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Evaluation of gluten-free noodles fortified by Spirulina algae

Youssef M. Riyad[(1)], Mai M.M. Naeem[(2)] and Salwa Slama[(2)]

[(1)]Food Science Department, Faculty of Agriculture
Cairo University, Giza, Egypt.
[(2)]Department of Special food and nutrition, Food Technology
Research Institute, Agricultural Research Center, Giza, Egypt.

Abstract

Spirulina is a unique algae. It is very rich in nutrients. Therefore, gluten-free noodles made from potato flour was fortified to raise its nutritional value by adding 5, 10 and 15% spirulina algae, as it is a suitable food for people suffering from celiac disease. The chemical composition of the spirulina algae, potato flour and gluten free noodles were determined. Vitamins, minerals, heavy metals, amino acids, pigments contents and in vitro protein digestibility were determined. The sensory characteristics of gluten-free noodles fortified with spirulina algae were also evaluated. The results indicated that heavy metals contents of spirulina algae (arsenic, cadmium, lead and mercury) were under the permeable limits according to the Egyptian Standards. The results indicated that the spirulina algae was rich in vitamins (with highest contain of inositol, 57.78 mg/100g), minerals (P 2100, K 1996, Ca 728 and Fe 438 mg/100g), from the determined pigments phycocyanin pigment showed the highest content (13.85%) and chlorophyll (1.5%). The total essential amino acids and non-essential amino acids of the spirulina algae were found approximately 38.97% and 61.05%of

protein content, respectively. Addition levels of 5%, 10% and 15% of spirulina algae to potato flour led to increase the contents of protein by about 24%, 49% and 73% respectively, Ca by 66, 275 and 423% respectively, P by 528, 1192 and 1734% respectively, K by 40, 84 and 159% respectively, Fe by 348, 576 and 952% respectively and in vitro protein digestibility values by 11, 21 and 32% respectively compared to control sample. Results of the sensory evaluation revealed that addition of spirulina algae powder to potato flour at levels up to 15% could be recommended, since all the produced noodles scored higher values for all the evaluated sensory characteristics compared to control sample.

Introduction

Spirulina is a microalgae rich in protein content that reached to 70%, so many nutritionists consider it an unconventional food source (***Benahmed-Djilali, 2012***). The algae could play an important role in some countries to meet the challenge of self-sufficiency of food and also have other functions such as treatment of some diseases (***Fox, 1999***).

Blue or green filamentous spirulina (microalgae) is a source of high biological value because it is considered a rich source of protein, vitamins, especially vitamin A and vitamin B12 and rich in minerals, especially iron, as well as it rich in essential fatty acids especially γ-linolenic acid, which are very important in the synthesis of prostaglandins (***Habib et al., 2008***).

Spirulina contains many compounds that have antioxidant activity both in vitro and in vivo, such as carotene, alpha-tocopherol, phycocyanin, xanthophyll and phenolic compounds (***Mao et al., 2005 and Patel et al., 2006***).

Spirulina contains a complete protein with a high digestibility index, where the proportion of protein up to about 60%. It contained all the essential amino acids and is one of the most nutrient sources rich in contents of beta-carotene, gamma linolenic fatty acid, vitamins B, minerals, trace elements, enzymes and chlorophyll as well as other valuable nutrients such as carotenoids, sulfolipids, glycolipids, phycocyanin, superoxide dismutase, RNA and DNA (***Henrikson, 2010; Moorhead et al., 2011 and Parry, 2014***). Micro-algae can be a sustainable alternative as coloring agents, resulting in products similar to vegetable-based pasta that presents nutritional advantages over synthetic colorings (***Fradique et al., 2010***).

One of the applications where spirulina has been used in human food is instant noodles for children (***Xu, 1993***). Noodles is a food product that most people of all ages love and prefer (***Keyimu, 2013 and Martin et al., 2004***).

Celiac disease (CD) is a digestive disease that damages the small intestine and interferes with absorption of nutrients from food. Celiac disease is an ailment caused by an abnormal immune response to gluten proteins in wheat, rye, barley and possibly oats products. About 1-2% of the world's population suffers from this disease (***Reilly et al., 2011***). When celiac patients eat any food that contains gluten protein, this leads to villi atrophy from the small intestine, causing severe stomach pain, swelling, diarrhea and weight loss. It was also noted that these patients suffer from a lack of micronutrients due to the failure of absorption by the small intestine (***Green and Cellier, 2007***).

Some scientists have studied the effect of adding nutrients such as dietary fiber, vitamins and minerals from natural sources on the quality of pasta noodles (***Kulkarni et al., 2012***). Potato is an

important food crop where the world produces about 300 million metric tons annually (***International Potato Center 201***5).

The objective of this investigation was to study the effect of added spirulina algae as source of protein on physico-chemical characteristics, cooking quality and sensory properties of cooked gluten free noodles.

Materials and methods

Materials:

The blue green algae *Spirulina platensis* (free from impurities like pesticides, rodent hairs and insect fragments) was obtained from Algal Biotechnology Unit, National Research Centre, Dokki, Giza, Egypt. Potato flour was purchased from the local market in Giza, Egypt.

Methods:

Chemical analysis

Spirulina algae, potato flour and gluten free noodles were analyzed for its moisture, ash, protein, crude fiber and fat according to the methods of ***AOAC (2005)***. Nitrogen free extract (N.F.E.) was calculated 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 by ***Haeng-Shin et al., (2006)***.

Determination of phytopigments and vitamins

Phytopigments and vitamins (Thiamine, riboflavin, niacin, pyridoxine, cobalamin, folic acid, inositol, E, K, pantothenate and

biotin) were determined by the HPLC system method according to ***AOAC (2005)***.

Processing of gluten free noodles fortified by spirulina algae

Gluten free noodles fortified by spirulina algae formulas were prepared using a mixture of commercial potato flour, water and different ratio of spirulina algae (5, 10 and 15% w/w) as shown in Table **1**. The gluten free noodles with and without spirulina algae (control) were prepared according to Owen (2001) and then packed in polyethylene bags and stored at room temperature for 6 months.

Cooking quality of gluten free noodles fortified by spirulina algae

Cooking losses

The weight gain and cooking loss of gluten free noodles fortified by spirulina algae were determined according to the method described by ***Lai (2002).***

Sensory evaluation of cooked gluten free noodles fortified by spirulina algae

The sensory evaluation was carried out in order to get consumer response for overall acceptability of the gluten free noodle fortified by spirulina algae compared to the traditional noodle. Ten panelists from Food Technology Research Institute, Agricultural Research Center evaluated the sensory characteristics of the cooked noodles, i.e., texture, taste, color, and overall acceptability according to the method of ***Jayasena et al., (2008).***

In vitro protein digestibility

In vitro protein digestibility of gluten free noodle and gluten free noodle fortified by spirulina algae were carried out using the method of ***Mertz et al. (1983).***

Statistical analysis

All the obtained data were subjected to statistical analyses at least significant difference (L.S.D. at 0.05 level). Analysis of variance was used to compare between means by Duncan multiple range at significance 5%. Means with different letters are significantly different. ANOVA was carried out by Statistical Analysis System ***SAS Program, (1996)***.

Results and discussion

Vitamins, minerals, heavy metals and pigments contents of spirulina algae

The results presented in Table **2** indicated that heavy metals contents of spirulina algae (arsenic, cadmium, lead and mercury) were under the permeable limits according to the ***Egyptian Standards for heavy metals (2007)***. These results are in agreement with ***Haeng-Shin et al. (2006).*** These results revealed that obtained spirulina algae could be considered healthy material and could be used in food products.

Spirulina algae as indicated in Table **2** was found to be contained B1, B2, B3, B6, B12, folic acid, pantothenate, biotin, inositol, E and K vitamins. Inositol showed the highest content (57.78 mg/100g), also biotin content was the lowest (8.52 µg/100g). These results are in agreement with ***Sharoba (2014) andVijayarani et al. (2012)*** they reported that spirulina contains complete vitamin B

groups as well as vitamins A, E, H, K and they also found that inositol is the highest. While, ***Fox (1993)*** reported that spirulina contain vitamin B12 more than cow liver.

Concerning minerals contents, the results presented in the same Table indicated that P showed the high amounts (2100 mg/100g), followed by k (1996 mg/100g), then Ca (728 mg/100g) and finally Fe (438 mg/100g). However, the lowest value was that of Mg (74 mg/100g). These results are in agreement with those obtained by ***Shimamatsu (2004) and Branger et al. (2003).*** They reported that spirulina is an excellent source of minerals and it contains essence minerals like calcium, magnesium, potassium, phosphorus, iron, and zinc. ***Fox (1993)*** reported that spirulina contain calcium more than milk.

The same results showed also the presence of some phytopigments (β-carotenoids, xanthophylls, zeaxanthin, chlorophyll and phycocyanin). However, phycocyanin showed the highest content (13.85%)followed by chlorophyll (1.5%). Zeaxanthin recorded the lowest content (119µg/100g). The blue green color of algae *Spirulina platensis* could be related to phycocyanin and chlorophyll phytopigments. These results are in agreement with those obtained ***by Fox (1993) and Sharoba (2014)*** which reported that *spirulina platensis* contained phycocyanin.

Phycocyanin is a nontoxic blue pigment in Spirulina and can act as a free radical scavenger and has a powerful antioxidant. Studies have shown that phycocyanin can exert a wide range of anti inflammatory effects. It has been claimed that consumption of Spirulina is beneficial to health due to its chemical composition. ***Dolly***

(2014) reported that the anti-oxidant phycocyanin can only be found in spirulina.

Amino acids contents of potato flour and spirulina algae

The results presented in Table **3** indicated that potato flour and spirulina algae contained approximately same percentages of total essential amino acids (36.07 and 38.97% of protein content, respectively). Spirulina algae was found to contain isoleucine, leucine, lysine, methionine and tryptophan amino acids in percentages higher than those of potato flour, while the reverse was observed for phenylalanine, threonine and valine amino acids. Concerning non-essential amino acids, it was also found that potato flour and spirulina algae contained approximately the same percentage (63.95 and 61.05% of protein content, respectively). However, spirulina algae was found to contain higher percentage of alanine, arginine, cysteine, glycine and proline amino acids than those of potato flour. The reverse was observed for aspartic, glutamic, histidine, serine and tyrosin amino acids. ***Vijayarani et al. (2012)*** found that spirulina contains all the essential amino acids in fairly high amounts. It contains 18 of the 20 known amino acids and it is an excellent source of proteins with high quality. ***Mudambi and Rajagopal (1990)*** mentioned that potato protein has particularly favorable lysine content in comparison with cereal proteins, whose amino acid scores are much lower. ***Murray et al. (1998)*** reported that the basic role of potato protein in nutrition is the contribution to sufficient amounts of essential amino acids for protein endogenous synthesis by human body.

Chemical composition of raw materials and gluten free noodles fortified by different concentrations of spirulina algae and *in vitro* protein digestibility

The results presented in Table **4** indicated that spirulina algae contained high amount of protein, fat and crude fiber compared to potato flour, while ash content was found to be approximately the same. Potato flour contained N.F.E. higher than that of spirulina algae. The protein content of spirulina algae represent about tenfold compared to potato flour. So, it could be added to potato flour to raise the protein content. These results are in agreement with those reported by ***Shah (2001***) who mentioned that spirulina is a blue multicellular bacterium which used as a food source from ancient times, and the protein content reaches 55% to 70% based on dry weight.***Spolaore et al., (2006)*** reported that spirulina is an excellent source of proteins, it is complete proteins in comparison with other protein sources which have very negative properties. ***Vijayarani et al., (2012)*** found that spirulina contained protein (62.84 %) higher than any other natural food. However, potato flour was reported to contain 6.9% protein (***Singh et al., 2007***).

However gluten free noodleswere prepared using potato flour which mixed with spirulina algae at level of 5, 10 and 15% to be suitable for celiac disease. The chemical components of the resulted gluten free noodle were determined and the results are presented in the same Table. From these results it could be observed that addition of spirulina algae lead to increase the protein contents of the gluten free noodle by about 24%, 49% and 73% for addition levels of 5%, 10% and 15%, respectively compared to control gluten free noodle. Fat content, was also increased by about 40%, 81% and 121% and ash increased by 62%, 80% and 120% for the same addition levels, respectively compared to control gluten free noodle. However, slightly

increase was observed for crud fiber contents of the prepared gluten free noodle which contained spirulina alga. N.F.E. contents of the resulted gluten free noodle were decreased by about 4%, 8% and 12% with addition of spirulina alga at levels of 5, 10 and 15%, respectively compared to control gluten free noodle. Similar results were reported for noodles made of composite flour of wheat, two microalgae flours (*Chlorella vulgaris* and *Spirulina platensis*), and a seaweed flour (*Eucheuma cottonii*) (***Kumoro et al., 2016***).

Moreover the protein contents of the gluten free noodles and gluten free noodles fortified by different concentrations of spirulina algae were evaluated for its digestibility (*in vitro)* and the results are shown in the same Table. The results showed that *in vitro* protein digestibility value of the gluten free noodles was 61.32%. Adding spirulina algae with 5, 10 and 15% led to increase the *in vitro* protein digestibility values by about 11, 21 and 32%, respectively. The *in vitro* protein digestibility values increased by increasing the addition of spirulina algae. Protein contents in the fortified noodles were found to be increased significantly with the increase in the added spirulinapowder, the increased in protein content could be due to the high content of protein in spirulina (64.4%). Our results are in agreement with those reported by (***Tomaselli, 2004; Marco et al., 2014 and Ghaly et al., 2015***). Also, these results are in agreement with ***Saharan and Jood (2017)*** which reported that adding spirulina to fortify bread led to increase *in vitro* protein digestibility values.

Mineral contents of gluten free noodles fortified by spirulina algae

Spirulina is an excellent source of minerals and it contains essence minerals like calcium, magnesium, potassium, phosphorus, iron, and zinc (***Branger et al., 2003***). The mineral contents of the

gluten free noodleswhich prepared by mixing of potato flour with spirulina algae at levels of 5, 10 and 15% were determined and the obtained results are presented in Table **5**. Form these results it could be observed that addition of spirulina alga to potato flour lead to increase Ca contents of the gluten free resulted noodles by about 66, 275 and 423%, P contents by about 528, 1192 and 1734%, K contents by about 40, 84 and 159% and Fe by about 348, 576 and 952% for addition levels of 5, 10 and 15%, respectively compared to the control gluten free noodles. Mg contents of control noodle and other treatments which contained the same levels of spirulina algae were found to be approximately the same. These results revealed that spirulina algae cold be considered good source for minerals. These results are in agreement with ***Carolin et al., (2015).***

Cooking quality of gluten free noodles fortified by spirulina algae

Cooking losses are an important indicator of the overall spaghetti cooking performance for both consumers and industry, being mainly influenced by dissolving and releasing gelatinized starches from the surface of pasta through cooking water (***Brennan et al., 2003***). The results presented in Table **6** indicated also that there are small significant differences in cooking loss and water absorption between the gluten free noodles samples that containing spirulina algae at levels of 5, 10 and 15% and the control sample. While, volume increase values were higher than those of control sample. Volume increase values were increased by about 39, 62 and 87% for the same addition levels of spirulina algae, respectively. These results may be attributed to the ability of the alga to absorb water and retain it in the protein–starch net as explained by ***Prabhasankar et al., (2009)***, who mentioned that the addition of dried seaweeds to pasta, led to increase the volume of the resulted

product which being related to the hydration afforded by the hydrocolloids present in the seaweed powder.

Sensory evaluation of the gluten free noodles fortified by spirulina algae

From the results presented in Table **7** it could be observed that control samples (gluten free noodles) and samples fortified with 5, 10 and 15% of spirulina algae were found to be significantly different for their appearance, taste, color, odor, firmness and total acceptability. However, the gluten free noodles sample which fortified by 10% of spirulina algae recorded the highest values for the evaluated characteristics compared to other treatments followed by the gluten free noodles which fortified by 5% of spirulina algae. The gluten free noodles sample fortified by 15% of spirulina algae recorded high values for all the evaluated characteristics compared to control sample with exception of appearance. These results revealed that addition of spirulina algae to potato flour at levels up to 15% could be recommended, since all the produced noodles scored higher values for all the evaluated characteristics compared to control sample.

These results are in agreement with ***Abd El-Salam et al., (2017).*** They found that instant noodles and crackers with addition of spirulina algae till level of 10% resulted very good overall acceptability and with 15% addition level in the resulted products showed good overall acceptability.

Conclusion

The results showed that using 5, 10 and 15% of the spirulina alga with potato flour was able to prepare noodles with high nutritional value in terms of protein, minerals, vitamins and essential amino acids. Meanwhile, these noodles are gluten-free and suitable for people suffering from celiac disease.

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Table 1. Formula of gluten free noodles fortified byspirulina algae prepared from potato flour and different ratio of spirulina algae.

Ingredients(g)	Treatments			
	Control	5%	10%	15%
Potato flour	967.6	917.6	867.6	817.6
Spirulina algae	-	50	100	150
Guar gum	2.4	2.4	2.4	2.4
Salt	30	30	30	30

Table 2. Vitamins, minerals, heavy metals and phytopigments contents ofspirulina algaefor each of 100 g (on dry weight basis).

Vitamins		Minerals (mg)		Phytopigments	
Components	Content	Components	Content	Components	Content
B1 (mg)	5.25	Ca	728	β – carotenoids (µg)	240
B2 (mg)	4.84	P	2100	Xanthophylls (µg)	281
B3 (mg)	16.99	K	1996	Zeaxanthin (µg)	119
B6 (mg)	0.92	Mg	74	Chlorophyll (%)	1.500
B12 (µg)	190	Fe	438	Phycocyanin (%)	13.85
Folic acid (mg)	8.89	Heavy metals (ppm)			
Pantothenate (µg)	140				
Biotin (µg)	8.52	Arsenic	< 0. 09		
Inositol (mg)	57.78	Cadmium	< 0. 04		
E (mg)	9.62	Lead	< 0. 04		
K (µg)	1135	Mercury	< 0.006		

Table 3. Amino acids content of potato flour and spirulina algae (% of protein).

Amino acids	Potato flour	spirulina algae
Essential amino acids		
Isoleucine	3.93	6.57
Leucine	5.76	7.78
Lysine	3.91	4.56
Methionine	0.97	2.45
Phenylalanine	6.22	4.50
Threonine	5.67	4.78
Valine	8.91	6.40
Tryptophan	0.70	1.93
Total	36.07	38.97
Non-essential amino acids		
Alanine	3.90	7.33
Arginine	4.43	7.73
Aspartic	18.16	11.25
Cysteine	0.80	1.21
Glutamic	14.98	13.70
Glycine	4.80	5.23
Histidine	3.35	2.71
Proline	3.85	4.39
Serine	5.70	4.16
Tyrosin	3.98	3.34
Total	63.95	61.05

Table 4. Chemical composition of raw material and gluten free noodles fortified by different concentrations of spirulina algae and *In vitro* protein digestibility (g/100g on dry weight basis).

Components		Protein	Fat	N.F.E.*	Ash	Crude fiber	In vitro protein digestibility (%)
Potato flour		6.710 ±0.162b	0.15 ±0.013b	83.4 ±0.216a	6.22 ±0.025b	3.52 ±0.165b	-
Spirulina algae		64.4 ±0.0a	6.48 ±0.0a	15.12 ±0.0b	6.75 ±0.01a	7.27 ±0.02a	-
Gluten free noodles		10.42 ±0.00d	0.68 ±0.06d	85.01 ±0.06 a	0.71 ±0.02d	3.16 ±0.06d	61.32 ± 0.62d
Gluten free noodles fortified by spirulina algae	5%	12.96 ±0.06c	0.95 ±0.00c	81.59 ± 0.02 b	1.15 ±0.00c	3.35 ±0.00c	68.17 ± 0.13c
	10%	15.49 ±0.04b	1.23 ±0.08b	78.47 ±0.01 c	1.28 ±0.02b	3.53 ±0.02b	74.47 ± 0.55b
	15%	18.03 ±0.00a	1.50 ±0.02a	75.18 ± 0.00 d	1.56 ± 0.08 a	3.73 ± 0.00a	81.04 ± 0.24a

Values are meaning of three replicates ± SD, number in the same column for each (potato flour and spirulina algae) and (Gluten free noodles) followed by the same letter is not significantly different at 0.05 level.

* N.F.E: Nitrogen free extract was calculated by difference.

Table 5. Mineral contents of gluten free noodle fortified by spirulina algae.

	Gluten free noodle	Gluten free noodle fortified by spirulina algae		
		5%	10%	15 %
Mineral contents (mg/100g)				
Ca	51.3	85.1	192.3	268.5
P	19.70	123.7	254.5	361.2
K	222.5	311.2	409.1	576.5
Mg	60.27	61.02	61.29	62.87
Fe	6.2	27.8	41.9	65.2

Values are meaning of three replicates ± SD, number in the same row followed by the same letter is not significantly different at 0.05 level.

Table 6. cooking quality of gluten free noodle fortified by spirulina algae.

	Gluten free noodle	Gluten free noodle fortified by spirulina algae		
		5%	10%	15 %
Cooking quality (%)				
Cooking loss	6.35 ± 0.02^{d}	7.14 ± 0.16^{a}	6.98 ± 0.17^{c}	7.08 ± 0.06^{b}
Volume increase	103.45 ± 0.08^{d}	144.25 ± 0.02^{c}	167.40 ± 0.48^{b}	193.21 ± 0.51^{a}
Water absorption	79.13 ± 0.85^{d}	83.43 ± 0.70^{c}	85.73 ± 0.65^{b}	89.76 ± 0.25^{a}

Values are meaning of three replicates ± SD, number in the same row followed by the same letter is not significantly different at 0.05 level.

Table 7. Sensory evaluation of gluten free noodle fortified by spirulina algae.

Parameter (10)	Glutenfree noodle	Gluten free noodle fortified by spirulina algae		
		5%	10%	15%
Appearance	8.60±0.87 [c]	8.87±0.53 [b]	9.25±0.49 [a]	8.37±0.33 [d]
Taste	8.45±0.45 [d]	8.80±0.62 [b]	9.08±0.33 [a]	8.60±0.22 [c]
Color	8.23±0.53[d]	8.96±0.65 [b]	9.65±0.26 [a]	8.86±0.45 [c]
Odor	8.80±0.63 [d]	9.12±0.41 [b]	9.40±0.25 [a]	9.02±0.31 [c]
Firmness	8.60±0.66 [d]	8.95±0.76 [b]	9.50±0.17 [a]	8.65±0.46 [c]
Total acceptability	8.57±0.63 [d]	8.96±0.59 [b]	9.44±0.30 [a]	8.76±0.29 [c]

Values are meaning of three replicates ± SD, number in the same row followed by the same letter is not significantly different at 0.05 level.

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تقييم النودلز الخالي من الجلوتين والمدعم بطحلب الاسبيرولينا

يوسف مصطفي رياض[١] مي محمد مجدي نعيم[٢] سلوي سلامة[٢]

[١]قسم علوم الأغذية، كلية الزراعة، جامعة القاهرة، الجيزة، مصر.

[٢]قسم بحوث الأغذية الخاصة والتغذية، معهد بحوث تكنولوجيا الأغذية، مركز البحوث الزراعية، الجيزة، مصر.

الملخص العربي

يعتبر الاسبيرولينا طحلب غني جداً بالمغذيات. لذلك تم تدعيم النودلز المجهز باستخدام دقيق البطاطس التي تعتبر خالية من الجلوتين مع اضافة ٥, ١٠, ١٥% من طحلب الاسبيرولينا لرفع القيمة التغذوية. تم تقدير التركيب الكيماوي لكل من طحلب الاسبيرولينا ودقيق البطاطس والنودلز الخالي من الجلوتين وكذلك المدعم بالاسبيرولينا. كذلك تم تقدير المحتوي من المعادن الثقيلة والصبغات النباتية في الطحلب وقابلية البروتين للهضم معملياً للنودلز الناتجة. كما تم تقييم الخصائص الحسية للنودلز الخالي من الجلوتين وكذلك المدعم بالاسبيرولينا. ودلت النتائج علي ان طحلب الاسبيرولينا يحتوي علي المعادن الثقيلة (الزرنيخ والكادميوم والرصاص والزئبق) في الحدود المسموح بها في المواصفة القياسية المصرية. دلت النتائج ايضاً أن طحلب الاسبيرولينا غني في محتواه من الفيتامينات وكان الانسيتول هو الاعلي في نسبته (٥٧,٧٨ ملجم/١٠٠جم) والمعادن (الفسفور ٢١٠٠، البوتاسيوم ١٩٩٦، الكالسيوم ٧٢٨، الحديد ٤٣٨ ملجم/١٠٠جم) ومن الصبغات النباتية التي تم تقديرها كان الفيكوسيانين هو الاعلي نسبة (١٣,٨٥%) ثم الكلوروفيل (١,٥%) ونسبة الاحماض الامينية الاساسية والغير الاساسية ٣٨,٩٤%، ٦١,٠٠% علي التوالي. أظهرت النتائج أن إضافة الطحلب الي دقيق البطاطس بمستويات ٥، ١٠، ١٥% أدت الي زيادة محتوي البروتين للنودلز الخالية من الجلوتين بنسبة ٢٤، ٤٩، ٧٣% علي التوالي والكالسيوم بنسبة ٦٦، ٢٧٥، ٤٢٣% علي التوالي والفسفور بنسبة ٥٢٨، ١١٩٢، ١٧٣٤% علي التوالي والبوتاسيوم بنسبة ٤٠، ٨٤، ١٥٩% علي التوالي والحديد بنسبة ٣٤٨، ٥٧٦، ٩٥٢% علي التوالي وكذلك زيادة قابلية البروتين للهضم معملياً بنسبة ١١، ٢١، ٣٢% علي التوالي مقارنة بعينة المقارنة. نتائج التقييم الحسي أظهرت أنه يمكن إضافة مسحوق طحلب الاسبيرولينا الي دقيق البطاطس حتي نسبة ١٥% للحصول علي نودلز خالية من الجلوتين ذات خصائص حسية أفضل من عينة المقارنة.