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Development and quality evaluation of cookies fortified with spirulina

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Abstract
The present study was undertaken to assess the nutritional composition of Spirulina powder, development of Spirulina based value added products and their nutritional composition and shelf life. Value added biscuits were prepared by using Spirulina, Flour mixture, Amul butter, Sugar, Baking powder and 5, 10 and 15 percent level of Spirulina powder. Mean score for overall acceptability of value for 10% spirulina added cookies was 6.2 against the control sample on nine point hedonic ranking scale. The developed value added cookies contained 4.29 percent moisture, 12.43 g protein, 27.26 g fat, 1.99 g ash on dry weight basis. Spirulina supplemented biscuits contain β-carotene, vitamin C, iron and potassium contents. Fat acidity revealed satisfactory quality of the value added biscuit at the end of three months of storage period. Thus, Spirulina based value added products may be beneficial for vulnerable populations due its high nutritive value. These would also be advantageous for those who are suffering from degenerative diseases because of its therapeutic properties.

Keywords: Spirulina, cookies, fortifications, refined wheat flour

Introduction
The term cookie is derived from the Dutch words "Koekje" or "koekie" and refers to "small cakes." Cookies contain many of the same constituents as cakes, with the exception of a higher proportion of sugar and fat to flour and a lower proportion of liquid. Cookies, which contain a high amount of sugar and fat and a low amount of water, are a globally popular baked good. Cookies with a lower moisture content are resistant to microbial spoilage and have an extended shelf life. Unlike bread, pastries and biscuits require only a minimal amount of gluten development. The resulting dough is cohesive but not overly elastic, and it can be readily rolled out and cut. (De la Barca *et al*. 2010; Torbica *et al*. 2012; Rai *et al*. 2014; Duta and Culetu 2015; Inglett *et al*. 2015; Mancebo *et al*. 2015) [2, 11, 12, 13, 14, 15] have published scientific articles on gluten-free cookie dough/batters and the resulting baked products.

Spirulina, a non-toxic, safe food composed of microscopic, filamentous cyanobacteria currently known as Arthrospira, has a lengthy history of consumption. The chemical composition of Spirulina, which consists of proteins (The highest concentration of any natural food, 55-70%), carbohydrates, essential amino acids, minerals (Especially iron), essential fatty acids, vitamins, and pigments, has recently sparked interest in its potential health effects and nutritional benefits. Children who were chronically malnourished during their formative years would have been shorter as adults. Spirulina is one of the most nutritious nutrients. It contains between 65 and 71 percent complete protein in its natural state. This is higher than virtually all other unprocessed foods. It is essential to consume a sufficient amount of complete proteins. Spirulina is a nutrient-dense super-food that promotes exceptional health. In addition to their typical nutritional value, super-foods are distinguished by their additional health benefits and disease-preventing properties. It is the most nutrient-dense natural dietary source in its entirety. Spirulina, a type of blue-green algae, can be consumed as a dietary supplement. Due to its high nutritional value and numerous health benefits, spirulina is considered a super-food. Spirulina is an excellent nutritional supplement for vegetarians and vegans due to its high protein and vitamin content. This article discusses eleven potential health benefits of consuming spirulina.

Spirulina is utilized in food technology processes due to its unique biochemical composition and high concentrations of proteins, essential amino acids, vitamins (Especially B12), mineral salts, and pigments (carotenoids, phycocyanins, and xanthophylls). (Colla *et al*., 2007; Mazokopakis *et al*., 2008; Oliveira *et al*., 2010) [1, 6, 16] Other biologically active substances include chlorophylls and polyunsaturated fatty acids, especially Omega-3 fatty acids. Iron, manganese, zinc, and copper are the micronutrients that stand out. (Moreira *et al*., 2013) [8]. Carrots contain ten times as much beta-carotene as any other nutrient. (Mohammed and Mohd, 2011) [7]. In the past 60 years, there has been a significant increase in interest in the production of algal biomass due to the global food shortage. Consider the following two factors when determining the role of spirulina biomass in the human diet: the rate of microorganism reproduction and the extent to which their growth conditions can be manipulated. (Sassano *et al*., 2010; Kim *et al*., 2013) [9, 17].

Materials and Methods

Raw materials

Spirulina powder used in this study was purchased from amazon shopping. & other ingredients like wheat flour, sugar, baking soda, butter, milk powder was purchased from local market Satna. The experiment was conducted in the research laboratory of the Department of Food Technology, Aks University, Satna (Madhya Pradesh)

Experimental Setup

Table 1: Experimental Setup

Variables	Levels	Description
Product	1	Spirulina Fortified cookies
Constituents	4	Spirulina, Flour mixture, Amul butter, Sugar Baking powder
Treatment	4	T_0 – control T_1,-5% of spirulina T_2, -10% of Spirulina T_3 – 15% of Spirulina
Replicates	3	Each of four treatments
Total no. of samples	9	3 treatment, 3 replicates
Physico-chemical properties	8	Protein analysis, Dry Ash content, Moisture content and sensory analysis
Storage condition	-	Room temperature

Preparation of samples

Sample preparation

Four samples are taken for experimental in this study, for fortification of cookies.

Table 2: Sample preparation ratio

S. No	Sample Ingredients	Ratio Ingredients
1.	Flour with spirulina powder	95%+5%
2.	Flour with spirulina powder	90%+10%
3.	Flour with spirulina powder	85%+15%
4.	Flour without spirulina powder	100%

Preparation of control Sample

Take 250 g wheat flour + 25 g butter and mix it well
↓
Add 100g ground sugar
↓
Prepare the soft dough and add 1g of baking powder.
↓
Add 10 g cardemom and cinnamon powder into it and kneaded again.
↓
Cut the dough into round shape and bake them 180° c properly.

Fig 1: Control Cookie preparation method

Preparation of Test Samples

Cookies (as control) were prepared using the following formulation: flour, sugar, shortening oil, and baking powder. The cookies were baked in an oven at 180 °C for 15 min. The following ingredients were used in cookie production:

- Flour mixture
- Amul butter
- Sugar
- Baking powder 0.1%
- Spirulina – spirulina 5% water

The cookies were prepared in four treatments: T_1- 0%, T_2- 5%, T_3- 10%, and T_4- 15% spirulina as a flour replacement added to the total dough weight. Rich in bioactive compounds, Spirulina powder should not exceed 2.5 grams per day. The sugar was then added, and the dough was stirred for an additional five minutes. The remaining dry components were combined and kneaded until the dough reached a uniform consistency. The dough was then rolled out to a 6-millimeter-thick sheet and cut into 55-millimeter-diameter circles. The biscuits were baked for 10 minutes at 170 °C in a convection oven. The cookies were sealed in polyethylene containers and kept at room temperature for nine weeks without exposure to light.

Take 250 g wheat flour add Spirulina powder acc. to ratio
↓
Add 100 g grinded sugar + 25 g butter into it
↓
Prepare the soft dough and add 1 tsp. of baking powder.
↓
Add 10 g elaichi and cinnamon powder into it and kneaded again
↓
Cut the dough into round shape
↓
Bake the cookies at 180 F until turns it turns golden brown

Fig 2: Showing development of Spirulina fortified cookies sample

Fig 3: Spirulina Powder

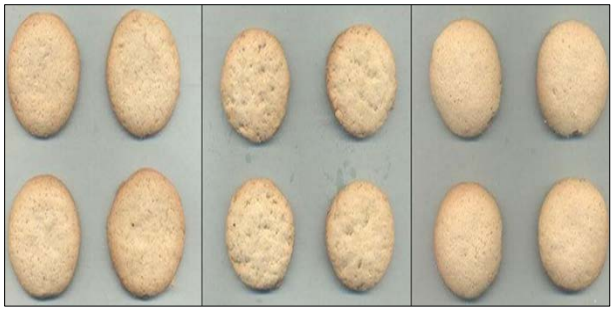

Fig 4: Prepared Cookies Samples

Results and Discussion

Protein analysis

Johann Kjeldahl, a Danish brewer, created the Kjeldahl method in 1883. The protocol is based on the premise that strong acid aids in the metabolism of food, releasing nitrogen that can be measured using an appropriate titration technique. Upon observing the food's nitrogen concentration, the protein content is then calculated. This method is optimal for insoluble proteins, proteins in foods, and proteins immobilized covalently on chromatographic supports.

Fig 5: Protein analysis by Kjeldahl method

Table 3: Protein content of the samples

S. No	Sample Ingredients	Ratio Ingredients	Protein%
1.	Flour with spirulina powder	95%+5%	10.23%
2.	Flour with spirulina powder	90%+10%	12.43
3.	Flour with spirulina powder	85%+15%	15.41
4.	Flour without spirulina powder	100%	4.75%

Calculation for Dry Ash content

Ash Content: The ash content measures the total amount of minerals present in a food, whereas the mineral content measures the amount of specific inorganic components, such as Ca, Na, K, and Cl, present in a food. It is essential to determine the ash and mineral content of foods for a variety of reasons:

Nutritional labeling: Frequently, the concentration and type of minerals present must be specified on the label of a food product.

Quality: The concentration and type of minerals in many foods determine their flavor, appearance, texture, and stability, among other qualities.

Microbiological stability: Sometimes, high mineral content is used to inhibit the proliferation of certain microorganisms.

Nutrition: Some minerals, such as calcium, phosphorus, potassium, and sodium, are necessary for a healthful diet, whereas others can be toxic. (e.g., lead, mercury, cadmium and aluminum).

Processing: During processing, it is often crucial to know the mineral content of foods because this impacts their physicochemical properties.

$$\% \text{ Ash Content} = \frac{\text{weight of ash}}{\text{Weight of sample}} \text{ x } 100$$

Table 4: Dry Ash content of Spirulina cookies

S. No	Sample Ingredients	Ratio Ingredients	Ash%
1.	Flour with spirulina powder	95%+5%	4.52%
2.	Flour with spirulina powder	90%+10%	1.99%
3.	Flour with spirulina powder	85%+15%	2.12%
4.	Flour without spirulina powder	100%	0.47%

Calculation of moisture content

1 hour was spent drying 5 grams of crushed biscuits in a laboratory convection dryer at 130 °C. The samples were weighed prior to and following drying. The moisture content of cookies was derived from the difference and expressed as a percentage. The test was performed in triplicate. The moisture content of the control cookie was 4.30 percent and progressively decreased after the addition of spirulina powder. T_1 cookies had the highest moisture content, while T_3 biscuits had the lowest moisture content. The pastries T_1, T_2, and T_3 have respective moisture levels of 4.33, 4.29, and 4.17 percent.

S. No	Sample ingredients	Sample ratio	Moisture%
1	Flour with spirulina powder	95%+5%	4.33
2	Flour with spirulina powder	90%+10%	4.29
3	Flour with spirulina powder	85%+15%	4.17
4	Flour with spirulina powder	100	4.30

Calculation of Fat content

Fat content of control biscuits was 27.23 per cent. The fat level of the biscuits containing spirulina was found to be comparable to the control sample. T_3 had the highest fat content, whereas T_2 had the lowest. T_1, T_2, and T_3 have respective fat contents of 28.39, 27.26, and 29.51 percent.

S. No	Sample ingredients	Sample ratio	Fat%
1	Flour with spirulina powder	95%+5%	28.39
2	Flour with spirulina powder	90%+10%	27.26
3	Flour with spirulina powder	85%+15%	29.51
4	Flour with spirulina powder	100	27.23

Sensory evaluation of cookies fortified with different level of Spirulina

According to the preceding results, Spirulina powder has been added to certain foods to enhance their bio functional and nutritional value. Different concentrations of Spirulina were used to make pastries (5%, 10%, and 15%). The sensory evaluation of a potential industrial or commercial approach is a crucial step. The most important sensory attributes (Color, smell/odor, flavor, texture, and

recognition) of cookies made with varying concentrations of spirulina were evaluated by untrained panels. Overall, panels did not prefer control cookies over treated samples; however, there is no positive correlation (T_1 5%) between cookies with Spirulina added and the control cookie. The cookies made with the maximum amount (T_3 15%) were evaluated identically in terms of hue, aroma, and consistency. In the structure concept, biscuit strength increased considerably and linearly as spirulina content increased. These results indicate that spirulina has a protective influence on cake structure. This may be due to the high protein and carbohydrate content of Spirulina. Similar findings have been reported in the scientific literature, where microalgae proteins and carbohydrate molecules play a significant role in the water absorption process and contribute to the strength of cookies (32, 33). None of the biscuits containing varying quantities of spirulina displayed color or flavor differences. The panel did not detect a fishy flavor in cookies with a higher spirulina content, resulting in a positive rating. These results demonstrated that cookies, a traditional and nutritious food, can be both healthful and aesthetically pleasing when prepared with spirulina. (Rich in proteins, antioxidant compounds and phycocyanin). In addition, the enhanced textural properties, high color and texture stability, and high nutritional value of the resulting cookies indicate a new market niche. Based on a nine-point hedonic test* (9; like very much and 1; dislike very much). A total of was deemed acceptable in the end.

Based on a nine-point hedonic test* (9; like extremely and 1; dislike extremely). Finally, the total acceptability was computed using the given equation. Total acceptability = (flavor and odor) x 6 + (color) x 2 + (texture uniformity) x 2 + (mouth texture) x 3.5 + (non-mouth texture) x 1. The assessors utilized the point's hedonic scale: 9 (excellent) to 1 (terrible). (Very poor).

	Sample Code			
	Control	**T_1 (5%)**	**T_2 (10%)**	**T_3 (15%)**
Appearance	7	6	7	8
Color	8	5	6	7
Texture	7	6	5	7
Flavor	7	4	6	8
Mouth Feel	7	5	7	8
Overall Acceptability	7.2	5.2	6.2	8.2

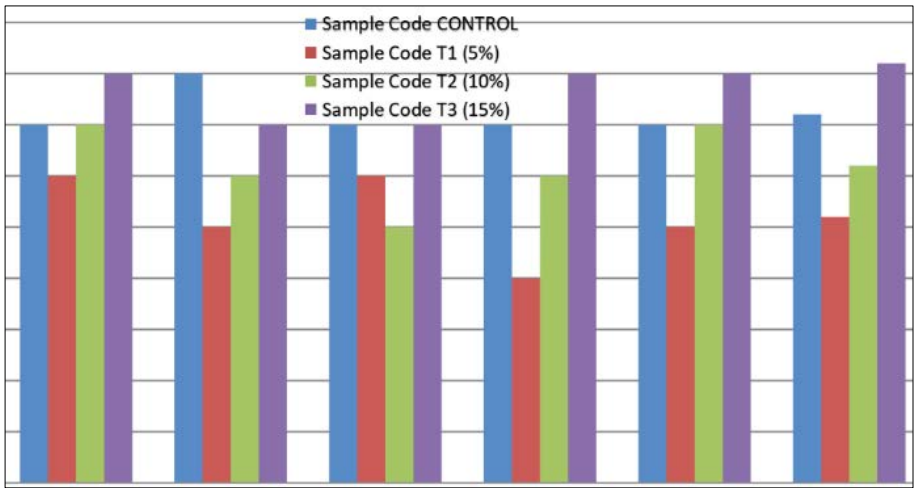

Fig 6: Graph showing evaluation of Spirulina fortified cookies through composite scoring

Conclusion

On the basis of organoleptic parameters and proximate analysis, spirulina-enriched biscuits containing 10% spirulina were deemed acceptable in the present study. The results indicate that the developed cookies were significantly more nutritious than the samples used as controls. Thus, this valuable product has a high extrusion potential and increased acceptability on organoleptic parameters; consequently, the improved quality of spirulina-enhanced cookies confers substantial benefits to the community.

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