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Production and evaluation of crackers and instant noodles suplemented with spirulina algae

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ABSTRACT

In this study, spirulina algae which is one of the blue-green algae rich in protein 61.50%, and high content of amino acids isoleucine and treptophan(6.77 and 1.93% of protein). Also, a good source of vitamins especially vitamin B complex such as vitamin B12 (193 µg / 100 g) and folic acid (9.66 mg/100 g), many phytoepigamates such as chlorophyll, phycocyanins, total carotene (1.470%, 14.17% and 0.550 mg / 100 g) and those considered as potent antioxidants.As well as minerals such as potassium, calcium, phosphorus and iron (2180.79, 1042.925, 1899.71 and 336.965 mg / 100 g, respectively). In addition to a high of natural fibers. Asperolina was used in the production of crackers and instant noodles by ratio of 5, 10, 15 and 20%. Data of sensory evaluation results showed that the adding spirulina algae until level 15%, still have good overall acceptability. The chemical analysis, sensory evalu overal ation, physical and cooking properties, rheological properties were done. The obtained data showed that the adding spirulina algae play a large role in increasing protein and ash contents and improved the physical properties of the crackers and cooking properties of instant noodles. Therefore it could be produced for industrial level to improve the nutritional status of these products for consumers among children's and adults

Key words: Spirulina, crackers, instant noodles, chemical composition, cooking properties and rheological properties.

Introduction

Crackers currently represent a significant share of the snack market and provide key opportunities for new product development particularly in the area of functional foods (Business Insights, 2012).

The snacks market is an ever-expanding area, including foods such as crisps, crackers, cookies, biscuits and bars. Now more than ever, consumers are seeking broader and more nutritive functions from their snacks as they become a bigger part of their daily diet (Kim *et al.* 2017).

Crackers are thin, crisp wafers or biscuits, usually made of unsweetened and unleavened dough.Crackers are generally made with stronger flours than the ones used in cookie baking. The protein percentage of this flour is approximately 10%. Crackers belong to a special group of dry long shelf-life biscuits (Manley, 2000).

Crackers are basically saltine and low in sugar, thin and crisp. Usually sponge-and-dough method is used in the production. After processed, the dough is laminated, while layers of fat are rolled in, which contributes to flaky cracker structure. Regarding eating quality, crackers should not be hard but soft and should not shatter and crumble. The expected flavor of crackers is rather neutral than saltine but nutty flavor is strongly desirable. Crackers are used to substitute bread(Business Insights, 2012).

The reasons noted for the increasing popularity of instant noodles. One book described instant noodles as “supercheap” which appeals to low-income populations (Errington *et al.* 2013).

Instant noodles are very popular foods around the world and are considered healthy and an ideal food to be enriched with nutrients (Wang *et al.*2012).

Instant noodles gain popularity due to their ready-to-eat convenience, cost competitiveness, availability of various products with different taste and texture, beneficial nutrition, and long shelf-life. Globally, the consumption of wheat instant noodles is the second to bread (Shin and Kim, 2003), with nearly 40% of wheat being processed into instant noodles in Asia (Hou, 2001). Recently, the

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consumption of instant noodle has been increasing in the fastest pace in cereal foods (Choy *et al.* 2010). Therefore, understanding dough functionality and promoting quality are of high interest for a successful and controlled production of instant noodles.

Spirulina is the dried biomass of the cyanobacterium Arthrospira platensis, it has been widely used in several countries, it is considered generally recognized as safe(GRAS), without toxicological effects, and it is approved by the FDA (U.S.A.) and ANVISA. Rich in protein (up to 65%), formulators use spirulina in specialty food bars, powdered nutritional drinks, popcorn, beverages, baby foods and fruit juices, frozen desserts and condiments (Sharoba*,* 2014 and Morsy *et al.,*2014).

Spirulina algae fusiform is, a blue-green algae, Oscillotoreacea is rich in proteins, lipids and carbohydrates, as well as elements such as zinc, magnesium, manganese, selenium, and some vitamins including β-carotene, riboflavin, cyanocobalamin, α-tocopherol and α-lipoicacid. Spirulina is also reputed to be an external source of the vital antioxidant enzyme superoxide dismutase (Upasani and Balaraman 2003).

Spirulina is claimed to be the richest whole-food source of provitamin A (*β*-carotene), with 20 g of Spirulina algae also fulfilling the significant body requirements of vitamins B1 (thiamine), B2 (riboflavin) and B3 (niacin) (Sharma *et al.* 2011).

Chemical analysis of Spirulina algae showed that it is an excellent source of proteins, vitamins, dietary minerals and pigments. The biochemical composition depends upon the specific Arthrospira source, culture conditions and season of production (Sharoba 2016).

The aim of this study is to produce that are popular for young and old people, crackers and instant noodles, using dried Spirulina algae, which contains a high percentage of amino acids and minerals.

Materials and Methods

Materials:

Wheat flour: (soft and hard 72% ext.) was obtained from South Cairo Mills Company, Giza, Egypt.

Spirulina: Spirulina was obtained from Aquaculture Research Center at Arab Academy for Science, Technology & Maritime Transport, Arab League.

All other materials used in prouduct processing were obtained from the local market in Dokke, Giza governorate, Egypt.

Methods:

Preparation of crackers:

Crackers were prepared in laboratory by using soft wheat flour 72% ext. (as control), while the supplemented crackers were preparted by addition spirulina algae at levels of 5, 10, 15 and 20%. Crackers were made according to Bose and Shams–Ud- Din (2010) the formulas are shown in Table (A).For making crackers, the following procedure was followed,- shortening, sugar , salt and water were mixed in a dough mixer using the flat beater for 1 minute , then scraped down , and continued to mix for 3 min. at high speed . Dry ingredients soft wheat flour or its blends and baking powder were added to mixture gradually and mixed at low speed for 3 min., and the resulted dough was let to rest for 5 min., then sheeted to 3mm. Thickness circle pieces cut of dough were formed using the templates with an outer diameter of 5 mm. The crackers were baked at 170 C^o for 15 min., after baking, crackers were allowed to cool at room temperature for 1h before sensory evaluations .The produced crackers was weighed., chemical and physical evaluated.

Preparation of instant noodles:

Instant noodles was prepared in laboratory by using hard wheat flour 72% ext. according to the method described by Park *et al.* (2004).

The formulas are shown in Table (A).One kilogram of each dough blends of the tested combinations of raw materials was mixed with the required amount of water in the Hobart mixer (model C- 100, Germany). After the complete addition of water, mixing was continued for 8 min. The premixed dough was placed in the vacuum mixer of the Demaco molder and extended at a rate of 21 rpm. at 25 C^o extruding auger to the instant noodles die. An extension tube was added to ensure uniform hydration of the instant noodles dough prior to extrusion. The instant noodles was steamed for 2 to 3 min.

Table (A): Formulation of crackers and instant noodles blends.

Ingredients	Crackers (g)					Instant noodles(g)				
	Control	Blend 1 (5%)	Blend 2 (10%)	Blend 3 (15%)	Blend 4 (20%)	Control	Blend 1 (5%)	Blend 2 (10%)	Blend 3 (15%)	Blend 4 (20%)
Soft wheat flour	1000	950	900	850	800	-	-	-	-	-
Hard wheat flour	-	-	-	-	-	1000	950	900	850	800
Shortening	100	100	100	100	100	0	-	-	-	-
Sugar	10	10	10	10	10	0	-	-	-	-
Salt	20	20	20	20	20	10	10	10	10	10
Baking powder	30	30	30	30	30	-	-	-	-	-
Spirulina	-	50	100	150	200		50	100	150	200
***Water (ml)**			As required					330-360		

Chemical analysis:-

Moisture, protein, ash, crude fiber and crude fat were determined according to the methods described in A.O.A.C. (2005) total carbohydrates were determined by difference.

Analytical methods of heavy metals in spirulina:

The determination of arsenic, cadmium and lead in spirulina sample was performed according to the methods described in the Korean Food Code (KFDA 2003) which described byHaeng-Shin *et al.* (2006). About 20 g of sample were placed into crucibles, weighed precisely, heated at low temperature on a hot plate, and then completely burned in a furnace at 550 °C. Ten millilitre of deionized H_2O was added to the pre-treated samples and this was acidified by adding 3–5 ml of HCl. Then, the crucible was heated at a low temperature under a fume hood until the ash was completely solubilized. After cooling, the contents were transferred to a volumetric flask quantitatively and made up to 50 ml by adding deionized H_2O. The completed samples were analysed for arsenic, cadmium and lead by inductively coupled plasma–emission spectrometry (Model JY 38 S; Horiba, Jobin Yvon Cedex, France).The content of mercury was determined by a combustion gold amalgamation method using a mercury analyzer SP-3D.

Rodent hairs and Insect fragments in spirulina:

Rodent hairs and insect fragments in spirulina were determined according to Thind (2000). Which used the Wildman trap.

Microbiological determination of Spirulina

Microbiological assay were determined according to the method described by the methodology of the APHA (1992).

Determination of vitamins:

Thiamine, Riboflavin, Niacin, Pyridoxine, Cobalamin, folic-acid, inositol, vitamin E, vitamin K, Pantothenate and biotin were determined by the HPLC system method according to AOAC (2005).

Phytopigments Assay:

Total carotenoids were determined according to AOAC (2005) by using HPLC.

All chemicals and reagents used were of analytical grade and the water was distilled and filtered through a membrane filter. Thiamine chloride hydrochloride, pyridoxine hydrochloride, nicotinamide, inositol hexanicotinate, folic acid and cyanocobalamine were used as working standards. Methanol for HPLC heptanesulphonic acid sodium salt (Sigma), triethylamine,(Aldrich Chemical Company, Inc.)were used to prepare themobile phase and orthophosphoric acid (Merck) for adjusting the pH values. vitamin E-K1and β-carotene, were used anhydrous ferric chloride, n-hexane and 85% orthophosphoric acid (H_3PO_4)

Determination of total amino acids was carried out as described in the K.F.D.A. (2003) and AOAC (2005).

Tryptophan was analysed in triplicate by HPLC, according to the method of Slump*et al.* (1991),

Rheological properties of dough:

Farinograph test was carried out to determine the water absorption, arrival time, dough development time, dough stability and degree of weakening according to the method described in A.A.C.C. (2005).

Extensograph test was carried out to determine resistance to extension (BU), extensibility (mm), proportional number and energy (cm^2) according to the method described in A.A.C.C. (2005).

Sensory evaluation of crackers and instant noodles*:*

The crackers and instant noodles were evaluated for their sensory characteristics after baking for crackers and after cooking for instant noodles by ten panelists from the staff of bread and pastry, research Dep., Food Tech. Res. Institute, Giza.

Determination of cooking quality of instant noodles:

Cooking quality was calculated as follows:

Weight increase (%) = [(Weight of cooked sample- weight of uncooked sample) / (weight of uncooked sample)] X100.

Volume increase % = [(volume of cooked sample-volume of uncooked sample) / (volume of uncooked sample)] X100.

Cooking loss% = (weight of residues in cooking water/weight of uncooked sample) X100.

Instant noodles firmness:

Shear force (kg/cm^2) was measured by determination the firmness of different instant noodles samples using testing machine model No. AIM Desk top micro computer (A 65 - 500 Series, Serial No 9148812). Each sample was sheared with special cutter (1.0 mm thickness and 6-5 mm wide) then firmness was measured accordding to the method described by Greaves *et al.* (1982).

Physical properties of crackers:-

Physical properties of cooled baked crackers were determined for each sample according to the method described in A.A.C.C (2005). Diameter (mm), Thickness (mm), Expansion (D/T), Volume (Cm^3), Weight (gm) and specific volume V/W. (Cm^3/gm).

Minerals analysis:-

Magnesium (Mg), sodium (Na), zinc (Zn), manganese (Mn), iron (Fe), calcium (Ca), copper (Cu) and potassium (K) were determined using a pye Unicom SP 19000 atomic absorption spectroscopy technology described by A.O.A.C (2005).

Phosphorus was spectrophotometrically determined according to the method of Rangana, (1978) which has been based on phosphorus reaction with molybdic acid to form phosphomolybdate complex. It was then reduced with amino naphtholsulphonic acid to complex molybdenum blue which was measured colormeterially at 650 nm.

Statistical analysis:

Statistically analyzed using analysis of variance and least significant differences (L.S.D) according to method of Snedecor *et al.* (1976) and Gomez and Gomezz (1984).

Results and Discussion

Contaminant specifications of spirulina:

Organisms can be a source of toxins, antinutrients or other potentially harmful compounds. Data in Table (1) indicated that, the spirulina algae was free from pesticides, rodent hairs and insect fragments. On the other hand, the level of heavy metals in line with the specifications of the global food, these results are in agreement with those obtained by Llobet *et al.* (2003) and Haeng-Shin *et al.* (2006).

Table 1: Contaminant specifications of spirulina algae.

Elements	Values
Arsenic	< 1.0 ppm
Cadmium	< 0.5 ppm
Lead	< 0.5 ppm
Mercury	< 0.05 ppm
Pesticides	Negative
Rodent hairs	ND
Insect fragments	ND

Nd = Not detected

Microbiological quality of spirulina:

Data in Table (2) indicated that, the total viable bacterial count and mesophilic spore formers bacteria were cannot be detected. The pathogenic bacterial count took the same trend of total viable bacterial count. Coliform group, salmonella and staphylococcus were not detected these results are in agreement with those reported by Morsy, (2015).

This is more save for producing crackers and instant noodles. Also, yeasts and molds cannot be detected, this may be that yeasts and molds cannot resist for drying.

Table 2: Microbiological quality of spirulina algae(CFU/g).

Test	Values
TVBC (Total viable bacterial count)	ND
MSB (Mesophilic Spore formers bacteria)	ND
Y&M (Yeasts and Moulds)	ND
Coliform	ND
Salmonella	ND
Staphylococcus	ND

Nd = Not detected

Amino acids content of hard and soft wheat flour and spirulina algae

Data presented in Table (3) showed that the essential amino acids and non-essential amino acids content of spirulina algae.It was observed that, spirulina algae had a highest content of all essential amino acids except leucine and lysine in fairly amounts compared with hard and soft wheat flour. These results are consistent with Theodore and Georgios, (2013).

Vitamins and phytopigments in spirulina algae:

Spirulina algae is a rich source of beta-carotene, human bodies convert βcarotene to vitamin A. Data in Table (4) indicated that the total carotenoids and β-carotonoids were 0.550 and 0.242mg/100gm, respectivly.

Spirulina algae contains an antioxidant complex of ten carotenoids. These mixed of carotenes and xanthophylls had function at different sites in the body and work synergistically with the other vitamins, (Vitamin E, and minerals) in spirulina (Tang and Suter 2011).

Spirulina algae is the richest source of B-12, which was 193µg /100gm and there have been no complaints of vitamin B-12 deficiency from spirulina algae consumers, including children and vegetarians.

One hundred grams of spirulina provides significant quantities of thiamin (5.55 mg), riboflavin (4.50 mg) and niacin (17.13 mg). Spirulina algae is a rich source of these vitamins than common whole grains, fruits, vegetables and some seeds (Guangwen and Paolo, 2011) B-6, niacin, biotin, panthothenic acid, folic acid, inositol and vitamin E are also present in smaller amounts (Rosell, 2007).

Table 3: Amino acids content of hard and soft wheat flour (72%ext.) and spirulina algae (% of protein).

Amino acids	Hard wheat flour (72%ext.)	Soft wheat flour (72%ext.)	Spirulina algae
Essential amino acids			
Isoleucine	6.50	6.48	6.77
Leucine	8.50	8.45	7.89
Lysine	7.00	6.8	4.36
Methionine	2.30	2.25	2.40
Phenylalanine	4.22	4.20	4.42
Threonine	4.70	4.68	4.85
Valine	6.11	6.10	6.35
Tryptophan	1.17	1.15	1.93
Total	40.50	40.11	38.97
Non-essential amino acids			
Alanine	7.20	7.19	7.37
Arginine	7.4	7.5	7.63
Aspartic	10.90	11.10	11.17
Cysteine	1.90	1.88	1.25
Glutamic	13.00	12.99	13.78
Glycine	5.11	5.10	5.20
Histidine	2.60	2.55	2.70
Proline	3.99	4.20	4.34
Serine	4.10	4.09	4.14
Tyrosin	3.30	3.29	3.45
Total	59.50	59.89	61.00
% Protein	12.40	10.70	61.57

Table 4: Vitamins and phytopigments in spirulina algae(100gm)

Components		**1. Vitamins**	
Vitamin B1(Thiamine)	5.55 mg	Pantothenate	135 µg
Vitamin B2 (Riboflavin)	4.50 mg	Biotin	8.30µg
Vitamin B3 (Niacin)	17.13 mg	Inositol	58.38 mg
Vitamin B6 (Pyridoxine)	0.89 mg	Vitamin E	9.58 mg
Vitamin B12	193 µg	Vitamin K	1120µg
Folic acid	9.66 mg		
		2. Phytopigments	
Total Carotenoids	0.550 mg	Zeaxanthin	0.127 mg
β – carotenoids	0.242 mg	Chlorophyll	1.470 %
Xanthophylls	0.270 mg	Phycocyanin	14.17 %

Chemical compositions of the raw materials:

The chemical compositions of raw materials under investigation are presented in Table (5). It could be noticed that the soft wheat flour (72% ext.) contained the highest value of digestible carbohydrates 87.67%), whereas it was the lowest values of crude fat, crude fiber and ash (0.65, 0.50 and 0.48 %, respectively), than the hard wheat flour (72% ex.) which contained the lowest value of digestible carbohydrates (85.13%), but spirulina algae called a super food because its nutrient profile and unusual phytonutrients are more potent than any other food, plant, grain or herb so we found the dried spirulina algae had the highest values of protein(61.50), fat (7.10%), crude fiber (7.90%) and ash (7.00%)These results are confirmed by those obtained by NB Laboratories (2014) and Morsy (2015).

Minerals in hard and soft wheat flour (72%ext.) and spirulina algae:

The minerals content of hard and soft wheat flour (72%ext.) and spirulina algae are shown in Table (6) The major element detected in hard and soft wheat flour was potassium (219.3 and 117.3 mg/100g),while the other elements were arranged as follows, magnesium (160.85 and 113.40 mg/100g), calcium (30.20 and 20.0 mg/100g), sodium (4.60 and 4.10 mg/100g), iron (2.18 and 1.23 mg/100g), copper (0.82 and 0.54 mg/100g) manganese (2.88 and 0.71mg/100g) and zinc (1.08 and

0.94 mg/100g) respectively. Spirulina algae was higher in mineral elements of K, P,Na, Ca, Fe, Mn and Zn were 2180.79, 1899.71, 1500.16, 1042.92, 336.96, 6.92 and 4.49 mg/100g respectevly.These findings agree with Diaa *et al.* (2014) where he mentioned that spirulina is a rich source of potassium and contains considerable amounts of calcium, copper, iron, magnesium, manganese, phosphorus, sodium and zinc.

Table 5: Chemical composition of raw material (g/100g).

Raw materials	Component					
	Protein (%)	Ash (%)	Crude Fiber (%)	Crude fat (%)	Moisture (%)	carbohydrates
Hard wheat flour (72% ext.)	12.40^{b}	0.76^{b}	0.67^{b}	1.04^{b}	12.10^{a}	85.13^{a}
Soft wheat flour (72%ext.)	10.70^{b}	0.48^{b}	0.50^{b}	0.65^{c}	13.00^{a}	87.67^{a}
Spirulina	61.50^{a}	7.00^{a}	7.90^{a}	7.10^{a}	5.40^{b}	16.50^{b}
LSD 0.5	2.01	0.12	1.03	0.094	2.09	0.94

Means in the same column with different letter are significantly different ($P \leq 0.05$).

Table 6: Minerals content of hard wheat flour, soft wheat flour and spirulina algae (mg/100g).

	Minerals	Minerals concentation (mg/100g)		
		Hard wheat flour	Soft wheat flour	Spirulina algae
Macro elements	**Potassium (K)**	219.30	117.30	2180.79
	Calcium (Ca)	30.20	20.00	1042.92
	Magnesium (Mg)	160.85	113.40	1.39
	Sodium (Na)	4.60	4.10	1500.16
	Phosphor (P)	13.7	11.00	1899.71
Micro elements	**Iron (Fe)**	2.18	1.23	336.96
	Copper (Cu)	0.82	0.54	1.40
	Manganese (Mn)	2.88	0.71	6.92
	Zinc (Zn)	1.080	0.94	4.49

Sensory evaluation of crackers and instant noodles:

From the presented results in Tables (7, 8) it could be noticed that the sensory characteristics were decreased with increasing the level addition of spirulina. Also, it could be noticed that instant noodles and crackers produced from hard and soft wheat flour with addition of spirulina algae until level 15%, still have good overall acceptability which was (82.97 and 80.00%) in instant noodles and crackers, and have no significant differances between 5and 10% levels of spirulina, so these levels of supplementation were selected with their control sample to continue the investigation, in order to study their physical properties, chemical composition, antioxidation activity and cooking quality parameters.

Table 7: Sensory evaluation of produced supplemented crackers with spirulina algae.

Blends	Color (20)	Taste (20)	Texture (20)	Appearance (20)	Odor (20)	Total score 100	Acceptance
Control	16.45^{b}	16.35^{b}	18.83^{b}	15.00^{c}	18.50^{a}	85.13^{b}	G
Blend (1)	17.37^{a}	18.20^{a}	19.80^{a}	18.70^{a}	16.30^{b}	90.30^{a}	V
Blend (2)	17.36^{a}	18.15^{a}	19.51^{a}	18.69^{a}	16.29^{b}	90.00^{a}	V
Blend (3)	15.85^{c}	15.55^{c}	18.85^{b}	15.60^{b}	14.15^{c}	80.00^{c}	G
Blend (4)	12.38^{d}	13.33^{d}	13.33^{c}	12.38^{d}	10.66^{d}	62.08^{d}	Un s
LSD 0.5	0.277	0.313	0.579	0.423	0.573	0.245	----

90-100 Very Good (V). 80-89 Good (G). 70-79 Satisfactory (S). Less Than (70) unSatisfactory
Means in the same column with different letter are significantly different ($P \leq 0.05$).

Table 8: Sensory evaluation of produced supplemented instant noodles with spirulina algae.

Blends	Appearance (20)	Color (20)	Tenderness (20)	Flavor (20)	Stickiness (20)	Overall acceptability (100)	Acceptance
Control	18.10^{b}	17.60^{c}	18.40^{a}	17.40^{b}	18.00^{b}	89.50^{b}	G
Blend (1)	19.20^{a}	19.20^{a}	18.20^{a}	18.90^{a}	19.80^{a}	95.30^{a}	V
Blend (2)	18.90^{a}	18.90^{b}	17.90^{b}	18.33^{a}	19.70^{a}	93.73^{a}	V
Blend (3)	15.80^{c}	15.40^{d}	17.00^{c}	17.77^{b}	17.00^{c}	82.97^{c}	G
Blend (4)	12.90^{d}	12.60^{e}	12.20^{d}	13.80^{c}	12.80^{d}	64.30^{d}	Un s
LSD 0.5	0.302	0.202	0.268	0.584	0.385	0.424	-----

90-100 Very Good (V). 80-89 Good (G). 70-79 Satisfactory (S). Less Than (70) unSatisfactory
Means in the same column with different letter are significantly different ($P \leq 0.05$).

Rheolgical evaluation of hard and soft wheat flour and their blends with spirulina algae:

Data in Table (9) showed that the water absorption was increased from 54.60 % to 62.00 %, and from 60.50% to 65.50%, respectively in soft and hard wheat flour, with adding 15% of spirulina algae. Similarly, dough development time was also increased from 1.50 to3.00 min., and 1.50 min. to 3.50 min., respectively,in soft and hard wheat flour. This may be due to the delay in hydration time of the fibers in spirulina. On the other hand, dough stability was decreased with the increase in the spirulina level. This study may be due to the disruption of the protein and fiber particles . Results of this may be correlated with the earlier studies, which were reported about the increase in the water absorption and dough development time with the use of multigrain mixture in bread preparation (Indrani *et al*. 2010 and Mohammed and Cornelia 2011).

Table 9: Farinograph parameters of dough used to prepare crackers and instant noodles from soft and hard wheat flour and their blends with spirulina algae

Blends	Farinograph parameter									
	Water absorption (%)		Mixing time.(min)		Development time.(min)		Stability time .(min)		Degree of weakening (B.U)	
Control	54.60	60.5	0.5	0.75	1.50	1.50	8.5	9.00	90	120
Blend (1)	55.10	62.00	1.00	1.50	2.00	2.5	7.00	8.00	100	110
Blend (2)	58.50	63.00	1.50	1.90	2.5	3.00	5.50	6.50	130	120
Blend (3)	62.00	65.5	1.75	2.30	3.00	3.5	4.00	5.00	140	130

Table (10) Summarize data obtained from the extensogram. The results showed that, in general, increasing the addition of spirulina algae reduced the energy, the resistance to extension, extensibility, and maximum resistance of the dough to extension; while the ratio number between resistance and extensibility was increased. The decrease in energy may be that less work would be needed to stretch and break the dough as Spirulina algae increased. Also Similar findings were reported by Carson *et al.* (2000) reported that addition of high fiber foods as spirulina to wheat flour produces marked negative effects on rheological properties of dough. The decrease in energy, resistance and extensibility of dough may be due to the presence of appreciable amounts of crude fiber which give a strong and rigid dough .

Table 10: Extinsograph parameters of dough used to prepare crackers and instant noodles from soft and hard wheat flour and their blends with spirulina algae

Blends	Extinsograph parameter							
	Resistance toextension		Extensibility		Proportional number.(R/E)		Energy(cm2)	
	Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard
Control	560	670	160	175	3.50	3.83	110	130
Blend (1)	540	650	140	168	3.86	3.87	90	120
Blend (2)	500	620	120	145	4.28	4.00	82	115
Blend (3)	480	585	110	130	4.50	4.18	75	100

Chemical composition of produced crackers and instant noodles supplemented with spirulina algae:

Data in Table (11) show the chemical composition of produced crackers and instant noodles. They had high value of protein, ash, crude fiber and fat and low value of total carbohydrate compared with the control sample (cracker and instant noodles without spirulina algae). Samples of crackers which contained spirulina algae powder contain protein content ranged from 13.78-19.93%, fat 1.01-1.73%, ash 0.84-1.55%, crude fiber 0.90-1.69 % and available carbohydrate 83.47-75.10 % while the control sample contain protein 10.69%, ash 0.48%, crude fiber 0.50%,fat 0.64% and total carbohydrate 87.69% Also instant noodles with spirulina algae contain protein content 15.48-21.64%, ash 1.12-1.83%, crude fiber 1.10-1.86 % and fat 1.40-2.12% and available carbohydrate 80.90-72.55 % while the control sample contain protein 12.10%, ash 0.75%, crude fiber 0.50 %fat 1.04% and available carbohydrate 85.61.

These results are in agreement with those found by Vijayarani *et al.* (2012),Nour El-Deen (2013) and Joshi *et al.*(2014).

Table 11: Chemical composition of produced crackers and instant noodles suplemented with spirulina algae (g/100g).

Sample	Chemical composition of crackers					Chemical composition of instant noodles				
	Protein	Ash	Crude fiber	Fat	* Available carbohydrates	Protein	Ash	Crude fiber	Fat	* Available carbohydrates
Control	10.69d	0.48d	0.50d	0.64d	87.69a	12.10d	0.75d	0.50d	1.04d	85.61a
Blend (1)	13.78c	0.84c	0.90c	1.01c	83.47b	15.48c	1.12c	1.10c	1.40c	80.90b
Blend (2)	16.86b	1.19b	1.30b	1.37b	79.28c	18.56b	1.47b	1.45b	1.76b	76.76c
Blend (3)	19.93a	1.55a	1.69a	1.73a	75.10d	21.64a	1.83a	1.86a	2.12a	72.55d
LSD 0.05	0.179	0.090	0.289	0.113	1.64	0.160	0.138	0.160	0.189	1.64

*Calculated by difference. Carbohydrates =100-% (Protein +Fat +Crude fiber +Ash)
Means in the same column with different letter are significantly different ($P \leq 0.05$).

Minerals content of produced suplemented crackers and instant noodles with spirulina algae:

Data presented in Table (12) showed the minerals content of crackers and instant noodles samples which contained spirulina algae powder. They had high values in all minerals content compared with the control sample (crackers and instant noodles without spirulina algae).Hence crackers and noodles samples containing spirulina algae powder are favorable because of their high content of important minerals which depend upon the spirulina algae powder levels of substitution. These results are in agreement with Carolin *et al*. (2015).

Table 12: Minerals content of produced crackers and instant noodles suplemented with spirulina algae

Blends	Instant noodles								
	Ca	K	Mg	Na	P	Cu	Fe	Mn	Zn
Control	20.00	117.3	113.40	4.00	11.00	0.82	1.23	0.710	1.08
Blend (1)	72.18	226.29	113.47	79.61	106.89	0.90	18.17	1.06	1.30
Blend (2)	124.36	335.57	113.55	155.12	202.77	0.97	35.11	1.411	1.53
Blend (3)	176.54	444.85	113.63	230.63	298.66	1.05	52.04	1.76	1.75
Treatment	**Crakers**								
	Ca	K	Mg	Na	P	Cu	Fe	Mn	Zn
Control	30.20	219.30	160.85	4.60	13.70	0.54	2.18	2.88	3.94
Blend (1)	82.38	328.77	160.92	79.69	109.59	0.616	18.12	3.23	4.17
Blend (2)	107.56	438.04	160.99	155.63	205.47	0.692	36.06	3.582	4.39
Blend (3)	186.74	547.11	161.07	231.14	301.36	0.740	52.99	3.99	4.61

Cooking properties of produced instant noodles suplemented with spirulina algae:

The cooking quality of instant noodles those prepared with the addition of 5,10 and 15 % of spirulina, was evaluated by cooked weight and cooking loss, (Table 13).The percentage of weight gain and percentage of volume gain of instant noodles suplemented with spirulina was higher than the control sample. This may be due to the higher swelling power of instant noodles suplemented with spirulina compared with the control sample. Instant noodles with spirulina showed in contrast cooking loss.These results are similar with those obtained by Zahran *et al.,* (2004).

Table 13: Cooking quality properties of produced instant noodles suplemented with spirulina algae.

Blends	Cooking time (min)	Percentage of volume gain (%)	Percentage of weight gain (%)	Cooking lose (T.S.S%)
Control	4.50	175	190	5.30
Blend (1)	4.50	182	199	5.70
Blend (2)	4.50	191	210	5.90
Blend (3)	4.50	211	229	6.70

Data in Table (14) showed the firmness which is positively affected by the inclusion of spirulina algae, compared to the control sample. The increase of instant noodles firmness may be related to the addition of components rich in protein that, probably have a significant influence in the reinforcement of the gluten network (Abd El-slam ,2005).

Table 14: Effect of steaming process on firmness of produced instant noodles suplemented with spirulina algae.

Instant noodles sample	Steaming time (min)	Firmness (shear force) Kg / cm^2 Force
Control	2.30	0.22
Blend (1)	2.30	0.25
Blend (2)	2.30	0.30
Blend (3)	2.30	0.40

Physical properties of crackers supplemented with spirulina alga.

From the results presented in table (15), it could be noticed that all samples of crackers products supplemented with spirulina algae were increased in total moisture content from 5.90 to7.80 % compared with control sample 4.70. Also results observed that the diameter (mm) was increased with supplementation ranged from 48.80 to 53.00 mm.The Expansion factor (D/T) was increased with supplementation ranged from 10.84 to 15.14 and 8.76 in control. The results also showed that the specific volume (volume / weight ratio) was decreased with crackers supplementation with spirulina algae ranged from 2.33to2.20 and 2.93cm^3/g in control. These results are confirmed by those obtained byAziah *et al.* (2012).

Table 15: Physical properties of produced crackers supplemented with spirulina algae.

Blends	Moisture %	Diameter(D) (mm)	Thickness (mm)	Expansion (D/T)	Volume (cm3)	Weight(g)	specific volume ratio(cm^3/g)
Control	4.70	42.90	4.90	8.76	11.70	4.90	2.39
Blend (1)	5.90	48.80	4.50	10.84	11.90	5.10	2.33
Blend (2)	5.50	50.50	4.00	12.63	12.25	5.50	2.23
Blend (3)	7.80	53.00	3.50	15.14	13.40	6.10	2.20

Conclusion

Finally, it could be concluded that the use of spirulina at 5–10% for the manufacture of crackers and instant noodles considerably improves the textural and sensory properties of the final products.Spirulina fortification also increase the protein content, levels of vitamins and essential amino acids in products. The cooking quality of instant noodles was not affected by addition spirulina algae to the instant noodles, especially cooking losses, resulted in a very attractive colour (green) products due to the major pigments that exist in the algae. Also, importance from a nutritional viewpoint and thus spirulina provides a novel opportunity for the manufacture of healthy bakery products.

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