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RESEARCH ARTICLE

NUTRITIONAL COMPOSITION OF *SPIRULINA PLATENSIS* POWDER AND ITS ACCEPTABILITY IN FOOD PRODUCTS.

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Abstract

The aim of the present study was to evaluate the physico-chemical properties of *Spirulina platensis* powder and its incorporation in wheat flour for development of value added products and their consumer acceptability. *Spirulina* was found to be very rich source of protein i.e 71.90% with high *in vitro* digestibility (92.59%) and containing all essential amino acids specially total lysine (5.72 g/16gN) as this amino acid is lacking in wheat flour. It also contained good amount of crude fibre (9.70%), ash (3.50%) and total dietary fibre (14.98%), whereas, carbohydrate (13.63%) and fat (1.27%) were found to be in very low amount which contributed low energy (353.55 Kcal/100g) content. With regard to total minerals such as calcium, phosphorus, magnesium, iron and zinc were 620.80, 790.42, 285.90, 49.50 and 3.95 mg/100g, respectively were reported in *Spirulina platensis* powder. α -linolenic and γ -linolenic acid which accounted for 14.80 and 30.00% of total fatty acids, respectively were reported in *Spirulina* powder. Hence, keeping in view its excellent nutritional profile, *Spirulina* powder was incorporated at different levels i.e 2, 4, 6 and 8% in wheat flour for development of biscuits, buns, noodles and macroni and evaluated for their consumer acceptability. It was observed that all the products up to 6% level of incorporation were found acceptable by majority of respondents.

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Introduction:-

In India the problems of protein energy malnutrition, anemia, and vitamin A deficiency are more prevalent among children and adolescents (Udayasree *et al.*, 2013). To overcome these problems, the need of nutrient rich foods came into existence. One of such foods which constitute the most remarkable concentration of nutrients is "*Spirulina*". *Spirulina*, which is commercially known as *Arthrospira*, is one of blue-green algae due to presence of chlorophyll, carotenoid and phycocyanin pigments. It is a simple one celled form of algae that thrives in warm, alkaline fresh-water bodies (Devinamerin *et al.*, 2007; Navacchi *et al.*, 2012; Vijayarani *et al.*, 2012). *Spirulina* is the common name for human and animal food supplements produced primarily from two species of Cyanobacteria i.e. *Arthrospira platensis* and *Arthrospira maxima*. *Spirulina platensis* is commonly produced and cultivated in Asian countries particularly in India, Japan and China whereas *Spirulina maxima* production is mainly confined to Central America (Moorhead *et al.*, 2011).

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Countless beneficial effects of *Spirulina* attributed due to its high nutritional value and bioactive compounds, vitamins and polyunsaturated fatty acids including the gamma-linolenic and linoleic acids (Devinamerin *et al.*, 2007). It has many therapeutic properties such as hypocholesterolemic, immunological, antiviral and antidiabetic effects (McCarty, 2007). It is an excellent source of good quality protein (60-70%) with all essential amino acids in perfect balance and also provide high concentration of minerals and B-complex vitamins specially vitamin B₁₂ which is usually found in animal tissues (Devinamerin *et al.*, 2007; Vijayarani *et al.*, 2012). *Spirulina* supplements are available in powder, flakes, capsule and tablet forms. In spite of being highly nutrient-rich, its use is still restricted in food products. Therefore, utilization of nutrient-rich *Spirulina* powder in development of food products may be encouraged to improve the nutritional status of the general population. Keeping these facts in view, an attempt has been made to analyze nutrient composition of *Spirulina* powder and to explore the use of nutrient dense *Spirulina* powder in development of bakery and pasta products and their consumer acceptability.

Materials And Methods:-

Procurement of raw Materials:-

Spirulina platensis powder was purchased from Herbo Nutra, Wholesale Trader from New Delhi. Wheat variety (WH-1105) was procured from Wheat and Barley Section of Department of Genetics and Plant Breeding, CCSHAU, Hisar. Other ingredients were purchased from local market.

Nutritional Composition:-

Proximate composition, carbohydrate and energy:-

Moisture, protein, fat, crude fiber, ash were estimated by standard method of analysis (AOAC, 2000). Total carbohydrates was estimated by calculation method as given:

Total carbohydrate (%) = 100 – [crude protein + crude fat + crude fibre + ash]

Total energy was calculated theoretically by using the following conversion factors 4.0, 4.0 and 9.0 kcal/100g for protein, carbohydrates and fat, respectively according to the method described by Paul and Southgate (1979).

In vitro protein digestibility and total lysine:-

In vitro protein digestibility was carried out by using the modified method of Mertz *et al.* (1983). Total lysine was estimated as per the method described by Mertz *et al.* (1975).

Dietary fibre, total minerals and fatty acid profile:-

Total, soluble and insoluble dietary fibre constituents were determined by the enzymatic method given by Furda (1981). The sum of insoluble dietary fibre and soluble dietary fibre contents were calculated as total dietary fibre. The samples were wet acid-digested using a nitric acid and perchloric acid mixture (HNO₃ : HClO₄ :: 5:1, w/v). The total amount of calcium, magnesium, iron and zinc in acid digested samples were determined by Atomic Absorption Spectrophotometer according to the method of Lindsey and Norwell (1969). Whereas, phosphorus was determined colorimetrically by using the method of Chen *et al.* (1956). Fatty acid profile of *Spirulina platensis* powder was determined by the method of gas liquid chromatography (Vasudev *et al.*, 2008).

Development of products:-

Various products like biscuits, buns, noodles and macroni were developed by using 2, 4, 6 and 8% level of *Spirulina* powder in wheat flour along with their respective control products.

Selection of panel Members:-

For carrying out organoleptic acceptability of the developed products, a panel of 20 judges were selected from college of Home Science CCS Haryana Agriculture University, Hisar. The selected subjects were in the age group of 20-40 years.

Organoleptic acceptability of developed products:-

Various products like biscuits, buns, noodles and macroni were developed using standard recipes by incorporation of *Spirulina platensis* powder at 2, 4, 6 and 8 % levels in wheat flour along with their respective control products. All the products like biscuits, buns, noodles and macroni were evaluated by the 20 panelists for their acceptability using Hedonic Scoring Technique. The method is actually a measure of acceptability gauged from the reaction in terms of their degree of like or dislikes for a given product. The reactions are indicated by descriptions in words on a scale for e.g ranging from 'liked extremely' (9) to 'disliked extremely' (1).

Table 1:- Proximate composition, *in vitro* protein digestibility and total lysine of *Spirulina platensis* powder (on dry matter basis)

Parameters	<i>Spirulina platensis</i> powder
Moisture (%)	5.27±0.12
Protein (%)	71.90±3.35
Fat (%)	1.27±0.08
Crude fibre (%)	9.70±1.20
Ash (%)	3.50±0.36
Carbohydrates (%)	13.63±1.15
Energy (Kcal/100g)	353.55±3.42
<i>In vitro</i> protein digestibility (%)	92.59±0.85
Total lysine (g/16gN)	5.72±0.49

Table 2:- Dietary fibre (%) and total mineral (mg/100g) contents of *Spirulina platensis* powder (on dry matter basis)

Parameters	<i>Spirulina platensis</i> powder
Total dietary fibre	14.98±1.11
Soluble dietary fibre	5.52±0.91
Insoluble dietary fibre	9.46±1.26
Calcium	620.80±11.22
Phosphorus	790.42±9.00
Magnesium	285.90±8.28
Iron	49.50±6.61
Zinc	3.95±0.29

Table 3:- Fatty acid profile of *Spirulina platensis* powder

Fatty acid profile (% of total fatty acids)	
Palmitic	30.50±3.52
Stearic	1.90±0.09
Oleic	10.60±1.12
Linoleic (omega-6)	2.50±0.08
Alpha-linolenic (omega-3)	14.80±2.03
Gamma-linolenic (omega-6)	30.00±2.58

Table 4:- Percentage of acceptability scores of biscuits and buns by the respondents (n=20)

Products	Liked extremely (9)	Liked Very much (8)	Liked Moderately (7)	Liked Slightly (6)	Neither liked nor disliked (5)	Disliked slightly (4)	Disliked moderately (3)	Disliked very much (2)	Disliked extremely (1)
Biscuits									
Control	2 (10)	2 (10)	14 (70)	2 (10)	-	-	-	-	-
Supplemented									
2%	2 (10)	3 (15)	14 (70)	1 (5)	-	-	-	-	-
4%	-	2 (10)	12 (60)	6 (30)	-	-	-	-	-
6%	-	-	14 (70)	6 (30)	-	-	-	-	-
8%	-	-	2 (10)	12 (60)	6 (30)	-	-	-	-
Buns									
Control	2 (10)	6 (30)	10 (50)	2 (10)	-	-	-	-	-
supplemented									
2%	3 (15)	6 (30)	10 (50)	1 (5)	-	-	-	-	-
4%	-	6 (30)	10 (50)	2 (10)	2 (10)	-	-	-	-
6%	-	-	15 (75)	4 (20)	1 (5)	-	-	-	-
8%	-	-	2 (10)	12 (60)	6 (30)	-	-	-	-

Figures outside parentheses indicate number of respondents

Values in parentheses are percentage

Table 5:- Percentage of acceptability scores of noodles and macroni by the respondents (n=20)

Products	Liked extremely (9)	Liked Very much (8)	Liked Moderately (7)	Liked Slightly (6)	Neither liked nor disliked (5)	Dislike d slightly (4)	Disliked moderately (3)	Dislike d very much (2)	Disliked extremely (1)
Noodles									
Control	2 (10)	2 (10)	14 (70)	-	-	2 (10)	-	-	-
Supplemented									
2%	2 (10)	4 (10)	10 (70)	2 (5)	-	2 (5)	-	-	-
4%	-	2 (10)	10 (50)	8 (40)	-	-	-	-	-
6%	-	-	16 (80)	4 (20)	-	-	-	-	-
8%	-	-	5 (25)	10 (50)	5 (25)	-	-	-	-
Macroni									
Control	2 (10)	2 (10)	14 (70)	-	-	2 (10)	-	-	-
Supplemented									
2%	2 (10)	4 (30)	10 (50)	2 (10)	-	2 (10)	-	-	-
4%	-	1 (5)	14 (70)	5 (25)	-	-	-	-	-
6%	-	-	16 (80)	2 (10)	2 (10)	-	-	-	-
8%	-	-	2 (20)	10 (50)	8 (30)	-	-	-	-

Figures outside parentheses indicate number of respondents

Values in parentheses are percentage

Results and Discussion:-

Nutritional composition:-

The results of proximate composition, *in vitro* digestibility and total lysine are presented in Table 1. *Spirulina* powder exhibited 5.27% moisture, it is very good source of highly bioavailable protein i.e 71.90%, fat 1.27%, crude fibre 9.70% and ash 3.50%. Other workers also reported high amount of protein (65-70%) in *Spirulina* powder (Vijayarani *et al.*, 2012; Salmeàn *et al.*, 2015). *Spirulina* powder had very low carbohydrate content i.e 13.63% and 353.55 Kcal/100g energy content. Similarly, Tang and Suler (2011) also reported 17.8% of carbohydrate and 373 Kcal/100g of energy in *Spirulina* powder. Other workers also reported similar results in *Spirulina* powder (Vijayarani *et al.*, 2012; Udayasree *et al.*, 2013; Bensehaila *et al.*, 2015).

In vitro protein digestibility of *Spirulina* powder was 92.59% which has been reported to be highly digestible. Total lysine content of *Spirulina* powder was also found very high i.e 5.72 g/16gN than any other plant foods. Other workers also reported that *Spirulina* contained 65-71% protein which was higher than that of soybean and more digestible due to absence of antinutrients such as phytic acid and polyphenols which are known to inhibit the proteolytic enzymes (Tang and Sauter, 2011; Salmeàn *et al.*, 2015).

Dietary fibre and total mineral of *Spirulina platensis* powder is presented in Table 2. *Spirulina* powder exhibited very high content of total, soluble and insoluble dietary fibre. The contents were 14.98, 5.52 and 9.46%, respectively of total, soluble and insoluble dietary fibre. *Spirulina* contained many folds higher total mineral contents, 620.80 mg/100g calcium, 790.42 mg/100g phosphorus, 285.90 mg/100g magnesium, 49.50 mg/100g iron and 3.95 mg/100g zinc. Among the minerals, phosphorus had the maximum composition followed by calcium, magnesium, iron and zinc (Table 2). Similar results in *Spirulina* powder were also reported by (Vijayarani *et al.*, 2012; Bensehaila *et al.*, 2015; Ghaly *et al.*, 2015; Salmeàn *et al.*, 2015). Moreira *et al.*, (2013) reported that calcium, sodium and potassium are the major minerals in *Spirulina* powder. They also reported that iron and calcium are readily absorbed in *Spirulina* as compared to other plant foods.

Fatty acid profile of *Spirulina platensis* powder is presented in Table 3. *Spirulina* powder contained 30.50 and 1.90% of total fatty acids palmitic and stearic acid (saturated fatty acids) whereas oleic acid (monounsaturated fatty acid) was only 10.60% of total fatty acids. *Spirulina platensis* was found to be very rich source of gamma linolenic acid (GLA) which accounted for 30.00% of total fatty acids. Two other polyunsaturated fatty acids i.e linoleic acid

(omega-6) and alpha-linolenic acid (omega-3) were also present in *Spirulina* powder which were represented only 2.50 and 14.80% of total fatty acids, respectively. Similar results were also found by (Bensehaila *et al.*, 2015; Ghaly *et al.*, 2015).

Acceptability of developed products:-

Mean scores of acceptability of biscuits and buns are presented in Table 4. Control biscuits was 'liked moderately' by majority of respondents (70%) followed by 'liked extremely' (10%), 'liked very much' (10%) and 'liked slightly' (10%). In case of supplemented biscuits, majority percentage (70, 60 and 70%) of respondents were 'liked moderately' *Spirulina* incorporated biscuits up to 6% levels. *Spirulina* fortified biscuits up to 6% level of incorporation were found at par with control biscuits. Whereas, 8% *Spirulina* powder incorporated biscuits were found unacceptable by the respondents in terms of their organoleptic characteristics. Hence, only 10% of the respondents were 'liked moderately' followed by 60% 'liked slightly' and 30% 'neither liked nor disliked'.

Similar trend was also observed in case of buns, majority of respondents (50%) were 'liked moderately' followed by 'liked very much' and 'liked slightly'. *Spirulina* supplemented buns at 2, 4 and 6% level of incorporation were also found at par with control by the majority (50, 50 and 75%) of respondents. Whereas, 8% *Spirulina* incorporated buns was 'liked slightly' by 60% of respondents.

Acceptability scores of control and supplemented noodles and macroni are presented in Table 5. It was found that majority of respondents (70%) were 'liked moderately' the wheat based noodles and macroni. Similarly, *Spirulina* incorporated noodles and macroni up to 6% level were also found at par with their respective control. Results indicated that 2, 4 and 6% *Spirulina* fortified noodles and macroni were 'liked moderately' by majority of the respondents. Whereas, 8% *Spirulina* incorporated noodles and macroni were 'liked slightly' by majority (50%) of respondents followed 'neither liked nor disliked' and 'liked moderately' by 30 and 20% of the respondents, respectively. Similar results were also reported by other workers in *Spirulina* supplemented bread, biscuits, muffins and pasta (Fradique *et al.*, 2010; Lemes *et al.*, 2012; Navacchi *et al.*, 2012; Hafsa *et al.*, 2014; Minh, 2014).

Conclusion:-

It may be concluded from the present study that *Spirulina platensis* powder exhibited high amount of protein, total lysine, dietary fibre, total minerals, α -linolenic and γ -linolenic acid. Whereas, low amount of carbohydrate and fat was noticed in *Spirulina* powder. Hence, its incorporation in wheat flour would be advantageous for enhancing the nutritional quality of wheat based products. *Spirulina* incorporated products up to 6% level were 'liked moderately' by majority of respondents.

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