions of the 850 chronically undernourished are children under five years old. During this period of growth, malnutrition causes irreversible troubles of growth retardation and illnesses. Under these conditions, children can’t study properly and compromise their future capacity of working. Furthermore, women touched by malnutrition carry on the vicious cycle of malnutrition by giving birth to low birth-weight babies.

Against these plague, states, international organizations and NGOs try to find solutions to improve this situation. For that, a blue alga called spirulina has been found and presented by some of the actors as one of the best ways to fight durably and effectively against malnutrition.

II. The characteristics and benefits of spirulina

1. History

Spirulina has been used for years. In his memories, Cortès the Spanish colonizer relates the utilization of the algae by the Aztec. It was consumed in dried palets; the *tecuitlatl*. Later, the benefits of the algae were rediscovered by Europeans in Tchad, Africa where Spirulina has always been used as food complement by the Kanembous tribes. Today, spirulina is consumed in Africa as a cure with less than 10g per day. It is taken pure or with another product to mask the strong taste of the algae.

In the 80s, seeing the multiple benefits of the alga, scientists started researches to determine where the spirulina effects were coming from.

2. Taxonomy of spirulina

Actually, spirulina is a cyanobactery, Gram +. Like the other blue algae, spirulina is able to photosynthesis and so to produce its own organic matter.

There are more than 39 species but for its composition stability and balance of nutrients, *Spirulina platensis* is the specie most used in developing countries cultures.

Spirulina classification	
Domain	Bacteria
Kingdom	Archaeplastida
Division	Cyanobacteria
Class	Cyanophyceae
Order	Oscillatoriales
Family	Pseudanabaenaceae
Subfamily	Spirulinoideae
Genus	Spirulina

Photo Roland Boyer - CNRS

***Arthrospira (Spirulina) platensis* PCC 8005**

3. Nutritional contribution of spirulina

Proteins

The rate of protein in Spirulina is high and represents between 60% and 70% of the dry matter (Clément 1975b, Fox 1999) what is more than fish (25%) or than soya (35%) (Henrikson 1994). With this rate of protein, 10g of spirulina bring between 6g and 7g of protein which represent almost 50% of a 10kg child needs. However, for the adults, the interest of spirulina as a hyperprotein ingredient is limited.

The composition of protein is balanced in amino acids and contains more than 40% of essential amino acids (Borowitzka 1988) like isoleucine (IIe), leucine (Leu), Lysine (Lys), methionine (Met), phenylalanine (Phe), threonine (Thr), tryptophane (Trp), and valine (Val).

However, composition of Spirulina is too low in sulphured amineo acids (cystéine and methionines) which are essential for malnourished people and especially children.

Even if it contains a large part of essential amino acids, spirulina must be associated with other protein sources rich in amino acids. We will use cereals rich in sulphured amineo acids like rice mil which are common in Africa or legumes like sesame or pea.

Mineral and vitamins

Spirulina brings a large panel of minerals and vitamins.

vitamin and minerals (µg)	needs per day for a child between 6 and 23 months (µg)	content in 10g of spirulina (µg)
Iron	7-11	5,8-18
Vitamin 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

On the one hand, spirulina covers all the needs in vitamin B1, B2, B3 and phosphorus. It also provides a non negligible quantity of brass, magnesium and calcium. However, its real interest resides in its capacity to bring Iron and vitamin A which are one of the most deficient elements in malnutrition. Indeed, spirulina brings between 5.8 µg and 18µg of Iron for a need between 7 and 11µg. Otherwise, spirulina is composed by β-carotene which produces vitamin A. With its rate of β-carotene spirulina can bring between 1560 µg and 3780 µg of vitamin A which is so much more than the required 300µg or 500µg.Hopefully only the quantity needed is transformed into vitamin A that protects the consumers against hypervitaminoses.

On the other hand, we can mark that spirulina doesn't bring any iodine or zinc which are one of the most important deficiencies in malnourished countries. To cure iodine and vitamin E deficiency, we will need another food complement.

Other compounds

Some other compounds of spirulina would have antioxydative, anti-inflammatory, anticancer antiviral, neuroprotective, hepatoprotective and immunoenhancing properties. Most of these effects would be associated with antioxydative effect by substances like selenium, carotenoid, phenolics, essential fatty acids and phycocyanins. Essential fatty acids constitute more than ¾ of spirulina fatty acids and are mainly constituted by linoleique (C18:2) and linolenique (C18:3) acids. The phycocyanine is the blue pigment of the algae and its concentration is determined by the light intensity.

Even if complementary scientific studies have to be done to valid all the different positive effects of spirulina, these effects do not stop to be proved by local experiences.

However, if the FAO contributes to spirulina development, other international organization like WHO (World Health Organization) or NGOs like WFP (world food program) and ACF (Action Contre la Faim) do not support spirulina. They are waiting for more studies to analyze more precisely the effects of the algae.

4. Spirulina exploitation

Spirulina can be easily cultivated in basins of about 6 by 3 meters. Spirulina is perfectly adapted to the hot and dry conditions of Africa and grows in hot climate between 25 and 40 degrees. All you need is a tank of water about 20 centimeters deep, some light heat and a mixture of alkaline solution and fertilizers which are absorbed by the algae and contribute to avoid any risk of pollution. With this kind of culture, experts from NGOs estimate the average productivity at about 6g per m² per day.

The production process is relatively easy and can be done by village people. Regularly the water of the basins has to be blended to prevent spirulina to enter in dormancy. Every day, spirulina is harvested with large filters which keep the spirulina and release the water. Then spirulina is pressed and dried in threads which will be conserved before the use.

Spirulina exploitation: filtration

III. Spirulina today and tomorow

Spirulina has the advantage to be a natural product which can be grown by local structures leading to a local autonomy. Today, there are about 45 spirulina farm in Africa, spread over 18 countries.On average, 28% of their production is distributed and the rest is sold in pharmacies, cooperatives, on the internet or directly from the farm.

In Burkina Faso, in collaboration with l'OCADES and TECHNAP, the government and the health minister led a large project in Nayalgué. Financed over 5 years, the 1 455 000€ project had the target to create a perennial and autonomous corporation. Furthermore, the sales made by spirulina had to enable the distribution of a part of the production in areas touched by malnutrition. Today the project has 1200m² of basins and is going to rise 3600m².

However, after more than 20 years since its rediscovery, spirulina is not very famous yet and most people don't know the benefits of the algae and its strong taste combined with green color does not push the consummation.

For these reasons, students from the *Institut Lasalle Beauvais* tried for few months to find solutions to make spirulina more attractive to the consummation. Indeed, Sophie GHESQUIER, a fifth year student decides helped by Lasalle Beauvais Institute to create the project Vitaspir. After having found a NGO interested in developing a new product based on spirulina, she offers to make spirulina marmalade in two concentrations: a 2% one designated to be sold, and a 4% one designated to be distributed to malnourished people. Indeed, the benefits made by the 2% marmalade were used to finance the confection and the distribution of the 4% one.

Vitaspir project: spirulina marmalade

Along the same idea, Vitanutril® sells products spirulina based like spirulina mixed with mashed spinach or cereal bars (http://www.sunosi.fr/Gamme.htm). They are popular product in which the strong spirulina taste has been hidden. With the funds collected in Europeen sales, the corporation finances projects involved in spirulina development in Africa.

IV. Conclusion

Even if spirulina does not fill some deficiencies (iodine), spirulina brings all vitamin A, vitamin B, and iron needs and a signifiant quantity of other essential minerals like brass, magnesium and calcium. With a recommendation of 10g per day, its rate of protein between 60% and 70% contributes to bring the major part of protein needs of a child (50%). In this condition, the algae can be considered as a real ingredient.

Furthermore, comparing with other complements like enriched flours distributed by international organizations (OMC), spirulina has different advantages: first, spirulina doesn't have only nutritive benefits but also contributes to reinforce immune system and even if these effects still have to be proven by scientific studies, spirulina is recognized and used by NGOs and FAO yet.

Finally, where enriched flours are imported from Europe, spirulina is produced on the premises which create an economical activity and an autonomy that these areas of the world have lost.

So, at the age of modernity where technologies become more and more performing and impressive, that is one of the oldest forms of life and the oldest food complement used by humanity which affirms itself as one of the best solutions against malnutrition and gives hope back to developing countries.

References

1: Can Spirulina be considered as benefic for health and development in Africa? DPEI, DGPEI / Research Institute for development, L. Charpy ; M-J Langlade ; R.Alliod. 01/08/2008
http://agriculture.gouv.fr/sections/publications/etudes/spiruline-peut-elle-etre1808

2: TECHNAP projects in Africa:
http://www.technap-spiruline.org/content/view/7/. 30/072009.

3: Innovation Project, Sophie GESQUIER. 4th June 2008, Institut Polytechnique Lasalle Beauvais.

5: Hunger and Malnutrition, FAO and the FMFH Partners, 2006,
http://www.feedingminds.org/info/info_level.htm

6: Visit a local culture of spirulina in Madurai, Antenna Technologies, 05/01/2008
http://www.youtube.com/watch?v=U6cslNtc6P4&feature=channel_page

7: Vitanutril® products, Sunosi, 19/07/2009:
http://www.sunosi.fr/Gamme.htm