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Formulation optimization of hard candy fortified with spirulina (*Arthrospira platensis*)

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Abstract
The aim of the study is to define the optimal formulation of hard candy using optimal mixture design as the base for the incorporation of spirulina (Arthrospira). Hard candy is produced using three different polyols: Sucrose and Liquorice substitutes on physicochemical (moisture, color) hardness and sensory features of hard candies. Spirulina is long history in human nutrition. Spirulina's mineral composition is appealing since it has an iron content that is 12 times higher than that of other foods. Spirulina is also rich in magnesium (40 mg), potassium (160 mg) and Spirulina is also rich in magnesium (40 mg), potassium (160 mg) and calcium (100 mg). Spirulina benefits bone and tooth health as well as blood renewal. In addition to absorbing sunlight, spirulina also creates nutrients in the cells and changes carbon dioxide into oxygen. Multicellular filamentous cyanobacteria called spirulina are extremely well-liked in the aquaculture, food, and health industries. It is very high content of macro nutrients and micronutrients, essential amino acids, protein, lipids, vitamins, minerals and antioxidants. The blue-green alga Spirulina platensis or Spirulina maxima belongs to the Oscillatoriaceae family. One of the outstanding subgroups of basic photosynthetic plants, this group of algae is thought to exist. It shows a connection between green plants and microorganisms. It differs from most algae in that it is easily digestible and has a soft cell wall consisting of complex carbohydrates and proteins.

Keywords: spirulina, *Arthrospira platensis*, blue green algae

Introduction

The blue-green algae Spirulina platensis or Spirulina maxima belongs to the Oscillatoriaceae family. It is a small plant that develops in planktonic form in fresh water. Its thallus form is filamentous, unbranched and non-differentiated, and looks like tiny green spiral coils. It has the potential to flourish in environments that are too harsh for other algae. Spirulina is a rich form of food with neutraceuticals that also includes phytonutrients, probiotics, and antioxidants. Current world production of spirulina for human consumption is more than 1 thousand metric tones. The United States of America, which is where it is grown, produces the most of it, followed by Thailand, Mexico, India, and China.

Proteins (50–70%), proteinous nitrogen (11.36%), total organic nitrogen (13.35%), nitrogen from nucleic acids (1.9%), and net protein utilisation (NPU) of up to 62% are all present in spirulina. It contains lipids (5-6 %) having mostly essential fatty acids (vitamin F), composed of oleic, linoleic, gamma linoleic, palmitic, palmitoleic, heptadecanoic acids. Glycolipids, including sulpholipids (2–5%), which have significant anti–HIV activity, make up about 40% of the fats. Spirulina provides 8-14 percent of recommended daily allowance (RDA) of fats. Glycogen and rhamnose, two types of carbohydrates found in spirulina, are quickly absorbed and require less insulin.

Water and sugar should be mixed in a deep bottom saucepan and allowed to boil, added slight salt, stirred the mixture with a wooden spoon. Spirulina powder should be added with the help of spatula with constant stirring. Flavouring agent, sour testing agent and sweetening agent should be added to the mixture. Content should be poured immediately into the candy mould and allowed to cooled by placing in the cooling racks. After cooling, store the product safely at an appropriate temperature.

Spirulina has undergone extensive testing to determine its biological function. Some of the findings are promising. It has immuno-stimulant activities. It increases the number and activity of T-cells, macrophages, and bone marrow stem cells. Spleen and thymus gland shows enhanced function. In-vitro studies on spirulina indicate that it enhances cell nucleus enzyme activity and DNA repair and hence it has possible role in cancer treatment. Spirulina water extract prevents HIV-1 multiplication in human peripheral blood mononuclear cells and T-cell lines produced from humans. HIV-1, Herpes simplex, Human Cytomegalovirus, Influenza virus, Mumps, and Measles Virus are all inhibited in-vitro by Calcium Spirulina. Spirulina's gamma linolenic acid lowers cholesterol levels.

Spirulina is simple and has fast growth rate hence cultivation of spirulina can be undertaken even in waste water, this helps to solve the problems of waste water pollution. Spirulina grows well in sewage water which is best material for bio-degradations. Spirulina can fix atmospheric nitrogen during its growth, and can be used as a source of nitrogenous fertilizer. Spirulina resembles Chlorella and Aphanizomenon flos-aquae, which are also blue-green algae.

Chlorella is nutritious but lacks the antiviral and immune stimulant activities.

Advantages

- Source of all essential amino acid.
- Reduce pain sensitivity.
- Reduce stress naturally.
- Increase energy and metabolism.
- Prevents heart disease and improve digestion.
- Great source of protein and reduce anxiety.
- Source of non-animal protein.
- Chemo-protective and anti-cancer.
- Neuroprotective.

Disadvantages

- Nausea, Insomnia, Headaches.
- Spirulina may be contaminated with harmful compounds, thin blood and worsen autoimmune conditions.

Characteristics

- Hard candy is the functional food with shiny appearance and hard texture.
- It was created due of the long shelf life, easy manufacture, and sensory enjoyment.
- Colour of spirulina hard candy is dark green.
- Smell of hard candy is like seaweed.
- Spirulina grows well in regions having temperature between 25-35 degree Celsius.

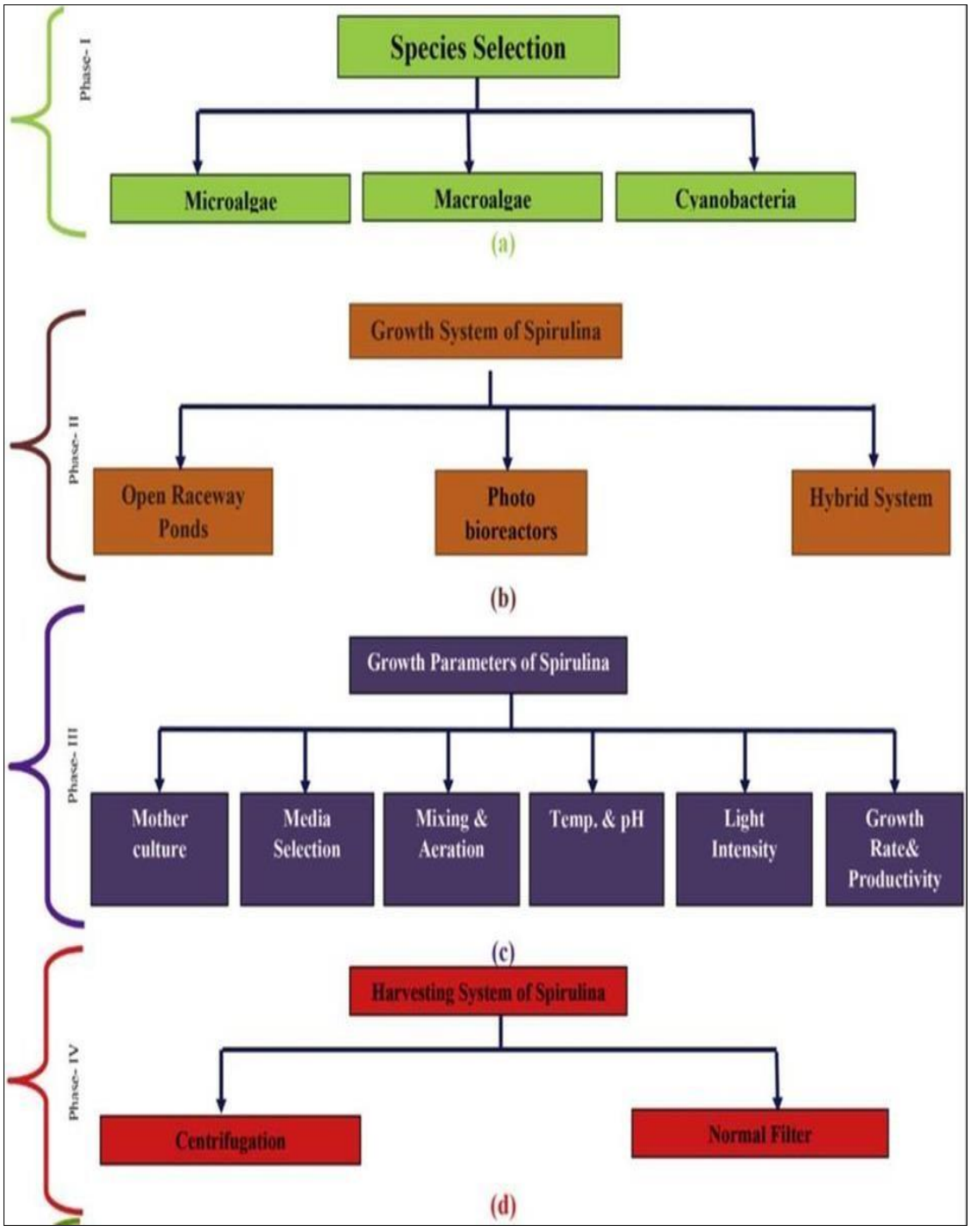

Fig 1

Fig 2

Materials and methods

Selection of ingredients

The following ingredients were used to make hard candies.

1. Natural flavourings: - Arthrospira platensis
2. Sweetening agents: - Sucrose
3. Sour testing: - Citric acid
4. Odour masking: - Orange essential oil and Rose water

Preparation

Common ingredients

- Citric acid – 0.5 gm
- Spirulina – 0.5 gm
- Orange oil – 0.5 ml

Table 1: Study design for preparation

Factor	Lower level (-1)	Higher level (+1)
Sucrose	4	6
Water	1	3

Table 2: Matrix for factorial design.

Formulation	Matrix	Factor A	Factor B
F1	0	(-1)	(-1)
F2	A	(+1)	(-1)
F3	B	(-1)	(+1)
F4	A, B	(+1)	(+1)

Table 3: Formula

Sr No	Name of Neutraceuticals	Quantity taken
1	Spirulina	0.5 gm
2	Sucrose	6 gm
3	Citric acid	0.5 gm
4	Orange oil	0.5 ml
5	Rose water	1 ml

Reference

1. A review of the red pigment used in 100 g of natural food colouring and as an antioxidant from purple carrots
2. Improving the formulation of hard candies without sucrose that are reinforced with cudrania tricuspidate extract

Reference for Procedure: Open Fire Cooking Method

- Sucrose and Glucose syrup dissolved in water (160 degree celcius)
- After 160 degree celcius, Candy paste was cooled at 112-115 degree celcius.
- Add extract, lemon, ginger extract.
- Moulds (20 degree celcius).

Formulation and evaluation of levocetrizine dihydrochloride lozenges.

Method

Heating and congealing method. ➢ Sucrose in heating pan + water (small)

- Add liquid glucose (110 degree Celsius)
- 145 – 185 degree Celsius = Drug, Polymer
- Moulds

Formulation of hard candy container pure honey as functional food.

Honey = 29 %

Bio-converted spirulina for neutraceutical chewing candy formulation rich in L-glutamic and gamma – aminobutyric acid.

Happy emotion – Agar and Ascorbic acid ,39 fermented spirulina, 0.1micro-liter of mentha spicata oil.

Formulation and evaluation of herbal candy based on Indian medicinal plants for cancer therapy via Immunomodulation.

3 gm = 2 gm

100 = X

X = 100 x 2 /3 = 66.66 %

Choose quantity according to moulds. 500 mg Spirulina in 1 candy irrespectively of weight of candy.

Preparation of neutraceutical

1. Water and sugar should be mixed in a deep bottom saucepan and allowed to boil, added slight salt, stirred the mixture with a wooden spoon.
2. Spirulina powder should be added with the help of spatula with constant stirring.
3. Flavoring agent, sour testing agent and sweetening agent should be added to the mixture.
4. Content should be poured immediately into the candy mold and allowed to cooled by placing in the cooling racks.
5. After cooling store properly at a suitable temperature.

Table 4: Evaluation test for spirulina

Test	Reported observation
A) Test for carbohydrate	
1**)** Molish's Test- To spirulina powder sample, added few drops of alpha-naphthol solution in alcohol, shaken and added concentrated sulphuric acid from side of the test tube.	The violet ring at the liquid fusion.
2) Fehling's Test- Spirulina powder was treated with 1 ml Fehling's A and 1 ml of Fehling's B solution mixed and boiled for 1 minute.	Yellow colored
Heated on boiling water bath for 5-10 minute.	Brick red ppt
B) Test for alkaloids	
1) Dragendroffs Test- Spirulina powder was treated with few drops of dragendroffs reagent.	Orange brown ppt
2) Mayer's Test- Spirulina powder was treated with few drops of Mayer's reagent.	White or pale yellow ppt
3) Hager's Test – Spirulina powder was treated with Hager's reagent.	Yellow ppt
4**)** Wagner's Test – Spirulina powder was treated with few drop of Wagner's reagent.	Reddish brown ppt
C) Test for polyphenol	
1) Ferric Chloride Test- 1 gm. of spirulina powder with 5% ferric chloride solution.	Deep blue color

Result

Test for carbohydrates, Alkaloids and Polyphenols was performed successfully.

The present study was formulated and the formulation is stable.

Table 5: Physicochemical characterization of hard candy

Batch code	Time of heating	Dissolution time
F1	3 min	2 min
F2	6 min	4 min

Dissolution studies

The amount of drug released from Spirulina was found to be 4 minutes.

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