Development and Proximate Evaluation of Spirulina Enriched Food for Elderly Population

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

ABSTRACT

Spirulina is a multicellular cyanobacterium that has achieved a considerable popularity in the health sectors due to high protein content, antioxidant and macro and micro nutrients. The consumption of food containing spirulina can forget the complications/diseases related with protein and iron deficiencies especially elderly population. This regard, a study to require to development of spirulina enriched food for elderly population. In the present study, spirulina enriched food bar (SEFB) was developed. SEFB accept overall acceptability by panelist such as color and appearance, aroma/odour, flavor and taste, body and texture. SEFB showed good amount of protein (11.86%), and iron (30.24%) as compared to control. Afterward, the developed SEFB exhibited good amount of antioxidants content (42.86%) and moisture content (12.86%), respectively. SEFB can be most attractive and nutritious food for elderly people due to rich source of protein and iron. This novel food can solve diseases/problems related with protein and iron deficiency.

Keywords: Spirulina; protein; iron; nutrition bar; elderly population.
1. INTRODUCTION

The nutritional status of elderly population changes in the aging process due to increased nutritional needs and reduced appetites [1].

The health hazards due to nutritional deficiency are very common in elderly people, and can cause numerous diseases such as malnutrition, frailty and morbidities (Sunita and Padhan 2011).

Aged is connected with inadequate consumption of diets including macro and micronutrients, vitamins, and other calories food.

Deficiency of protein, minerals, and vitamins are the common problems in elderly people [2]. Among them, protein is one of the major diets/food sources to require in the elderly people (Baum 2016). Weakness and laziness, or low physical activity is the common symptoms related with protein deficiency in elderly people.

In addition, malnutrition, gene problems and other medical issues are observed in elderly people due to protein deficiency (Mishra and Sharma 2014).

Iron is another major macronutrient of elderly population especially women [1]. Iron help increment of haemoglobin, and metabolic process such as oxygen transport, DNA synthesis, and electron transport (Baum 2016).

Aging time is stressful period, so in this required more protein in elderly bodies for maintain strength and muscles mass (Trasser 2018).

Ageing increases lean body mass and power in the elderly people and it has been related to the faster reintegration for hip breaks, and the lowered risk of becoming fragile (Helms 2014). These problems can be solved by food containing good amount of protein and iron. However, proteins and animals are the common sources of protein and iron [3].

Animal and plant based food containing proteins and iron help tissue repairing, development of new cells/tissue of the body, increase haemoglobin, and overall maintain all body building of human (Baum 2016). Intake of protein and iron enriched food can improved overall health and also improves immune system in the elderly people.

Spirulina (made of two types of cyanobacteria; 1) Arthospira platensis and 2) Arthospira maxima) is a richest source of protein for human and animals worldwide. In addition, it contains minerals (calcium, iron, magnesium mainly), vitamins especially B12, and A, and y-linolenic acid [4]. Spirulina or their based food can be easily digestible due to fragile, fibre and accessible to digestive enzymes.

The biomass of Spirulina contains c-phyocyanin and phenolic compounds and these are the part of antioxidant properties. Spirulina shows various medicinal properties including enhances immunity and diseases resistance against pathogens. It is useful against several diseases such as cancer, diabetes, antiviral disease, allergic rhinitis, asthma, hypertention, hyperlipidemia, heart stokes, anemia, eye disorders, and immunity booster [5].

Spirulina has nutraceutical properties and super food for women; it was record from the last few years. Currently, this product is consuming all over the world including India. This food can be used to improvement of human health especially elderly people such as inflammation, premenstrual disease and may be given to lactating mothers can prevent against neuroinflammation or decreased antioxidants, defence brain. Spirulina based food can fulfil the demand of overall nutrition in elderly people (Finamore 2017).

In the current study, spirulina based food developed by using natural ingredients and after the development of product and further it has been checked sensory and proximal properties.

2. MATERIALS AND METHODS

2.1 Collection of sample/ingredients

Beet root (Beta vulgaris), oats (Avenasativa,), jaggery (Saccharum officinarum), dates (Phoenix dactylifera), almond (Prunus dulcis), cashew nut (Anacardium occidentae) was purchased from the local market of the Lucknow, Uttar Pradesh, India. Spirulina (Arthospira platensis) powder was procured from the Patanjali, Pvt. Ltd., Kanpur, Uttar Pradesh India. All chemicals required for analysis of the sample were purchased from Merck, India.
2.2 Development of Bar Food

2.2.1 For the development of bar, above ingredients was washed with normal water (10 minute) removal of dust particles. Afterward, all ingredients was crushed by crusher (model:WCM, India) for 20 minutes (min). Development of bar, the following ratio was taken for one kg beet root. (250 gm), oats (250 gm), dates (250 gm), jiggery (200 gm), Spirulina (10 gm) as recommend dose (Santos et al 2016) and final mixed water to make 1 litre volume as per [6].

All ingredients except Spirulina was mixed properly and heated at medium heat (temperature: 80°C) for 30 min to form a homogenous liquid mixture. The mass was removed and manually mixed to ensure uniformity. After cooked materials, Spirulina Powder (10gm/1 kg bar) was further added [7] and mixed properly mixed and finally added ghee (10ml/1kg).

After the development of product, they were cut into small pieces or in rectangular shape (14cm x 3cm x 2cm) to obtain nutrition bars weighing 80gm each. For control sample, Spirulina powder was not added in the bar food. All process was done in the Laboratory of Bakery and Confectionary Lab, Department of Human Development and Family Studies from Babasaheb Bhimrao Ambedkar University, Lukhnow, Uttar Pradesh, India.

2.3 Sensory Evaluation

The developed food bar was analyzed for five mainly sensory characteristics (appearance, taste, texture, aroma, and overall acceptability). Sensory evaluation was performed by a panel of 10 trained panellists from the Laboratory of Bakery and Confectionary Lab, Department of Human Development and Family Studies from Babasaheb Bhimrao Ambedkar University, Lukhnow, Uttar Pradesh, India.

Sensory evaluation was performed at normal temperature. 10-point Hedonic rating scale (1 = dislike extremely, 2=, 4=, 6=, 8=, 10= like extremely) was used for evaluating of the food bar like the appearance, body and texture, aroma, taste and overall acceptability of the food bars.

2.4 Estimation of Protein of Bar Food

The developed food bar was examined for protein as per Lowry method (1951). Briefly, the sample was diluted with 1 mL distilled water and further added 0.9 mL of solution A [2 g L⁻¹ potassium sodium tartrate (KNaC₄H₄O₆·4H₂O) and 100 g L⁻¹ sodium carbonate (Na₂CO₃) in 0.5 M NaOH] mixed at 50 °C for 10 min.

Afterward, the sample was cooled at room temperature and added 1 mL of solution B [0.2 g L⁻¹ KNaC₄H₄O₆·4H₂O and 0.1 g L⁻¹ copper sulphate pentahydrate (CuSO₄·5H₂O) in 0.1 M NaOH] mixed properly for 10 min at normal room temperature).

In the last stage, before incubation 3 mL of solution C [Folin–Ciocalteu phenol reagent in H₂O (1:16 v/v)] was added and left for 10 min at 50 °C. For the standard curve preparation, bovine serum albumin (BSA) was used in the following ratio; 0.1, 0.5, 1, 2, 5, 10 g mL⁻¹] and absorbance of the sample was read at 650 nm by spectrophotometer.

2.5 Estimation of Iron in Food Bar

A volume of 1 mL of a neutral pH solution containing 0.1-100 μg of iron (II) in a 10-Ml of the morin reagent solution was made in 10 ml test tube.

Afterward, 1mL of 0.001 M sulfuric acid was added in the mixed sample and incubated for 1 min. 4 mL of ethanol was further added and maintained 10 mL volume with deionized water.

The absorbance of the sample and blank was read at 415 nm by spectrophotometer. For control, ferric chloride (Himedia, Mumbai) was used.

2.6 Estimation of Antioxidant Activity

For the estimation of antioxidant activity in food bar, 1,1-disphenyl- 2-picrylhydrazyl (DPPH) as radical scavenging agent was used (Braca et al. 2001). Briefly, 1 gm of food bar sample was dissolved in 100 ml ethanol and allowed to remain still overnight.
After overnight incubation, sample was centrifuged at 3000 rpm for 10 min and removed the pelleted or solid part of the sample. Further, 0.2 ml of sample was mixed with 1 ml of freshly prepared DPPH solution (80µg/ml ethanol) in a test tube covered with aluminium sheet. For control, 0.2 ml distilled water and 1 ml of DPPH solution was added into it.

All samples were allowed to remain in the dark for 30 min and further were the absorbance of the samples and blank sample were measured by UV-Vis spectrophotometer at 517 nm.

2.7 Moisture Content

For the estimation of moisture content, food bar sample (20 gm) was heated in the hot air oven with the lids of the moisture dishes off at the specified air temperature (100°C) and 72 h.

After heating, sample was cooled to room temperature. The initial weight and final weight was calculated using the given formula for estimation of moisture content-

\[ M = \frac{M_w}{M_a} + Md \times 100\% \]

Where M: moisture content, M_w: mass of water removed from the food bar after drying, Md: mass of food bar after drying, and M_w + Md: initial mass of food sample before drying.

2.8 Statistical Analysis

Each treatment had three replications and all the experiments were performed in triplicates. Data were analysed using means and using standard deviation as per Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

3.1 Development of Bar Food and Estimation of Protein Content

In the present study, there was two bar was developed namely: 1) common food bar and Spirulina enriched bar. After the development of bar food, the product was analysed for proximate.

Spirulina enriched bar was observed 11.86 g protein in 100 g sample, while in common food bar, there was found 4.66 g protein/100 g bar sample. Approximately 154.5% protein content was increased in Spirulina enriched bar sample as compared to control sample (common food bar) (Table 1).

Enhancement of protein content in Spirulina enriched bar was observed due to addition of Spirulina. It is a type of blue green algae and is a nature’s gift as super food to mankind due to rich source of protein, iron, vitamins, antioxidant, carbohydrate, micro- and macronutrient [8].

Studies have shown that Spirulina has been accepted in the world marketing including India due to easily digestibility and best food for human consumption [9].

3.2 Estimation of Moisture Content in Food Bar

The moisture content of the nutritional bars indicates the amount of liquid glucose present in the sample which works as a binding agent in the nutrition bar. It was found to be better moisture content (14.84%) in the common food bar in comparison to Spirulina food bar (Table 1).

Means addition of Spirulina did not affect the moisture content of the nutrition bar. In the presence of higher moisture content in the food, microbes such as bacteria, molds, and fungi can easily attack.

In this way, the self-life of the food has been decreased when the moisture content will be high [10]. However, moisture of the food did not change the taste, colour and other nutritional of the food bar [11].

3.3 Estimation of Antioxidant in Food Bar

In the present study, the total antioxidants content in Spirulina rich bar was 42.86 %, while in the common food bar it was recorded 8.84%, respectively. The antioxidant property of Spirulina rich bar was 384.84% higher as compared with common food bar.

Antioxidants are matters which neutralize the unstable free radicals present in the body produced by oxidative stress. The advantageous antioxidant assets of Spirulina are due to the presence of tocopherols, beta-carotene and phenolic acids.
In the presence of these assets, it may increase the production of antibody and cytokines and can prevent the inflammation and their associative damages in the cell/body [12].

High antioxidant foods increase the immune system, haemoglobin, and provide energy for elderly population [8].

3.4 Estimation of Iron in Food Bar

In the present study, iron content in Spirulina food bar was observed 30.24 mg, while in the common food bar, iron was 4.64 mg. Means Spirulina food bar was found 551.72% higher iron content as comparison with common food bar.

Iron is one of the important essential inorganic micronutrients that the body needs to carry out various functions and processes for healthy living system [13]. The property of rich source of iron i.e., Spirulina that makes economically important food [14].

Several diseases related with iron deficiency can be treating via Spirulina enrich food.

The cocktail properties (protein, iron, and antioxidant) of Spirulina enriched food helped in the prevention of several diseases related with nutrient deficiency and will help in the development of economy due to healthy life.

3.5 Sensory Evaluation

In this study, the colour of the Spirulina enriched bars was observed significantly different from control (common food bar) sample (Table 2). Sensory analysis was performed primarily to identify the nutrition bar with the highest acceptability and to contribute to one understands of elderly population product selection.

<table>
<thead>
<tr>
<th>Food bar</th>
<th>Protein</th>
<th>Moisture content</th>
<th>Iron content</th>
<th>Antioxidant activity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common food bar (CFB)</td>
<td>4.66±0.12</td>
<td>14.84±0.48</td>
<td>4.64±0.24</td>
<td>8.84±1.12</td>
</tr>
<tr>
<td>Spirulina enriched bar (SEB)</td>
<td>11.86±0.96</td>
<td>12.86±1.12</td>
<td>30.24±0.96</td>
<td>42.86±1.96</td>
</tr>
</tbody>
</table>

*Data are mean of three replicates ± standard error of means.*

![Graph](image_url)

Fig. 1. Comparative evaluation of common and spirulina based food bar.45
Table 2. Sensory evaluation parameters (10 Point Hedonic Scale) of developed food bar

<table>
<thead>
<tr>
<th>Developed Food Bar</th>
<th>Colour and appearance</th>
<th>Aroma/odour</th>
<th>Flavour and taste</th>
<th>Body and texture</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFB</td>
<td>8.26±0.16</td>
<td>9.12±0.36</td>
<td>8.96±0.48</td>
<td>8.32±0.12</td>
<td>8.6±0.28</td>
</tr>
<tr>
<td>SEB</td>
<td>8.94±0.12</td>
<td>8.64±0.24</td>
<td>8.24±0.24</td>
<td>8.46±0.24</td>
<td>7.16±0.12</td>
</tr>
</tbody>
</table>

Data are mean of three replicates ± standard error of means. Where, CFB: Common food bar, SEB: Spirulina enriched bar

![Graph showing sensory evaluation parameters](image)

In this study, higher content of protein in Spirulina enriched bar (11.86 g/100 g bar) was noticed and showed more the intense greenness of the bar, and the better the appeal as compared to control sample (Table 2).

It was observed that the panellists could not find significant difference between the common and Spirulina enriched bar in the terms of odour and aroma. The common food bar (sample) was scored higher acceptability in terms of odour/aroma (9.12±0.36) than Spirulina enriched bar (Table 2).

Taste is one of the main important factors of food for acceptability of elderly population. In addition, taste is a more powerful element than health-promoting aspects for product selection.

The better taste indicates that they likely it is for the product to gain the acceptability of elderly population. In the present study, sensory scores of taste and flavour of Spirulina food bar was 8.24±0.24 which was similar as control’s score 8.96±0.48 (Table 2).

This score was reduced might be due to some bitter taste of Spirulina food bar or it might be addition of jaggery as natural sweeter used in the developing of food bar. The acceptance of novel product like Spirulina enriched bar also depends on the properties of taste or bitterness.

Spirulina enriched bar was most acceptable in terms of body and texture as compared with control sample by the panellists. It was scored 8.46±0.24 (Spirulina based bar) which was closest to the control’s score (8.32±0.12) (Table 2).

Body and texture of the food bar were mainly affected by jaggery used for making the bar. In the presence of jaggery, texture of the bars in the reference of hardness was observed in the common and Spirulina food enriched bar [15].

The chewiness properties of the food bar also depend on the body and texture and jaggery added product has more hardness as compared to sugar added product (Anganadham et al. 2016).
Spirulina enriched bar had scores ‘like moderately’. It did not fall into the category of dislike means this product can be accept for elderly population. The control sample was “like very much” means it is indicated that the product is had the highest overall acceptability at 8.86±0.28 (Table 2).

Some researchers have been observed that food enriched with Spirulina has been received positively and with reasonably high acceptability [6]. However, addition of Spirulina in different food such as powdered shake and pasta did not affect the acceptance of the product by the target consumer [7].

4. CONCLUSION

The developed Spiruluna enriched bar was found most attractive and nutritious food. The sensorial evaluation of bar for the elderly population showed better and addition of algal biomass in food did not affect the acceptance of the product by the target consumer.

The Spirulina-enriched bar can be considered a source of protein, iron, and antioxidant which contributes to the energy, nutrient requirements and fighting against diseases due to oxidative stress of elderly people. This food can be Best food for future to malnutrition people especially elderly age.

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DISCLAIMER

The company name used for this research is commonly and predominantly selected in our area of research and country. There is absolutely no conflict of interest between the authors and company because we do not intend to use this company as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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