

Formulation and acceptability of Spirulina incorporated health mix

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Abstract

Spirulina or arthrospirais a blue-green alga that became famous after it was successfully used by NASA as a dietary supplement for astronauts on space missions. Spirulina is found to be the best alternative dietary supplement to the malnutrition and other nutritional deficiencies. Spirulina is a safe food with absolutely no side effects. To overcome such problems, an attempt has been concentrated on enhancing the organoleptic quality of spirulina through supplementation (SIFS). Nutrition policies can be taken to overcome the malnutrition problem among children by concentration on the alternative dietary supplements. The sensory analysis of the developed product using spirulina showed that 1g spirulina incorporated product got the maximum mean score compared to 1.5 and 2g due intensification of colour and odour. The nutrient content of spirulina was analyzed and it contains provided 350 kcal of energy, 8.81 per cent of protein, 1.39 IU of Vitamin A, 25 mcg of vitamin C, 13.66 mg of iron, and 280 mg of calcium. Per serving (30g) showed that it was 105 kcal of energy, 2.643 per cent of protein, 0.417 IU of Vitamin A, 7.5mcg of vitamin C, 4.098 mg of iron and 84 mg of calcium respectively. The developed products were subjected to microbial analysis for fungi and bacteria for six month and found to be safe.

Keywords: Spirulina, SIFS - Spirulina Incorporated Food Supplement

Introduction

Spirulina is a microscopic and filamentous cyanobacterium that derives its name from the spiral or helical nature of its filaments. It has a long history of use as food and it has been reported that it has been used during the Aztec civilization (Dillon *et al*, 1995). Spirulina is a low-fat, low-calorie, cholesterol-free source of easily-digestible vegetable protein containing all the essential amino acids that cannot be produced by the body but are needed to synthesize the non-essential amino acids. Spirulina has no cellulose in its cell walls and is therefore

easily digested and assimilated. It is called a 'super food' because its nutrient content is more potent than any other food. Many of the essential nutrients needed by our bodies are concentrated in spirulina. It is comprised of at least 60 per cent all-vegetable protein, essential vitamins and phytonutrients such as the rare essential fatty acid GLA, sulfolipids, glycolipids and polysaccharides. In the case of Vitamin A and iron – the two most important micronutrients – Spirulina is cheaper than any other natural product, including carrots and spinach.

Spirulina refers to the dried biomass of *Arthrospiraplatensis*, an oxygenic photosynthetic bacterium found worldwide in fresh and marine waters. This algae presents an important staple diet in humans and has been used as a source of protein and vitamin supplement in humans without any significant side-effects. Apart from the high (up to 70%) content of protein, it also contains vitamins, especially B12 and provitaminA (β -carotenes), and minerals, especially iron. It is also rich in phenolic acids, tocopherols and γ -linolenic acid. Many toxicological studies have proven Spirulina's safety. Spirulina now belongs to the substances that are listed by the US Food and Drug Administration under the category Generally Recognized as Safe (GRAS) (Tarantino, 2003, Salazar *et al*, 1998, Chamorro *et al*, 1997, Belay, 2002). Spirulina is relatively easy to cultivate but flourishes only in alkaline lakes with an extremely high pH and in large outdoor ponds under controlled conditions. There are only a few areas worldwide that have the ideal sunny climate for production of this alga, including Greece (Nigrita, Serres), Japan, India, United States and Spain. Currently, Spirulina can be found in health food stores and is sold mainly as a dietary supplement in the form of health drinks or tablets. Microalgae have been used for more than 10 years as dietary supplements without significant side-effects (Kay, 1991).

Materials and methods

A. Selection of Supplement

Spirulina is well known to have very high iron content; it was tested against a typical iron supplement, iron sulfate. Spirulina-fed rats absorbed 60 percent more iron than rats fed the iron supplement. This study suggested that there is a highly assimilable form of iron in spirulina. An earlier study also showed that it was effective in correcting anaemia in rats.

Studies on Spirulina supplementation have revealed health benefits such as prevention

of skeletal muscle damage (Lu *et al*, 2006). According to Volterille *et al* (2008), spirulina provided adequate protein quality to maintain body growth and muscle protein synthesis rates were increased by the ingestion of spirulina diet in young rats. Duan *et al* (2001) opine that spirulina has a certain factor which inhibits cancer, high blood pressure, diabetes and hastens the body to absorb Selenium and Molybdenum and is beneficial to cardiac muscles. The experiments indicated that spirulina is a good health care food with high nutritional and medicinal potentials. It exhibits therapeutic functions such as antioxidant, antibacterial, antiviral, anticancer, anti-inflammatory, anti-allergic and anti-diabetic and a wide plethora of beneficial functions. Spirulina consumption appears to promote the growth of intestinal micro flora as well (Kulshrestha *et al*, 2008). Premakumari *et al* (2011) carried out supplementation of spirulina in the form of candies for PTG children from the Nilgiris and revealed the efficacy of spirulina candies as a supplement to promote overall growth in under five tribal children. Supplementation for only six months could improve the nutritional status of children to a statistically significant extent ($p < 0.01$; $p < 0.05$) Therefore, Spirulina was selected as a food supplement in the present study.

Though spirulina is acclaimed to be an inexpensive source of complete proteins providing all essential amino acids and all micronutrients (except Vitamin C), yet, macro nutrients are not provided by the candies and it is well known that macronutrients are indispensable during childhood. Simpore (2006) has reported that spirulina plus misola (millet, soja and peanut) are good food supplements for undernourished children. Hence a food supplement was formulated using spirulina and inexpensive locally available cereals and millets. Nutritional Composition of Spirulina Powder was given in Table 1.

Table 1: Nutritional Composition of Spirulina Powder (per 100 g)*.

Energy Content	373 kcal
Total Fat	4.3 g
Saturated fat	1.95
PUFA	1.93
MUFA	0.26
Cholesterol	< 0.1
Gamma-Linolenic acid (GLA)	1080 mg
Carbohydrate	17.8 g
Protein	63 g
Vitamin A (as beta-Carotene)	352,000 IU
Total carotenoids (mean)	504 mg
β-carotene (mean)	211 mg
Zeaxanthin	101 mg
Vitamin K	1090 µg
Vitamin B1 (Thiamine HCL)	0.5 mg
Vitamin B2	4.5 mg
Niacin	14.9 mg
Vitamin B 6 (Pyridoxine HCL)	0.96 mg
Vitamin B12	162 µg
Calcium	468 mg
Phosphorus	961 mg
Iron	87.4 mg
Iodine	142 µg
Magnesium	319 mg
Zinc	1.45 mg
Selenium	25.5 mg
Copper	0.47 mg
Potassium	1660 mg
Manganese	3.26 mg
Sodium	641 mg

*Belay (2008)

B. Formulation of Spirulina Incorporated Food Supplement (SIFS)

A spirulina incorporated food supplement (SIFS) was prepared using the same quantity of spirulina (1g) as in the candies used as a supplement for E I. Spirulina powder was purchased from Antenna Nutritech Foundation, Madurai. Wheat, Maize, jowar, Roasted Bengal gram, ragi and jaggery were

included at 30g, based on the formulation of the ICDS health mix. These ingredients were purchased from the local grocery shops. It was ensured that all ingredients were of good quality. They were cleaned well, dry roasted separately, one by one and powdered in the mill, sieved and stored in air-tight containers (Figure 1).

C. Assessment of Acceptability

Thirty grams of this health mix powder was weighed, mixed with one gram of spirulina powder and was administered in the form of laddu and tested for acceptability. The acceptability of Spirulina Incorporated Food Supplement (SIFS) was tested on age and sex matched groups of children. Acceptability trials were performed in the morning, preferably between 10.30 and 11.00am, using child friendly scale. A child friendly five point scale, modified from the Age appropriate Hedonic Scales to measure the Food Preferences of young children, 1996; (Bredie, 2011) ranging from “super good” to “super bad” or a scale utilizing “smiley” faces was given to twenty children of 7-14 yrs age group for evaluating colour and appearance, texture flavor, taste and overall acceptability of the supplement.

D. Nutrient content of supplements

Nutrient content of the Spirulina Incorporated Food Supplement (SIFS) such as Energy, protein, iron, beta carotene, vitamin C and calcium were analysed in the present study.

E. Storage stability of Spirulina Incorporated Food Supplement

Storage stability of a product depends on the ability of the supplement to remain edible during the storage period without bacterial or fungal invasion and without change in colour, texture, flavour, odour, appearance and taste. Since the supplement has to be stored for future use it is always necessary to test the shelf life period/microbial activity of the spirulina Incorporated food supplement.

It has been suggested by Gahalawat and Sehgal, (1993) that supplementary foods should have a shelf life of six months. For testing the shelf life of the developed supplement it was packed in poly propylene covers and was stored in an air tight container at room temperature for a period of six months. After the storage period the total microbial counts i.e. both the number of bacterial and fungal colonies was determined by Serial Dilution Technique (AOAC, 1990). Plate count method is based

on the principle that when material containing bacteria or yeast and mould is cultured, every viable bacteria develops into a visible colony on a nutrient agar medium and every viable yeast and mould develops into a visible colony on a Malt Agar medium. The numbers of colonies are the same as the number of organisms contained in the sample.

The flow chart of the study is given in Figure 2.



Fig. 1: Ingredients and Formulation of SIFS.

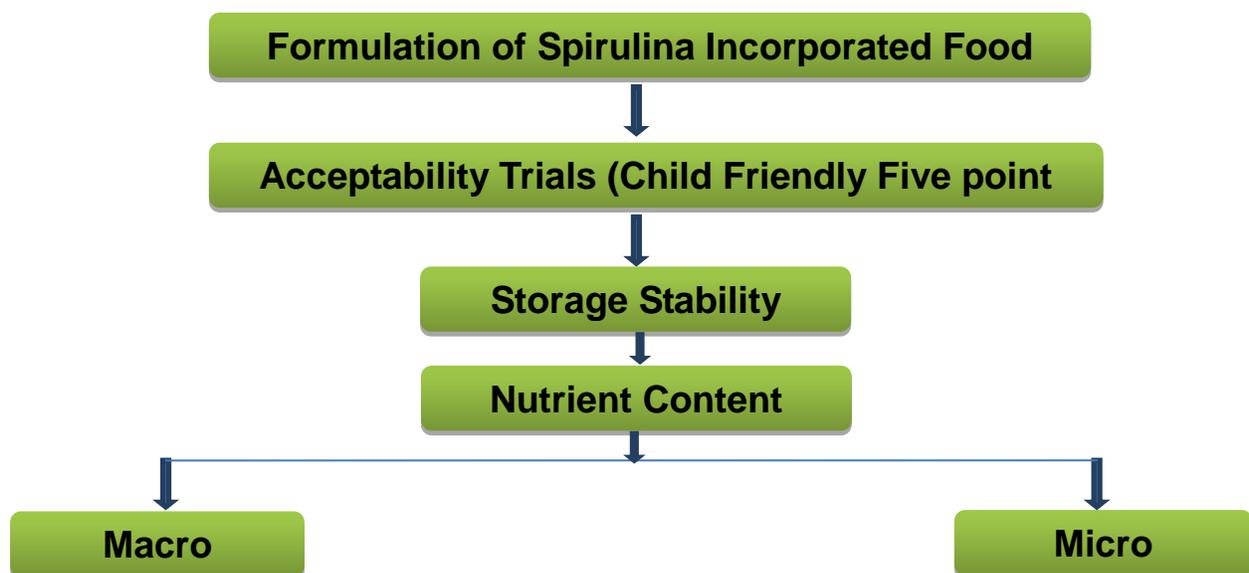


Fig. 2: Flow chart of the study.

Results

A. Composition of Spirulina Incorporated Food supplement.

Table 2 shows the composition of Spirulina supplement.

Table 2: Composition of Spirulina incorporated food supplement.

Ingredients	100 g	Per Serving (30g)
Wheat flour	18	5.4
Corn flour	16	4.8
Jowar flour	16	4.8
Bengal gram flour	12	3.6
Ragi flour	5	1.5
Jaggery powder	30	9
Spirulina	3.33	1

To prepare 100 grams of Spirulina supplement 18 g of wheat flour, 16 g of corn flour, 16 g of jowar flour, 12 g of Bengal gram flour, 5 g of ragi flour, 30 g of jaggery powder and 3.33 g of Spirulina powder were mixed. In one serving (30g based on acceptability trials) the composition of wheat flour, corn flour, jowar flour, Bengal gram flour, ragi flour, jaggery powder and Spirulina were 5.4g, 4.8 g, 4.8 g, 3.6g, 1.5g, 9g and 1 g respectively.

The composition of the supplement is based on ICDS Health mix. One serving of SIFS provided 6.2, 9, 0.8, 18.7, 25.6 per cent of suggested allowance of energy, protein, Vitamin A, vitamin C, iron and calcium.

Table 3: Acceptability trials.

Formulation	Amount of Spirulina (g)	Colour and appearance	Texture	Flavour	Taste	Overall acceptability
A	1	4.6±0.5	4.6±0.5	4.5±0.6	4.7±0.5	4.6±1.0
B	1.5	4±1.4	4.2±0.7	4±1.0	4.2±0.7	4.1±0.5
C	2	3.6±0.9	3.6±0.9	3.6±1.1	3.5±0.8	3.6±0.6

B. Acceptability Trials

The Spirulina supplement prepared from different levels of Spirulina was evaluated for their organoleptic properties by the children on the child friendly five point hedonic scale. The mean values of scores for colour and appearance, texture, flavor, taste and overall acceptability are presented in the Table 3.

Among the three different variations of 1, 1.5 and 2 g of Spirulina incorporated health mix; the one incorporated with 1 g of Spirulina obtained the maximum mean score of 4.6 in the acceptability trials. So, this formulation was selected for supplementation. The trials also revealed that on an average, the children could consume a maximum of 30g of the health mix at a time.

C. Nutritive value of Spirulina incorporated food supplement.

The nutrient content of Spirulina health mix is given in Table 4.

Table 4: Nutrient content of Spirulina incorporated food supplement.

Nutrients	100 g	Per Serving (30g)
Energy (kcal)	350	105
Protein (per cent)	8.81	2.643
Vitamin A (IU)	1.39	0.417
Vitamin C(mg)	25	7.5
Iron(mg)	13.66	4.098
Calcium(mg)	280	84

One hundred grams of Spirulina health mix provided 350 kcal of energy, 8.81 per cent of protein, 1.39 IU of Vitamin A, 25 mcg of vitamin C, 13.66 mg of iron, and 280 mg of calcium. Per serving (30g) showed that it was 105 kcal of energy, 2.643 per cent of protein, 0.417 IU of Vitamin A, 7.5mcg of vitamin C, 4.098 mg of iron and 84 mg of calcium respectively.

D. Storage stability of Spirulina Incorporated Food Supplement.

Microbial examination of foods may provide information concerning the quality of the raw foods, the sanitary conditions under which the food was processed and effectiveness of the method of preservation. The microbial examination results were tabulated in table 5.

Table 5: Storage stability of Spirulina incorporated food supplement.

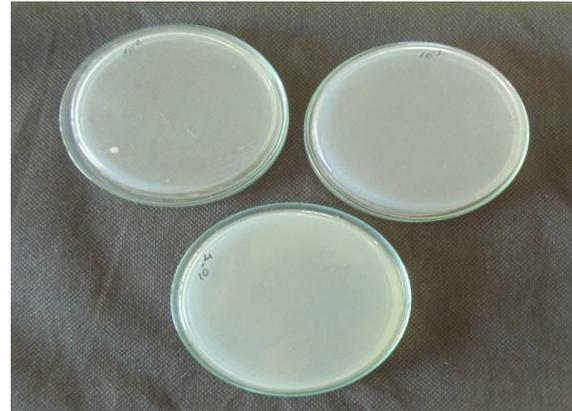
Presence of Micro organisms		
Total Bacterial Count		Fungi
Dilution	No. of colonies	
10 ⁻²	01	Nil
10 ⁻³	Nil	
10 ⁻⁴	Nil	

The mean TBC count in the sample was 01 in 10⁻² dilution and nil in the 10⁻³ and 10⁻⁴ dilution. The fungal (yeast and mold) count of sample showed was nil (Figure 3).

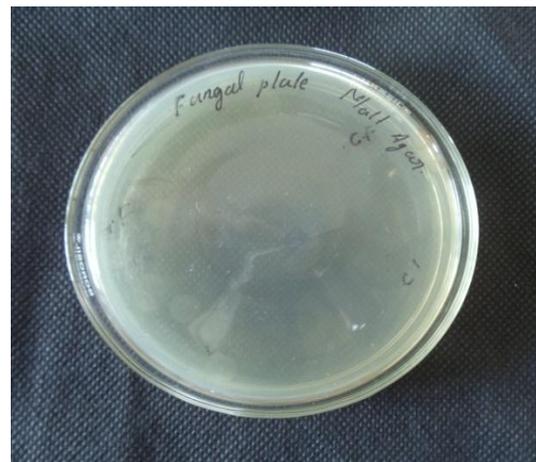
Microbial counts in flour can vary from one storage period to another depending on moisture content and storage conditions. Over a period of 6 months samples of the health mix did not show any insect infestation when examined microscopically. During the storage period of 6 months the results indicates that the microbiological quality of the product was satisfactory.

The antibacterial effect of ethanol extract of *Spirulina platensis* against different bacterial strains (*Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhi*, and *Enterococcus faecalis*) in addition to *Candida albicans*,

inhibition zones were observed with *Enterococcus faecalis* and *Candida albicans* was proved by El Bazet al (2013).



One bacterial colony detected after six months of storage



No fungal colony detected even after six months of storage



Fig. 3: Detection of microbial count.

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