Fortifying some low- protein food products with Spirulina,to increase the nutritional and vital value of the product.

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Abastract

Fortification of Food is the addition of nutrients to foods to improve their properties, and, more recently, studies on the functional properties, nutrition, and sensory quality of foods have increased. The aim of the study is to boost producers of pasta and baked crunchy snacks with spirulina by 5%. The results showed that a spirulina supplement of 5% increased the protein content of pasta by 30% (29.96%) and baked crunchy snack goods by 37.21%. The results said that the adoption of spirulina supplementation has a low proportion of carbohydrates and thermal calories, so spirulina supplementation does not threaten obesity. The results also showed that supplementation with spirulina by 5% increased vitamin B2, vitamin E and vitamin B3, the less increase was recorded but noticeable for B12, B9 and B6 and vitamin C in both producers, the metal increase of pasta and baked crunchy snacks supplemented by 5% of spirulina was in (Fe, P, Zn, Ca), as the results showed that there is no shortage of essential amino acids for pasta and baked crunchy snacks supplemented by 5% of spirulina, The results also showed that supplemented by spirulina in pasta and baked crunchy snacks goods led to an improvement in protein quality. because when supplementation with 5% calculated PER, BV, and Arginine/Lysine was increased and after supplementation Arg/Lys the Arg/Lys ratio still fell in the range reported for optimum ratio, being 0.8 - 1.7 . Finally, the results of supplementation with spirulina showed an increase in n-3 FA, while a decrease in n-6 FA. This study recommends eating foods fortified with spirulina because they contain many nutrients, especially essential amino acids.

Key words: ***spirulina – protein – amino acids – pasta – baked crunchy snacks.***

Introduction

Blue-green algae (Spirulina) are among the most primitive life forms on Earth. Their cellular structure is a simple prokaryote. They share features with plants, as they have the ability to perform photosynthesis. They share features with primitive bacteria because they lack a plant cell wall. Interestingly, they also share characteristics of the animal kingdom as they contain on their cellular membrane complex sugars similar to glycogen **(Saranraj and Sivasakthi ,2014) .**

Spirulina is a fresh-water cyanobacterium that has several biological activities and great nutritional value, because it contains high levels of proteins (more than 50% on a dry basis), Essentials amino acids, vitamins, polyunsaturated fatty acids, minerals, polyphenols, carotenoids and chlorophyll . Due to the presence of the pigment C-phycocyanin, the color of spirulina is green-blue . This microalga , has different industrial applications e.g., as a food supplement , in feed , in cosmetics and in health products. In several studies spirulina has been employed in food formulations in order to obtain or enhance the functional and technological properties of cheese , yogurt , soft drink beverages , bread, cookies and pasta **(Martelli *et al*., 2020)** .

Research conducted on spirulina by the World Health Organization (WHO) and scientists in the United States, France, West Germany, Mexico, Vietnam and Japan confirmed that it has a mixture of nutrients that no plant source can provide The NPU value of spirulina is equivalent to that of other vegetarian sources representing suitable amino acid composition, biological value and digestibility **(Lupatini *et al*., 2017).**

Spirulina offers a wide range of health benefits almost immediately upon ingestion as it lacks cellulose in the cell wall. It offers an instantaneous boost to one's energy, and helps in improving endurance and in reducing fatigue It is a natural immunity booster, and provides excellent support for the heart, liver, and kidneys. Spirulina is a natural detoxifier **(Singh *et al*., 2020).**

Pasta is a product consumed in various parts of the world and has large acceptance by consumers. This fact is mainly due to the easy and fast preparation, low cost, can also be used for different types of meals and long shelf life **(Teterycz *et al*., 2019).**

Despite these characteristics, the pasta shows a nutritional deficiency in its composition. Pasta consists mostly of carbohydrates (70–76%), protein (~10–14%), lipids (~1.8%), dietary fibre (~2.9%) and small amounts of minerals and vitamins **(Sissons *et al*., 2022).**

Improvements in the nutritional quality of pasta may occur through the incorporation of ingredients that increase protein content and also provide functional properties, such as fiber and antioxidants. The incorporation of microalgae, such as spirulina, is an alternative, as it can be used as a functional ingredient in a variety of food products. Spirulina microalgae is considered safe for consumption, has high protein content a large amount of vitamins and minerals, and is also considered a good source of natural antioxidants, such as water-soluble pigments and phycocyanin and phenolic compounds **(Zen *et al*., 2020).**

Snacks have gained importance and acceptability worldwide in recent years and are now part of contemporary culture. Most snacks are made from starch based products (corn,wheat, rice, oats and potato). These products are usually high in starch content, but low in nutritional value in terms of vitamins, minor minerals, amino acids and fiber. Indeed, many snack products are regarded as energy dense ،they are referred to as foods that provide "empty calories" and nutrient poor foods exhibiting high glycaemic index (**Ochoa *et al*., 2016 & Cortés *et al*., 2014).**

So snacks enriched with spirulina and thus improved nutritional characteristics are developed.These snacks were evaluated with respect to the nutritional content , physical properties and sensorial characteristics as well as microbiological analyses. The addition of spirulina provided a nutritional increase in proteins, lipids and in minerals, without significantly affecting the physical parameters such as expansion index and hardness. It was concluded that spirulina can be used in snacks with high nutritional content and sensory acceptance. Thus, this product can be used as ready to eat food by consumers which look for a healthier diet **(Lucas *et al*., 2018).**

Material And Methods

Materials:

Wheat flour with 72% extraction ,Corn flour and spices used in this study were obtained from the local market Menoufia Government ,Ashmoun, Egypt. Wheat flour with 72% extraction was obtained from Amoun Milling Company (Giza, Egypt). The blue green algae *Spirulina platensis* was obtained from Algal Biotechnology Unit, National Research Centre, Dokki, Giza, Egypt.

Experimental procedures

1. Preparation of uncooked pasta :

Pasta dough preparation. Two samples were prepared: control and supplemented . The control sample Pasta was produced according to

(Collins and Pangloli ،1997) with some modifications. All dry ingredients were sieved through a 100-mesh sieve, combined, and mixed to produce a homogenized mixture. Then, the mixture was placed in a mixing bowl and mixed until the dough formed (31 ± 1% of tap water). The dough was shaped into a ball, covered with plastic wrap, and allowed to rest for 30 min. Then, it was hand-kneaded for 1 min, divided into 100-g portions, and shaped in a cylindrical form by using a pasta machine without a vacuum (Philips Pasta Maker HR 2357/05, Italy). The supplemented sample was prepared with the addition of 5% Spirulina .

Pasta drying process. The pasta samples were air-dried at 23–25°C for 4 h in a room equipped with a fan . After drying in the open air, the samples were placed in a cabinet dehydrator and dried at 70°C to a moisture level of about 12%. After cooling to room temperature (25 ± 2°C), the samples were placed in plastic bags, sealed, and stored at 12–14°C until analysis **(Kishk *et al.*, 2011).**

2. Preparation of baked crunchy snacks (BCS) :

Two samples were prepared: control and supplemented. The control sample was formulated with 2:1 wheat flour and corn flour,respectively and some spice types .The supplemented sample was prepared by addition of 5% Spirulina . warm water was gradually added until a smooth dough formed. The dough was rolled with a very thin thickness, cut into triangles, then baked in a hot oven at 180 ° C until it was roasted and then served. **(Lucas *et al.*, 2018)** & **(Riaz ,2004)** .

Methods:

Chemical composition:

Moisture, protein (N x 6.25), lipids (ether extract), ash and crude fiber contents were determined according to **AOAC (2000)**. Total carbohydrates were calculated by difference. The determination of minerals (Ca, Zn, K, Na, Mg and Fe) was carried by the Atomic Absorption Spectrum, while phosphorus was determined by the Spectrophotometer series.

Determination of fatty acid composition

The fatty acid composition was determined by the transmethylation of the fatty chains to fatty acid methyl esters (FAMEs) according to the modified method by **Zahran and Tawfeuk (2019).**

Mineral contents:

Mineral quantification was carried out by Atomic Absorption Spectrophotometer (type AAnalyst 400, Perkin– Elmer, Waltham, MA, USA) after sample digestion with HCl as described by **AOAC (2000)**.

Amino acids pattern:

Amino acids were determined after hydrolyzing the defatted samples as well as its formulated samples with 6 N HCl at 110 ℃ for 22 h in a nitrogen atmosphere using a Beckman amino acid analyzer **(**Model 118/119 CL) according to the method described by **Moore and Stein (1963)**. Tryptophan was determined after alkaline hydrolysis **Moore and Stein (1963)**.

Dietary fiber:

Crude fibers were determined using the enzymatic-gravimetric method (Total dietary fiber assay kit, Product Codes TDF-100A) according to **(AOAC, 2000).**

Determination of vitamin C :

Ascorbic acid content was determined using the 2, 6-dichlorophenol-indophenol titration method described in **AOAC (2000)**. Extracts for vitamin C analysis were obtained by homogenizing one gram sample in 20 ml cold solution of 3% (w/v) oxalic acid, and 8% glacial acetic acid (v/v) in water until uniform consistency was achieved using the Ultra-Turrax homogenizer. The homogenates were centrifuged at 10,000 rpm at 4°C for 10 minutes. The supernatant was recovered and measured for vitamin C immediately by 2,6 dichlorophenol dye.

Determination of B complex by HPLC:

Preparation of Extraction Solutions :

Extraction solution was made by mixing 50 mL of ace-tonitrile with 10 mL of glacial acetic acid and the volume was finally made up to 1000 mL with double distilled water.

Analytical HPLC:

An Agilent 1100 chromatographic system (Agilent Ltd., South Queensferry, UK) was used for the analysis and quantitation of tocopherols. The ChemStation software controlled the whole chromatographic system. Reversed phase HPLC with fluorescence detection (excitation 292 nm, emission 325 nm) was used. Tocopherols were separated on Agilent Exlipse XDB-C18 column (5 μm, 150 mm × 4.6 mm i.d.) using isocratic elution with a mobile phase consisting of acetonitrile : methanol (70:30). The flow rate was adjusted to 1 mL/min. The column temperature was kept constant at 30◦C.

Sensory evaluation:

Control (pasta and baked crunchy snacks (BCS)) and supplemented (pasta and baked crunchy snacks (BCS)) were organoleptically evaluated for their external and internal properties by twenty staff members of the home economics dept, faculty of specific education. Menoufia University, Ashmoon, for: 1)colour, 2) texture, 3) aroma, 4)taste and overall acceptability as fallows:

Very good : 8<9 - Good : 7<8 - Fair: 6<7 - Weak: 5<6 - Rejected: 4<5 **(Watts *et al*., 1989)**.

Statistical analysis:

Analysis of variance was conducted for the data in accordance with procedures described by **(Steel and Ttorrie,1980).** L.S.D. at 5% level of significance was used to compare between means.

Results and Discussion

This work aimed to obtain 5% spirulina pasta as baked crunchy snacks (tortilla chips) to have functional foods assigned to cope with protein deficiency and malnutrition.

New suggested 5% spirulina foods evaluated when consumed by children (4-8 years old) , males (31-50 years old) and females (31-50 years old). analyses included the gross chemical composition, vitamins, minerals, amino acids and fatty acids compositions . Obtained results could be summarised as follows .

A: pasta :

It is clear (Table 1) that spirulina at a 5% level raised the protein content by about 30% (from 11.18 to 14.53%, 29.96%) this because spirulina contained (on DWB) 50-70% protein **(Dalla *et al*., 2022).** while pasta usually contents 10-14% protein **(Sissons ,2022).** This raised the level of protein as %of DRI for children, males and females (Table 1). No doubt spirulina pasta may be advised for malnutrition children, males and females.

Spirulina pasta was only a little higher than pasta in fat , fibre and ash less than pasta in carbohydrates and total calories.

Table (1) Gross chemical composition of pasta and evaluation when consuming by children (4-8) and adult male & female (31-50)

Chemical composition	Control							Supplemented				
	Content	% Of DRI Children	DBI	% Of DRI Male	DRI	% Of DRI Female	DRI	Content	% Of Control	%Of DRI Children	% Of DRI Male	% Of DRI Female
Crude protein	11.18	58.84	19	19.96	56	24.30	46	14.53	129.96	76.47	25.95	31.59
Fat	0.88	1.52	58	0.99	89	1.31	67	1.04	118.18	1.79	1.17	1.55
Crude Fibre	0.06	0.24	25	1.58	38	0.24	25	0.88	1466.67	3.52	2.31	3.52
Ash	0.06	_	_	_	_	_	_	1.31	2183.33	_	_	_
Total Carbohydrates	74.05	22.71	326	15.79	469	20.98	353	69.02	93.21	21.71	14.72	19.55
Total calorie	348.84	18.36	1900	12.03	2900	15.86	2200	343.56	98.49	18.08	11	15.62

Data from table (2) show the minerals of control and spirulina pasta as consumed by children, males and females.

It is evident that supplemented pasta contained more Ca than that of control ones, the increase was 136.52%, compared to control . This indicated that spirulina was rich in Ca as **(koli *et al.*, 2022)** reposted taking into consideration that supplemented pasta was with only 5% spirulina. The same authors retorted that spirulina is rich also in Fe, Na which was also found in the present work (Table 2). Supplementation with 5% spirulina raised Fe (by 144.04) Zn (by 24.23%) and Na (by 866.67%) compared to unsupplemented pasta meanwhile Mg decreased slightly (4.28% decrease) compared to unsupplemented pasta. Nevertheless away from the change in pasta due to 5% spirulina addition, supplemented food at this level resulted that the consumption of 100g will cover 72.39% ,22.41% and 29.41% of the DRI in Mg as calculated for children, males and females respectively, which was not far away from that calculated for unsupplemented pasta, being 130 , 420 and 320 % of DRI , showing that supplementation resulted in more reasonable Mg levels them control pasta.

Data in the table (2) show the vitamins of pasta as affected by supplementation with spirulina. It could be observed that all determined vitamins were raised in pasta during supplementation . Spirulina pasta has numerous, vitamins such as B1 (Thiamin)، B2 (Riboflavin) ،B3 (Niacinamide) ،B6 (pyridoxin), B9 (folic acid) ,vit.C, vit.D and vit.E as reported by **(Ciferri and Tiboni, 1985), (Sánchez *et al*., 2003) and (Habib *et al*., 2008),** therefore spirulina is described as the super food. From the results of table (2)

Table (2) Minerals and vitamins of pasta and evaluation when consuming by children (4-8 years) , and males & females (31-50 years)

Control								Supplemented				
Minerals and Vitamins	Content	% Of DRI Childr en	DRI	% Of DRI Male	DRI	% Of DRI Female	DRI	Content	%Of Control	% Of DRI Childr en	% Of DRI Male	% Of DRI Female
Ca	22.15	2.77	800	2.22	1000	2.22	1000	30.24	136.52	3.78	3.02	3.02
P	12.59	2.52	500	1.80	700	1.80	700	18.90	150.12	3.78	2.7	2.7
Fe	1.09	10.9	10	13.63	8	6.60	18	2.66	244.04	26.6	33.25	14.78
Mg	98.32	75.63	130	23.41	420	30.73	320	94.11	95.72	72.39	22.41	29.41
Zn	0.74	14.8	5	6.73	11	9.25	8	0.92	124.32	18.4	8.36	11.5
Na	0.006	0.5	1.2	0.4	1.5	0.4	1.5	0.058	966.67	4.8	3.87	3.87
B2	0.0065	1.08	0.6	0.05	1.3	0.06	1.1	3.22	49538.46	536.66	247.69	292.73
B3	0.650	8.13	8	4.1	16	4.64	14	1.175	180.77	14.7	7.34	8.39
B6	0.17	28.33	0.6	13.08	1.3	13.08	1.3	0.20	117.65	33.33	15.39	15.39
B9	0.138	0.069	200	0.035	400	0.035	400	0.184	133.3	0.092	0.046	0.046
B12	2.98	248.33	1.2	124.17	2.4	124.17	2.4	4.35	145.97	362.5	181.25	181.25
V.E	0.0061	0.087	7	0.04	15	0.04	15	0.028	459.02	0.4	0.19	0.19
V.C	33.11	132.44	25	36.79	90	44.15	75	36.43	110.03	145.72	40.48	48.57

The results of table (3) show the amino acids composition (EAA composition) of pasta as affected by supplementation with spirulina and evaluation in comparison with DRI for children, males and females.

It is evident that when pasta was supplemented none of the essential amino acids (EAA) of the protein revealed less than 100% of DRI, indicating no deficiency in any of the EAA. Neverless, unsupplemented pasta deficiency was recorded for 4 EAA .

Table (3) Amino acids compositions of pasta protein(g/100g protein) due to supplementation with spirulina evaluation as calculated with DRI for children, males and females

Amino acids compositions of pasta protein (g/100g protein)	Control			Supplemented		
	Content	% of DRI	DRI	Content	% of Control	% of DRI
Aspartic acid	5.32	_	_	6.05	13.72	_
Glutamic acid	18.39	_	_	14.23	77.38	_
Glycine	5.09	_	_	4.45	87.43	_
Histidine	1.44	80	1.8	1.92	133.33	106.67
Arginine	2.88			2.65	92.01	
Threonine	1.57	58.15	2.7	3.91	249.04	144.81
Alanine	7.35	_	_	6.52	68.99	_
Proline	9.43	_	_	8.97	95.12	_
Tyrosine + Phenylalanine	6.05	128.72	4.7	12.02	198.68	255.74
Valine	0.93	29.06	3.2	4.85	521.56	151.56
Methionine + Cystine	3.58	143.2	2.5	9.38	262.01	375.2
Isoleucine	3.21	128.4	2.5	6.94	216.20	277.6
Leucine	7.39	144.90	5.1	10.21	138.16	200.20
Lysine	2.18	39.64	5.5	2.58	118.35	46.91
Serine	4.97	_	_	4.29	86.32	_
Tryptophan	0.85	121.43	0.7	0.99	116.47	141.43

When the DRI of EAA was calculated according to sex and age and compared to EAA contents given in table (3) no deficiency was observed in any of the EAA. Calculated grams consumed of pasta to cover the DRI revealed that consumption of supplemented pasta was less than control to cover the DRI . Moreover more grams should be consumed to cover the DRI of males , followed by the females and higher grams are needed for children.

To confirm the value of spirulina in the supplementation of pasta, protein quality the quality of protein was judged by calculating PER1, PER 2, BV1, BV2 and arginine / lysine ratio. This was also calculated for spirulina. The results are presented in table (4).

It is evident that 5% spirulina supplementation raised the calculated PER1, PER 2, BV1, BV2, and arginine / lysine, still being in the level of optimum ratio (0.8 – 1.70) for good quality protein.

Table (4): Quality of protein as estimated for Pasta when supplemented with 5% Spirulina

Quality of protein as estimated for Pasta	Control	Supplemented	Increase as %of control
PER1	2.24	3.55	58.48
PER2	2.50	3.20	28.00
BV1	72.68	86.47	18.97
BV2	75.42	82.79	9.77
Arginine / lysine	0.46	1.03	123.91

Data from table (5) show the fatty acids compositions of pasta as affected by supplementation with spirulina at a 5% level . It should be observed (Table 5) that supplementation lowered the EFA n-6 while raised EFA n-3 , accordingly due to 5% spirulina supplementation% of DRI was lowered for n-6 while increased for n-3 which was also shown in table (5).

Table (5): Essential fatty acids of pasta and evaluation when consuming by children (4-8 years) , and males & females (31-50 years)

Control								Supplemented				
Essential fatty acids of pasta	Conte nt	%of DRI Childre n	DR I	%of DRI Male	DR I	%of DRI Femal e	DR I	Conte nt	%Of Contr ol	%of DRI Childre n	%of DRI Male	%of DRI Femal e
n_6	45.0 1	450.1	10	264.7 6	17	409.1 8	11	40.24	89.42	402.4	236.7 1	365.8 1
n_3	1.84	204.44	0.9	115	1.6	167.2 7	1.1	2.27	123.3 7	252.22	141.8 8	206.3 6

B- Baked (crunchy snack)

The results of table (6) show the gross chemical composition of baked crunchy snack . It is evident that due to the 5% spirulina addition the crude protein was raised from 9.54% to 13.09% showing a 37.21% increase.

Considering the fat content,it seems possible that supplementation with 5% spirulina did not affect the level of fat in the final supplemented product and this is because of low fat content in spirulina.

As for the fibres contents ,it seems that spirulina supplementation of BCS at 5% level seems to have no marked effect on fibres content , while increased a little from 1.97 to 2.11.

The ash content revealed 15.08% increase when BCS supplementation with 5% spirulina showed an increase from 1.79 to 2.06% . This increase, however , means some increase in some minerals.

T. carbohydrates indicated 5.43% decrease due to 5% spirulina supplementation, the content reduced from 76.31 to 72.17 % . The decline of fat & carbohydrates caused the decrease T. calories from 400.19 to 397.2/100g being very slight (at 0.75 % decrease only.

Table (6): Values of chemical composition baked crunchy snacks (BCS) as calculated for children, males and females

Chemical composition	Control							Supplemented				
	Content	%Of DRI Children	DRI	% Of DRI Male	DRI	% Of DRI Female	DRI	Content	% of Control	% Of DRI Childrен	% Of DRI Male	% Of DRI Female
Crude protein	9.54	50.21	19	17.04	56	20.74	46	13.09	137.21	68.89	23.38	28.46
Fat	6.31	10.88	58	7.09	89	9.42	67	6.24	98.89	10.75	7.01	9.31
Crude Fibre	1.96	7.84	25	5.16	38	7.84	25	2.11	107.65	7.84	5.55	8.44
Ash	1.79	_	_	_	_	_	_	2.06	115.08	_	_	_
Total Carbohydrates	76.31	23.41	326	16.27	469	21.62	353	72.17	94.57	22.14	15.3	20.45
Total calorie	400.19	21.06	1900	13.80	2900	18.19	2200	397.2	99.25	20.91	13.70	18.05

The results of table (7) show the minerals and vitamins of BCS as supplementation with 5 % spirulina. It is evident that spirulina supplementation showed a very slight increase in Ca . In this concern the present work results indicated that spirulina seems not to be rich in Ca, which disagreed with the results of **(Koli *et al*., 2022)** . For pasta similar trend was found as Ca , spirulina seems to be rich in Fe and Zn . A slight increase was observed for Ca & P, while Mg was slightly reduced.

Table (7): Minerals and vitamins of BCS and evaluation in comparison with DRI for children, males and females

	Control							Supplemented				
Minerals and vitamins of BCS	Content	%of DRI Children	DRI	%of DRI Male	DRI	%of DRI Female	DRI	Content	% of Control	%of DRI Children	%of DRI Male	%of DRI Female
Ca	24.98	3.12	800	2.50	1000	2.50	1000	28.10	122.49	3.2	2.81	2.81
P	286.82	57.36	500	40.97	700	40.97	700	291.32	101.57	58.26	41.62	41.62
Fe	4.83	48.3	10	60.38	8	26.83	18	6.28	130.02	62.8	78.5	34.89
Mg	57.82	44.48	130	13.77	420	18.07	320	57.70	99.79	44.38	13.74	18.03
Zn	2.98	59.6	5	27.09	11	37.25	8	3.19	107.05	63.8	29	39.88
Na	0.046	3.83	1.2	3.06	1.5	3.06	1.5	0.048	104.35	8.17	6.53	6.53
B2	0.00169	0.28	0.6	0.13	1.3	0.15	1.1	.0032	189.35	0.533	0.25	0.29
B3	0.388	4.85	8	2.43	16	2.77	14	1.175	302.84	14.7	7.34	8.39
B6	0.076	12.67	0.6	9.88	1.3	9.88	1.3	0.089	117.11	14.83	6.85	6.85
B9	0.103	0.05	200	0.03	400	0.03	400	0.184	178.64	0.092	0.046	0.046
B12	3.320	275.17	1.2	137.58	2.4	137.58	2.4	4.67	144.73	389.17	194.58	194.58
V.E	0.0097	0.139	7	0.065	15	0.065	15	.0026	26.80	0.037	0.017	0.017
V.C	41.21	164.84	25	45.79	90	54.95	75	45.48	110.36	181.92	50.53	60.6

Data from the table (7) show the content of vitamins in BCS as affected by supplementation with spirulina 5% level.

It could be observed that spirulina supplementation of BCS raised the levels of all vitamins except the Vit. E. Nevertheless pasta supplementation raised also all other vitamins including the B12 . This may be due to different additives (processing steps) during the processing of both products.

Supplementation resulted (Table 8) in raising the following amino acids: Aspartic acid, Histidine Threonine, Proline ،Tyrosine+ Phenylalanine, Valine, Methionine+ Cystine, Isoleucine, Leucine, Lysine and Tryptophan ,hence supplementation with spirulina raised all the EAA of BCS protein, indicating the more nutritional value.

Table (8): Amino acids compositions of BCS protein(g/100g protein) due to supplementation with spirulina evaluation as calculated with DRI for children, males and females

Amino acids compositions of BCS protein(g/100g protein)	Control			Supplemented		
	Content	% of DRI	DRI	Content	% of Control	% of DRI
Aspartic acid	6.37	_	_	6.80	106.75	_
Glutamic acid	16.02	_	_	12.54	78.28	_
Glycine	4.95	_	_	4.35	87.88	_
Histidine	1.92	106.60	1.8	2.26	117.71	125.55
Arginine	3.75	_		3.26	86.93	
Threonine	2.04	75.55	2.7	4.25	208.33	157.41
Alanine	6.25	_	_	5.74	91.84	_
Proline	7.63	_	_	7.69	100.79	_
Tyrosine + Phenylalanine	6.87	146.17	4.7	12.61	183.55	467.04
Valine	1.86	58.13	3.2	5.52	296.77	172.5
Methionine + Cystine	3.38	135.2	2.5	9.24	273.37	369.6
Isoleucine	3.39	135.6	2.5	7.07	208.55	282.8
Leucine	8.97	175.88	5.1	11.34	126.42	222.35
Lysine	2.36	42.91	5.5	2.70	114.41	49.09
Serine	4.54	_	_	3.98	87.67	_
Tryptophan	0.80	144.29	0.7	0.91	113.75	130.00

The value of supplementation with spirulina may be indicated from the results of table (9) , when supplementation with spirulina at 5 % raised PER 1,2 and B.V1,2 .Although BCS supplementation lowered the Arg., Lys. ratio from 1.59 to 1.21, the ratio was still indicative of good quality protein of the product ranging 0.8 to 1.7.

Table (9): Quality of protein as estimated for BCS when supplemented with 5% Spirulina

Quality of protein as estimated for BCS	Control	Supplemented	Increase as %of control
PER1	3.05	4.13	35.41
PER2	3.19	4.68	46.71
BV1	81.21	92.58	14.00
BV2	82.68	98.37	18.98
Arginine / lysine	1.59	1.21	- 23.90

% DRI considering supplementation BCS with 5% spirulina for n-3 FA increased, while n-6 FA decreased, for children was highest ,

followed by females then came the male considering BCS as indicated from data of (Table 10) . For pasta it was highest for children and less for both females & males .

Table (10) : Essential fatty acids of BCS and evaluation when consuming by children (4-8 years) , and males & females (31-50 years)

Control								Supplemented				
Essential fatty acids of BCS	Conte nt	%Of DRI Childre n	DR I	%Of DRI Male	DR I	%Of DRI Femal e	DR I	Conte nt	%Of Contr ol	% Of DRI Childre n	% Of DRI Male	%Of DRI Femal e
n_6	58.76	587.7	10	343.65	17	534.18	11	44.01	74.9	440.1	258.88	400.09
n_3	3.85	427.78	0.9	240.63	1.6	350	1.1	6.07	157.66	674.44	376.38	551.82

Data collected from the organolyptic evaluation that was carried out by panelists and statistically analyzed showed that pasta and baked crunchy snacks supplemented with 5% spirulina had fair scores in all investigated sensory attributes (aroma, taste ,color, texture, overall acceptability) as given in table (11&12). That is because the spirulina is a marine product that has an effect on the taste and aroma, and the dark greenness of this has an impact on the evaluation of the color.

Table (11) : Sensory evaluation of pasta control and supplemented with spirulina

Groups	Aroma Mean ±SD	Taste Mean ±SD	Color Mean ±SD	Texture Mean ±SD	Overall acceptability Mean ± SD
Control	8.7^{a} ±0.57	8.8^{a} ±0.52	8.85^{a} ±0.37	8.7^{a} ±0.44	8.78^{a} ±0.32
Supplemented	6.9^{b} ±0.79	6.8^{b} ±0.70	6.55^{b} ±0.76	6.7^{b} ±0.57	6.71^{b} ±0.42
LSD	0.44	0.39	0.38	0.33	0.24

Table (12): Sensory evaluation of baked crunchy snacks (BCS) control and supplemented with spirulina

Groups	Aroma Mean ±SD	Taste Mean ±SD	Color Mean ±SD	Texture Mean ±SD	Overall acceptability Mean ± SD
Control	8.85^{a} ±0.37	8.8^{a} ±0.41	8.95^{a} ±0.22	8.95^{a} ±0.22	8.89^{a} ±0.22
Supplemented	6.6^{b} ±0.68	7.1^{b} ±0.72	6.55^{b} ±0.51	6.85^{b} ±0.59	6.78^{b} ±0.32
LSD	0.35	0.37	0.25	0.28	0.18

It could be noticed that the colour scores seem to be responsible for a pronounced decrease in the supplemented food quality.Therefore it may be suggested to add a colorant agent to ovoid such a decrease.

References

AOAC (2000). Official Methods of Analysis of AOAC International. (Ed. Horwitz, W.), 17th Ed., Suite 500, 481 North Fredric avenue Gaithersburg, Maryland, USA.

Ciferri, O. and Tiboni, O. (1985). The biochemistry and industrial potential of Spirulina. Annual review of microbiology, 39, 503–526.https://doi.org/10.1146/annurev.mi.39.100185.002443.

Collins, J. L. and Pangloli, P. (1997). Chemical, physical and sensory attributes of noodles with added sweetpotato and soy flour. *Journal of Food Science*, *62*(3): 622-625.

Cortés, R., Guzmán, I. V., and Martínez-Bustos, F. (2014). Effects of some extrusion variables on physicochemical characteristics of extruded corn starch-passion fruit pulp (Passiflora edulis) snacks. Plant foods for human nutrition, 69(4), 365-371.

Dalla Costa, V؛ Filippini, R؛ Zusso, M؛ Caniato, R. and Piovan, A. (2022). Monitoring of spirulina flakes and powders from ctalian companies. Molecules, 27(10):3155.

Habib, M.A.B؛ Parvin, M؛ Huntington, T.C and Hasan, M.R. (2008). A review on culture, production and use of spirulina as food for humans and feeds for domestic animals and fish. FAO fisheries and Aquaculture Circular. No. 1034. Rome, FAO. 33p.

Kishk, Y. F؛ Elsheshetawy, H. E. and Mahmoud, E. A. (2011). Influence of isolated flaxseed mucilage as a non-starch polysaccharide on noodle quality. International Journal of Food Science & Technology, 46(3): 661-668.

Koli, D. K؛ Rudra, S. G؛ Bhowmik, A. and Pabbi, S. (2022). Nutritional, functional, textural and sensory evaluation of spirulina enriched green pasta: A potential dietary and health supplement. Foods, *11*(7) :979.

Lucas, B. F؛ de Morais, M. G؛ Santos, T. D. and Costa, J. A. V. (2018). Spirulina for snack enrichment: Nutritional, physical and sensory evaluations. *LWT*, *90*: 270-276.

Lupatini, A. L؛ Colla, L. M., Canan, C. and Colla, E. (2017). Potential application of microalga *Spirulina platensis* as a protein source. Journal of the Science of Food and Agriculture, 97(3) :724-732.

Martelli, F؛ Alinovi, M؛ Bernini, V؛ Gatti, M .and Bancalari, E. (2020). *Arthrospira platensis* as natural fermentation booster for milk and soy fermented beverages. Foods, 9(3): 350.

Moore, S. and Stein, W.H. (1963). Chromatographic determination of amino acids by the use of automatic recording equipment. in Methods in Enzymology, vol. 6 **(**Colowick S. P. and Kaplan N. O.; eds.), Academic New York, pp. 819-831.

Ochoa-Martínez, L. A؛ Castillo-Vázquez, K؛ Figueroa-Cárdenas, J. D. D., Morales-Castro, J؛ and Gallegos-Infante, J. A. (2016). Quality evaluation of tortilla chips made with corn meal dough and cooked bean flour. Cogent Food & Agriculture, 2(1), 1136017.

Riaz, M. N. (2004). Snack foods. Processing :98:108

Sánchez, M؛ Bernal-Castillo, J., Rozo, C؛ Rodríguez, I. (2003). Spirulina (*Arthrospira*): an edible microorganism: A review. Universitas Scientiarum. 8(1):7–24. PMC283708.

Saranraj, P. and Sivasakthi, S. (2014). Spirulina platensis–food for future: a review. Asian Journal of Pharmaceutical Science and Technology, 4(1): 26-33.

Singh, S؛ Dwivedi, V؛ Sanyal, D. and Dasgupta, S. (2020). Therapeutic and nutritional potential of spirulina in combating COVID-19 infection. AIJR Preprints, 49(1): 2-8.

Sissons, M. (2022). Development of novel pasta products with evidence based impacts on health—A Review. Foods, *11*(1): 123.

Steel, R.G.D. and Torrie, J.H. (1980) Principles and procedures of statistics. A biometrical approach, 2nd Edition, McGraw-Hill Book Company, New York.

Teterycz, D؛ Sobota, A؛ Kozłowicz, K. and Zarzycki, P. (2019). Substitution of semolina durum with common wheat flour in egg and eggless pasta. Acta Scientiarum Polonorum Technologia Alimentaria, 18(4): 439-451.

Watts, B.M.; Yamaki, L.E, Jeffery, L.E . and Elias, L.G. (1989): Basic Sensory Methods for Food Evaluation. IDRC, Pub. Canada .

Zahran ,HA. and Tawfeuk, HZ. (2019). Physicochemical properties of new peanut (*Arachis hypogaea L.*) varieties. OCL, 26: 19.

Zen, C. K؛ Tiepo, C. B. V؛ da Silva, R. V؛ Reinehr, C. O؛ Gutkoski, L. C., Oro, T. and Colla, L. M. (2020). Development of functional pasta with microencapsulated spirulina: Technological and sensorial effects. Journal of the Science of Food and Agriculture, 100(5): 2018-2026.

تدعيم بعض المنتجات الغذائيه منخفضة البروتين بطحالب الاسبيرولينا لرفع القيمة الغذائية والحيوية للمنتج

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الملخص العربي:

تدعيم الأطعمة هو إضافة مكونات غذائية للاطعمه لتحسين خصائصها، في الآونة الأخيرة ، زادت الدراسات حول الخصائص الوظيفية والمغذية والجودة الحسية للأطعمة. وتهدف الدراسة الي تدعيم منتجي المكرونة والوجبات الخفيفة المقرمشه المخبوزه بالاسبيرولينا بنسبه 5%. وقد أوضحت النتائج رفع مكمل السبيرولينا 5٪ محتوى البروتين في المكرونة بنحو 30٪ (29.96 ٪) وأيضاً في المخبوزات المقرمشه بنسبة 37.21 ٪، واوضحت النتائج أن بالتدعيم بالاسبيرولينا يحدث انخفاض نسبة الكربوهيدرات والسعرات الحرارية، لذلك فأن مكملات الاسبيرولينا لا تهدد السمنة، كما أوضحت النتائج أن التدعيم بالاسبيرولينا بنسبة 5٪ زيادة كبيرة في فيتامين B2 ، فيتامين E فيتامين B3، تم تسجيل ارتفاع أقل ولكن ملحوظًا لـ B12 و B9 و B6 و فيتامين C في كلا المنتجين، وكانت الزيادة في المعادن للمكرونة والمخبوزات المقرمشه المدعمة بنسبة 5% في مادة السبيرولينا في(Fe، P، Zn، Ca)، كما أوضحت النتائج أن لايوجد نقص في الأحماض الأمينيه الأساسية للمكرونة والمخبوزات المقرمشه المكمله بنسبة 5%من الاسبيرولينا، وأيضاً أظهرت النتائج أن التدعيم بالاسبيرولينا في المعكرونة والمخبوزات المقرمشه أدي إلى تحسين جودة البروتين هذا بسبب أن PER و BV و Arginine / Lysine تمت زيادتها وبعد التدعيم Arg / Lys لا تزال نسبة Arg / Lys تنخفض في النطاق المسموح به، حيث تبلغ 0.8 – 1.7، وأخيراً أوضحت نتائج التدعيم بالاسبيرولينا زيادة n–3 FA بينما انخفاض n–6 FA. وتوصي هذه الدراسة بتاول الأطعمة المدعمة بالسبيرولينا لاحتوائها على الكثير من العناصر الغذائية وخاصة الأحماض الأمينيه الأساسية.

الكلمات المفتاحية: الاسبيرولينا – البروتين – الأحماض الأمينيه – المكرونه – المخبوزات المقرمشه .