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Nutritional Evaluation of Cookies Enriched with Different Blends of *Spirulina platensis* and *Moringa oleifera* Leaves Powder

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ABSTRACT

Cookies were produced from wheat flour with partial replacement with a combination of dried spirulina biomass and moringa leaves powder at different concentrations T1 (95:2:3), T2 (90:4:6) and T3 (85:6:9), respectively. 100% wheat flour cookies were used as the control sample. Quality characteristics of produced cookies were evaluated including the physical, chemical, sensory and antioxidant properties. The results showed significant differences in the physical properties of all cookie samples. Cookies with replacement level 15% (T3) showed the highest weight (24.80 g), greater diameter (7.74 cm), lowest thickness and spread ration (0.68 cm and 9.27). Data revealed that using spirulina and moringa with different blending levels made cookies color greenness when compared to the control sample. All samples of cookies contain a moisture content and carbohydrate significantly lower than the control sample. Partial replacement of wheat flour with different concentration of spirulina and moringa blends was significantly increased all nutrients in produced cookies including ash, protein, lipids, crude fiber, and minerals with increasing replacement level compared to control cookies. There were no statistically significant differences between control cookies and both T1 and T2 cookies for all sensory properties. Sensory scores for T1 almost equal to control cookies. Otherwise, T3 cookies had the lowest scores of appearance, color, taste, and acceptability. However, all samples are reasonably acceptable. Total phenolic, flavonoid contents and scavenging ability of produced cookies increased significantly by increasing replacement level with spirulina and moringa leaves powder. In conclusion, the obtained data revealed the possibility of incorporating 6% dried spirulina biomass and 9% moringa leaves powder in cookies production to improve the nutritional and antioxidant status of cookies.

Keywords: Spirulina, Moringa, Cookies, Antioxidant status and physicochemical analysis

INTRODUCTION

One of the most important challenges in the area of human health in the next 50 years will be the prevention of non-communicable diseases (NCDs), which are not caused by infectious agents but by genetic, environmental and non-health factors. Such as tobacco use, salt/sodium intake, physical inactivity and perhaps more importantly, increased consumption of unhealthy foods such as fried foods that reduce fat from unsaturated fats and increase the content of bad fats in general (Lin *et al.,* 2018). In Egypt, Non-communicable diseases account for 84% of all deaths (WHO, 2018).

In all countries, people who are the poorest and most vulnerable are those most at risk and the least likely to access the services they need to detect and treat NCDs. (Miranda *et al.,* 2016 and Walker *et al.,* 2018).

Poor quality diets and widespread malnutrition were among the top six risk factors contributing to the global load of disease. Specifically, the NCD burden is associated with low diets in fruits and vegetables, which contain high sodium, low in dietary fiber, low in whole grains, low in omega-3 fatty acids derived from seafood.

Epidemiological evidence suggests that taking certain vitamins, minerals and other nutrients may help protect the body from heart disease. These antioxidants may have a protective effect, both in prevention and reduction of these diseases (Hsia *et al*., 2007). For example, dietary flavonoids have attracted lots of attention because of their potential role in the prevention of genetic mutations, chromosomal instability, and chronic diseases associated with oxidative stress such as ischemic heart disease, diabetes, and cancer (George *et al.,* 2017).

Moringa leaves are important nutrients sources in diets in developing countries because of its diversity of nutrients. Moringa leaves contain a diversity of flavonoids and phenolic acids, which have health-enhancing effects and thus reduce the burden of NCDs (Lako *et al.,* 2007 and Lin *et al.,* 2018). Traditionally, different parts of Moringa have been used to cure several diseases. In the last decades, many studies have estimated the beneficial effects of moringa on protective against diseases (Bais *et al.,* 2014; Metwally *et al.,* 2017; Omotoso *et al.,* 2018 and Tragulpakseerojn *et al.,* 2017).

Arthrospira platensis (Spirulina), microalgae that appear naturally in blue and green, can be an natural source of biologically active compounds that can be used as a functional food (Marcinkowska-Lesiak *et al.,* 2017).

Spirulina had complete protein source, and have positive benefits against malnutrition (Ravi *et al.,* 2010). Nutritional value of spirulina is well known for its exceptional protein (60-70% dry weight) and good source for minerals, essential fatty acids and vitamins (Deng and Chow, 2010). Spirulina have been studied not only because of potential as a source of protein but also because of their therapeutic properties, which include reports on the ability of its preparations to prevent cancers, to lower cholesterol levels, stimulate the immune system, to reduce renal toxicity (Colla *et al.,* 2007).

Cookies are a common example of a bakery product that is a ready-to-eat snack that has many engaging features, including a broad consumer base, relatively cheap, more appropriate with a long shelf life and has the ability to serve as vehicles for important nutrients. The main ingredients are flour, sugar, fat, and water, while other ingredients such as milk, salt, nutrients or other ingredients are supported to meet the needs of the malnourished population. Also, bakery products formulated to meet specific needs of consumers.

Several studies have been reported on the utilization of *Moringa oleifera* dried leaves and Spirulina powder individually in cookies manufacture, but there is no research on using a combination of Moringa and Spirulina in the manufacture of cookies. Therefore, the study presented to evaluate the influence of different levels of Spirulina and moringa leaves powder mixtures on the quality of high nutrient value cookies.

MATERIALS AND METHODS

Materials:

Spirulina (*Spirulina platensis*) biomass was obtained from The Algae Biotechnology Unit, National research center, Cairo, Egypt. Moringa leaves powder (sun-dried) was obtained from the Agricultural Research Centre (ARC), Cairo, Egypt. Wheat flour, margarine (fat), sugar powder, skimmed milk powder, baking powder, vanilla, eggs, and salt for cookies preparation were purchased from, the local market in Cairo. All chemicals and reagents used were of analytical grade and were procured from Sigma-Aldrich (St. Louis, MO).

Methods:

Preparation of cookies:

Cookies were prepared according to the formulations presented in Table 1. The control group (C) was produced only with wheat flour, while in treatment groups (T1, T2, and T3) a portion of wheat flour was replaced with spirulina and moringa powders as follows, (95:2:3, 90:4:6 and 85:6:9, respectively). All groups were prepared in the same way: The method of dough preparation was the creaming method, fat and sugar were creamed together using Kenwood mixer at medium speed for 2 min; then egg and vanilla were added and mixed two min. While, other ingredients added and mixed. The dough was moved to a clean tray and rolled using a roller. The dough pieces were placed in a pan previously painted with greasy substance and baked in the oven at 180 ° C for 40 minutes. Cookies were placed on a cooling rack for 30 minutes to cool before packing.

Physical characteristics of cookies

Cookies were evaluated for physical characteristics, including weight (g), diameter (cm) and thickness (cm) using five randomly selected cookies from each sample. The spread ratio of cookies was calculated by dividing values of the diameter by the thickness values according to Emelike *et al.,* (2015).

Table 1. Formulations used for cookies preparation

Ingredients	Cookies composition (g)			
	C	T1	T2	T3
Wheat flour	100.0	95.0	90.0	85.0
Moringa leaves powder	-	3.0	6.0	9.0
Spirulina powder	-	2.0	4.0	6.0
Margarine	50.0	50.0	50.0	50.0
Sugar	30.0	30.0	30.0	30.0
Baking powder	2.5	2.5	2.5	2.5
Salt	1.25	1.25	1.25	1.25
Vanilla	2.5	2.5	2.5	2.5
Milk skim powder	2.5	2.5	2.5	2.5
Water	25.0	25.0	25.0	25.0
Egg	30.0	30.0	30.0	30.0

C, cookies without moringa and spirulina powder (control group); T1, cookies with 2% spirulina and 3% moringa; T2, cookies with 4% spirulina and 6% moringa; T3, cookies with 6% spirulina and 9% moringa.

Color measurements of cookies

Surface color of cookies samples were determined by the tristimulus color system using spectrophotometer (MOM, 100D, Hungary). Color coordinates X, Y & Z were converted to corresponding Hunter L^*, a^*& b^* color coordinates according to the formula described by Francis (1983).

Sensory evaluation

Ten panelists made up of males and females were selected from the Food Science and Technology department, Faculty of Agriculture, Ain Shams University, Egypt. The panelists were requested to evaluate the various cookies samples for appearance, crust and crumb colors, taste, odor, texture and general acceptability using a 9-point Hedonic scale as described by Ihekoronye and Ngoddy (1985).

Proximate analysis of cookies:

Moringa leaves, Spirulina powder and cookies samples were analyzed for moisture, ash, crude protein, fat, crude fiber and total carbohydrate by difference according to methods described in (AOAC, 2012). The energy value for cookies samples was calculated using the Atwater factors of 4, 9, and 4 for protein, fat (Chaney, 2006). Also, the cookies samples analyzed for the contents of Ca, P, K, Mg, Fe and Se (ppm) by atomic absorption spectrometry ICP (optima 2000 DV – Perkin Elmer) according to AOAC (2012).

Antioxidant status:

Preparation of extracts:

Two mixture have been prepared: 1 g of Spirulina powder; Moringa leaves powder was dissolved in 10 ml of ethanol (80%), and 2.5 g of ground cookies were dissolved in 7.5 ml of ethanol (80%). Then, all mixtures were homogenized for 120 s at 12 rpm, extracted at room temperature for 10 min on a rotary shaker, and then centrifuged at 1,800 rpm for 10 min (Bolanho *et al.,* 2014).

Total phenolic content:

Total phenolic content (TPC) of Spirulina powder, Moringa leaves powder and cookies were determined using the Folin–Ciocalteu method according to (Singleton *et al.,* 1999). Absorbance was measured by spectrophotometer at a wavelength of 765 nm (HITACI, U-1900). The concentration of a TPC was expressed as gallic acid equivalents (GAE) in mg/g of sample (mg of GAE/g).

Total flavonoid content:

The total flavonoid content (TFC) of the extracts was determined using method reported by Meda *et al.,* (2005) at 415 nm with UV-Vis spectrophotometer (HITACI, U-1900). The TFC was expressed as quercetin equivalents (QE) in mg/g of sample (mg of QE/g).

DPPH Free Radical Scavenging Ability:

1,1-Diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging activity of Spirulina, Moringa leaves powder and cookies extracts was determined by spectrophotometer according to a modified method described by Espin *et al.,* (2000) at a 517 nm (HITACI, U-1900). The total antioxidant activity (TAA) expressed as % reduction of DPPH.

Statistical Analysis:

Data are presented as mean values ± SE. Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with significant level 5% according to (SAS, 1999).

RESULTS AND DISCUSSION

Chemical composition and antioxidant status of spirulina and moringa powders

Chemical composition and antioxidant status of spirulina and moringa powders were analyzed. The obtained data in (Table 2) revealed that the spirulina powder contained a high amount of protein. Therefore, its addition to food products seemed interesting. The high protein content in the spirulina (53.63%) and the presence of lipids (8.60%) with a high portion of essential fatty acids (Marcinkowska-Lesiak *et al.,* 2018) could be important to improve the nutritive value of the cookies. Also, it could be noticed that dried spirulina biomass contained 6.11% moisture, 5.65% ash, 4.92% crude fiber, and 21.90% carbohydrate. This means that this alga is a good source of nutrients and can be used to fortify some foods, such as special foods for certain groups like school children and people suffering from malnutrition. These results in agreement with Valeem & Shameel, 2005; and Marcinkowska-Lesiak *et al.,* 2018 who reported that spirulina biomass is a rich source of nutrients.

The chemical composition of Moringa Leaves powder is illustrated in (table 2), it could be noticed that moringa leaves contained 38.10% crude protein, 4.33% fat, 6.87% ash, 7.68% crude fiber and 34.17 carbohydrates.

These results are comparable to reported by (Kar *et al.,* 2013; Abdel-Samie and Abdulla, 2014; and Saleh, 2015).

According to table 2, the dried spirulina biomass showed a high content of phenolic compounds (33.03mg GAE/g). Colla *et al.,* (2007) studied different conditions of *S. platensis* cultivation, finding the content of phenolic compounds to range from 2.4 $g.kg^{-1}$ to 5.0 $g.kg^{-1}$. Phenolic compounds are known to have an antioxidant capacity and to interact with free radicals, without compromising their stability. In addition, they are able to inhibit lipid peroxidation in vitro by means of their ability to sequester free radicals and act as metal chelators (Gershwin & Belay, 2007). The addition of *S. platensis* contributed to the high content of phenolic compounds found in the cookies.

On the other hand, the total phenolic content of dried moringa leaves extract was significantly higher than spirulina powder extract (93.50 mg GAE/g). Accordingly, using a combination of spirulina and moringa leaves powder will substantially increase the total phenolic content in the formulated cookies.

Total flavonoid content and scavenging ability of spirulina powder and moringa leaves powder extract were 14.33, 78.77 mg QE/g, and 76.34, 83.77%, respectively as shown in table 2 and confirmed by Gad *et al*. (2011) reported that the extract of spirulina has higher DPPH scavenging capacity and Sahu *et al*. (2013).

Table 2. Chemical composition and antioxidant status of spirulina and moringa leaves powders

Constituents %	Spirulina powder	Moringa leaves powder
Moisture	6.11^{b}±0.58	8.85^{a}±0.52
Ash	5.65^{a}±0.64	6.87^{a}±0.58
Protein	53.63^{a}±1.01	38.10^{b}±0.52
Fat	8.60^{a}±0.64	4.33^{b}±0.52
Crude fiber	4.92^{b}±0.56	7.68^{a}±0.64
Carbohydrates	21.90^{b}±0.69	34.17^{a}±0.56
TPC (mg GAE/g)	33.03^{b}±0.42	93.50^{a}±0.22
TFC (mg QE/g)	14.33^{b}±0.18	78.77^{a}±0.34
% DPPH inhibition	76.34^{b}±0.12	83.77^{a}±0.19

Means with different letters in each row are significantly different at 5%.

Physical properties of cookies

Physical properties of cookies incorporated with different levels of spirulina and moringa powders mixture including the control sample (100% wheat flour cookies) are presented in Table 3. The weight of cookie samples with different levels Spirulina and Moringa powders significantly higher compared to the control cookie samples with the weight of 21.20g. This result is not compatible with the reported of Kiin-Kabari *et al.,* (2017); Emelike *et al.,* (2015) and Ajibola *et al.,* (2015) who observed a significant reduction in cookie weight fortified with moringa leaf samples.

The replacement of wheat flour with an increasing level of moringa leaves and spirulina powder significantly decreased the spread ratio from 11.42 to 9.27, compared to 11.50 for the control sample. This decrement was due to the decrease and increase in diameter and thickness, respectively. Similar results had been reported for cookies prepared from composite flour (Dachana *et al.,* 2010; Drisya *et al.,* 2015 and Ajibola *et al.,* 2015). The observed decrease in spread ratio has been attributed to dilution of gluten and less water available for gluten hydration (Sharma *et al.,* 2013). Onacik-Gür *et al.,* (2018) found that addition of microalgae powder decreased the spread ratio of cookies. Other researchers found that the addition of fiber may have such an impact on the spread ratio of cookies (Gupta *et al.,* 2011).

Table 3. Physical properties of cookies

Treatments	Weight (g)	Thickness (cm)	Diameter (cm)	Spread ratio
C	21.20^{c}±0.49	0.64^{b}±0.05	7.18^{b}±0.07	11.50^{a}±0.88
T1	23.00^{b}±0.63	0.76^{a}±0.02	7.02^{bc}±0.02	11.42^{a}±0.36
T2	23.40^{b}±0.24	0.72^{ab}±0.02	6.90^{c}±0.06	9.61^{b}±0.29
T3	24.80^{a}±0.20	0.68^{ab}±0.02	7.74^{a}±0.05	9.27^{b}±0.30

Means with different letters in each column are significantly different at 5%.

C, cookies without moringa and spirulina powder (control group); T1, cookies with 2% spirulina and 3% moringa; T2, cookies with 4% spirulina and 6% moringa; T3, cookies with 6% spirulina and 9% moringa.

Influence of spirulina and moringa with different blending levels on the surface color of cookies also studied. The color of cookies is an important characteristic for consumer preference and it depends on physicochemical parameters of used raw materials and baking. The L*, a*, and b* for prepared cookies samples containing spirulina and moringa with different blending levels were analyzed and the data are shown in Table 4. It could be observed that control cookies had the significant increase in luminosity (L*) 69.53, while the luminosity was gradually decreased from 61.48 to 48.92 with increased the adding level of blending ratio of spirulina and moringa in cookies. Regarding the negative value of (a*) which refer to green color, data revealed that using spirulina and moringa with different blending levels made cookies color greenness when compared to the control sample. The change in (b*) value, which indicates the yellowness, gradually decreased with the increase in spirulina and moringa level. These results may be occurred because of the green color of spirulina and moringa; also, the caramelization of sugar substances during cookies baking. Therefore, the brightness and yellowness of the cookies may be decreased as reported by Beatriz *et al.*, (2014).

Table 4. Influence of spirulina and moringa with different blending levels on the surface color of cookies

Treatment	L^{*}	a^{*}	b^{*}
Control	$69.53^{a} \pm 0.01$	$3.34^{a} \pm 0.02$	$34.69^{a} \pm 0.01$
T1	$61.48^{b} \pm 0.01$	$-4.56^{c} \pm 0.01$	$29.16^{b} \pm 0.01$
T2	$55.93^{c} \pm 0.01$	$-6.44^{d} \pm 0.04$	$29.17^{b} \pm 0.01$
T3	$48.92^{d} \pm 0.01$	$-3.79^{b} \pm 0.04$	$29.09^{c} \pm 0.02$

Means with different letters in each column are significantly different at 5%.

C, cookies without moringa and spirulina powder (control group); T1, cookies with 2% spirulina and 3% moringa; T2, cookies with 4% spirulina and 6% moringa; T3, cookies with 6% spirulina and 9% moringa.

Sensory evaluation of cookies

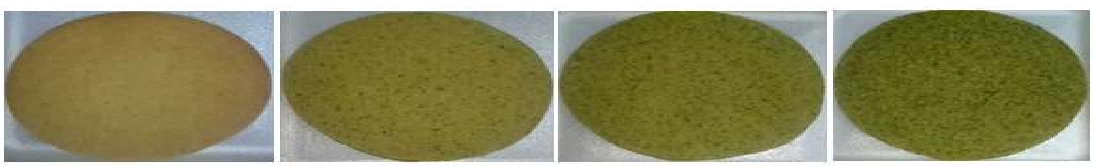
The effect of wheat flour replacement with different levels (5, 10 and 15%) of blends of moringa and spirulina powder on sensory characteristics (appearance, color, taste, odor, texture, and acceptability) of cookies is shown in table 5 and Figure 1. It could be observed that there were no significant differences between control cookies and both T1 and T2 cookies for all sensory properties. Sensory scores for T1 almost equal to control cookies. On the other hand, T3 cookies had the lowest scores of appearance, color, taste, and acceptability being 7.14, 6.57, 7.00, 7.14 and 7.14, respectively. The increase in darkness was reflected in L* values (Table 4); which due to the dark color of used Moringa leaves and spirulina powder. At the same time from Fig 1. It could be noticed that as the amount of moringa leaves and spirulina powder was increased, the appearance of cookies became darker. However, all samples are reasonably acceptable. Sensory evaluation results indicated that moringa and spirulina powder can be successfully used in fortification of cookies to benefit from their high nutritional value; they can be used until level 15%.

Table 5. Sensory evaluation of cookies

Parameter	C	T1	T2	T3
Appearance	$8.57^{a}\pm0.61$	$8.57^{a}\pm0.37$	$8.00^{ab}\pm0.31$	$7.14^{b}\pm0.26$
Crust color	$8.14^{a}\pm0.63$	$8.29^{a}\pm0.42$	$7.71^{ab}\pm0.42$	$6.57^{b}\pm0.20$
Crumb color	$8.86^{a}\pm0.70$	$8.57^{a}\pm0.30$	$7.71^{ab}\pm0.36$	$7.00^{b}\pm0.22$
Taste	$8.71^{a}\pm0.64$	$8.43^{a}\pm0.43$	$7.86^{ab}\pm0.34$	$7.14^{b}\pm0.34$
Odor	$8.86^{a}\pm0.67$	$8.14^{a}\pm0.46$	$7.86^{a}\pm0.40$	$7.57^{a}\pm0.57$
Texture	$8.71^{a}\pm0.68$	$8.00^{a}\pm0.49$	$7.71^{a}\pm0.47$	$7.29^{a}\pm0.52$
Acceptability	$8.86^{a}\pm0.51$	$8.14^{ab}\pm0.26$	$7.57^{b}\pm0.20$	$7.14^{b}\pm0.40$

Means with different letters in each row are significantly different at 5%.

C, cookies without moringa and spirulina powder (control group); T1, cookies with 2% spirulina and 3% moringa; T2, cookies with 4% spirulina and 6% moringa; T3, cookies with 6% spirulina and 9% moringa.



(Control) (T1) (T2) (T3)

Figure 1. Cookies external appearance with different ratios of moringa leaves and spirulina powder

Nutritive analysis of cookies formulated with moringa leaves and spirulina powder:

Nutritional characteristics of cookies formulated with blends of moringa leaves and spirulina powder at different levels were presented in table (6). The chemical composition of both Moringa and Spirulina as shown in Table (2) revealed their rich in nutrients, which was reflected in the composition of cookies containing a mixture of moringa and spirulina powder. It could be observed that moisture content of samples decreased slightly (9.15, 9.01 and 8.93%) by increasing replacement levels of moringa and spirulina blends compared to control (10.04%). Decreasing moisture content in the product can be related to a partial reduction of flour, which was replaced by blends of moringa and spirulina powder. These results were in agreement with that reported by other workers (Onyekwelu & Ogbu, 2017; and Onacik-Gür *et al.,* 2018).

The total ash content increased significantly with increase replacement levels of moringa and spirulina blends compared to control indicating an increase in the mineral content in the produced cookies. The lipid content of control and cookies with different levels of moringa and spirulina blends ranged between 30.82% and 34.15%. The protein content significantly increased from 7.48% in control to 9.00, 11.27 and 13.85% with replacement levels 5, 10 and 15%, respectively. Application of moringa and spirulina to the cookie formula as fiber-rich ingredients (7.68 and 4.92%) increased the fiber contents in cookie samples to 5.73, 6.54 and 7.65%, respectively in 5, 10 and 15% replacement level. Production of food rich in fiber is increasing significantly for its importance to promote health (Ajila *et al.*, 2008). Hence, the cookies supplemented with moringa and spirulina powder were found to possess higher nutritive profile than the control (Table 6).

Table 6. Proximate composition of cookies formulated with moringa leaves and spirulina powder

Treatments	Moisture (%)	Ash (%)	Protein (%)	Lipids (%)	Crude fiber (%)	Carbohydrate (%)	Energy value
C	$10.04^{a}\pm0.76$	$1.39^{c}\pm0.01$	$7.48^{d}\pm0.04$	$30.82^{b}\pm0.36$	$3.60^{d}\pm0.08$	$46.67^{a}\pm0.44$	$473.58^{a}\pm4.37$
T1	$9.15^{a}\pm0.03$	$1.47^{c}\pm0.03$	$9.00^{c}\pm0.03$	$31.15^{b}\pm1.36$	$5.73^{c}\pm0.08$	$41.48^{b}\pm0.30$	$458.55^{a}\pm12.56$
T2	$9.01^{a}\pm0.03$	$1.59^{b}\pm0.01$	$11.27^{b}\pm0.14$	$33.16^{ab}\pm0.27$	$6.54^{b}\pm0.14$	$40.43^{b}\pm1.50$	$476.84^{a}\pm8.17$
T3	$8.93^{a}\pm0.01$	$1.87^{a}\pm0.05$	$13.85^{a}\pm0.34$	$34.15^{a}\pm0.64$	$6.95^{a}\pm0.07$	$34.24^{c}\pm0.89$	$465.96^{a}\pm2.29$

Means with different letters in each column are significantly different at 5%.

C, cookies without moringa and spirulina powder (control group); T1, cookies with 2% spirulina and 3% moringa; T2, cookies with 4% spirulina and 6% moringa; T3, cookies with 6% spirulina and 9% moringa.

Minerals content of cookies:

Among the functional food ingredients, minerals have a fundamental function in their essential role for a healthy life. Minerals including trace minerals are important to help body metabolism, water balance, bone health, help heart functions, prevent fatigue and muscle spasm and help transport oxygen throughout the body. It is very important to include the right amount of minerals in the body (Watzke, 1998).

As shown in the table (7), there was a significant enhancement in the mineral content of cookies with the incorporation of moringa and spirulina blends. The calcium content of control cookies was 310 ppm and showed a significant increase on blending with moringa and spirulina at different levels. This may be attributed to the higher calcium content of dried moringa leave and spirulina powder as reported by (Saleh, 2015 and Burcu *et al.,* 2016). Replacement of wheat flour with blends of moringa and spirulina powder at 5, 10 and 15% increased the Mg content in a dose-dependent manner as a compared with control. Iron content increased significantly from 15.33 ppm for cookies in control group to21.122, 31.07 and 37.12 ppm for cookies supplemented with 5, 10, 15% moringa and spirulina powder blends. No significant change was observed in potassium content and a slight increase observed in phosphorus content for all fortified sample compared to control as shown in the table (7). On the other hand, data revealed a significant increase in selenium content for all samples fortified with moringa and spirulina blends compared to control. Previous results were in agreement with those reported by (Abdel-Samie and Abdulla, 2014; Abd El Baky *et al.,* 2015; and Dwi Ana *et al.,* 2017)

Table 7. Minerals content of cookies

Treatments	Elements (ppm)					
	Ca	P	K	Mg	Fe	Se
C	310^{d}±5.77	1270^{a}±57.74	600^{a}±11.55	65.53^{b}±2.89	15.33^{d}±1.15	26.37^{d}±0.58
T1	630^{c}±8.66	1300^{a}±115.47	510^{b}±5.77	67.28^{b}±2.31	21.12^{c}±0.58	37.67^{c}±1.15
T2	820^{b}±11.55	1400^{a}±28.87	590^{a}±11.55	80.39^{a}±2.89	31.07^{b}±2.31	48.97^{b}±1.73
T3	910^{a}±11.55	1420^{a}±11.55	560^{a}±17.32	87.93^{a}±1.73	37.12^{a}±1.87	79.10^{a}±0.58

Means with different letters in each column are significantly different at 5%.
C, cookies without moringa and spirulina powder (control group); T1, cookies with 2% spirulina and 3% moringa; T2, cookies with 4% spirulina and 6% moringa; T3, cookies with 6% spirulina and 9% moringa.

Antioxidant status of cookies:

Phenolic contents of cookies ethanolic extracts:

polyphenols are secondary compounds produced from plant metabolism that are effective to reduce reactive oxygen species (ROS) by donating hydrogen atoms of phenolic hydroxyls and by transferring electrons from such phenolic hydroxyls (Villaño *et al.,* 2007). Among the food ingredients, polyphenolics have been reported to play an important role as an antioxidant in the protective effect of food derived from plants and contribute significantly to sensory quality such as taste, color, and flavor of foods (Saxena *et al.,* 2007; and Oboh & Adefegha, 2010). In the present study, total polyphenolic content of ethanolic extracts of moringa leaves powder, spirulina powder, and the cookies are presented in Table 8.

Total phenolic content (TPC) was expressed as milligrams of Gallic acid equivalent (GAE) per gram (mg/g) of dry biscuit samples. Control cookies had the lowest total phenol content of 0.95 mg/g GAE while sample T3 had the highest total phenol content of 5.35 mg/g GAE.

Flavonoid contents of cookies ethanolic extracts:

The flavonoid content of the cookies ranged from 0.25 to 1.70 mg/g QE. The control sample (C) also had the least flavonoid content when compared to the moringa and spirulina blends supplemented cookies. Moringa leaves and spirulina powder have been known as rich sources of polyphenols as shown in the table (8) and reported by (Witt, 2013; Colla *et al.,* 2007; Abeer A. Abu Zaid *et al.,* 2015). Hence, the observed increase in phenolic compounds of the supplemented cookies could be attributed to blends of moringa leaves and spirulina powder that were added to them. A similar increase in polyphenolic compounds was observed in cookies supplemented with *Moringa oleifera* Leaves and Cocoa Powder when compared to 100% whole wheat biscuits (Ajibola *et al.,* 2015).

DPPH radical scavenging activities of cookies ethanolic extracts:

The supplemented cookies had better DPPH radical scavenging activity than the control (C) while the highest scavenging activity was observed in sample T3. This trend is consistent with the total phenolic content results presented for both non-supplemented and supplemented samples (Table 8); and agreement with those reported by (Ajibola *et al.,* 2011 and Marcinkowska-Lesiak *et al.,* 2017).

Table 8. Antioxidant properties of cookies

Samples	Antioxidant properties		
	% DPPH inhibition	TPC (mg GAE/g)	TFC (mg QE/g)
C	7.98^{c}±0.24	0.95^{c}±0.08	0.25^{c}±0.04
T1	22.15^{b}±4.90	1.91^{c}±0.50	0.50^{c}±0.01
T2	31.10^{b}±1.11	3.30^{b}±0.29	1.08^{b}±0.09
T3	53.55^{a}±5.95	5.35^{a}±0.19	1.70^{a}±0.16

Means with different letters in each column are significantly different at 5%.
C, cookies without moringa and spirulina powder (control group); T1, cookies with 2% spirulina and 3% moringa; T2, cookies with 4% spirulina and 6% moringa; T3, cookies with 6% spirulina and 9% moringa.

CONCLUSION

This research was carried out to enhance the prepared cookies by spirulina and moringa powder with different blending levels which considers a good source of phytochemicals components, health-promoting bioactive compounds, and free radical scavenging activity. It could be concluded that, the obtained data revealed the possibility of incorporating 6% dried spirulina biomass and 9% moringa leaves powder in cookies production to improve the nutritional and antioxidant properties of cookies.

At the same time, it might be possible to maximize the benefit of the spirulina and moringa in a preferred functional product for consumers, especially children who like cookies as favorite bakery product. We encourage such work to find new and novel sources of food nutraceuticals.

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التقييم التغذوي للكوكيز المدعمة بخلطات مختلفة من مسحوق طحلب الاسبيريولينا وأوراق المورينجا أوليفيرا

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تم إنتاج الكوكيز من دقيق القمح مع استبدال جزئي بمزيج من الكتلة الحيوية الجافة لطحلب الاسبيريولينا ومسحوق أوراق المورينجا عند تركيزات مختلفة وهي T_1 (٩٥:٢:٣) ، T_2 (٩٠:٤:٦) ، T_3 (٨٥:٦:٩) ، على التوالي. أستخدم الكوكيز المصنع من ١٠٠% دقيق قمح كعينة مقارنة. تم تقييم خصائص الجودة للكوكيز المنتج من حيث الخصائص الفيزيائية ، الكيماوية ، الحسية والمضادة للأكسدة. أظهرت النتائج اختلافات معنوية في الخصائص الفيزيائية لكل عينات الكوكيز. أظهرت عينات الكوكيز ذات نسبة استبدال ١٥% (T3) أعلى قيمة للوزن (٢٤.٨٠ جم) ، القطر (٧.٧٤ سم) ، وأقل قيم للثخانة ونسبة الفرد (٠.٦٨ سم ، ٩.٢٧). بينت النتائج أن إستخدام مزيج مسحوق الاسبيريولينا والمورينجا جعل لون الكوكيز أكثر إخضرار عند مقارنته بعينة المقارنة (الكنترول). احتوت كل عينات الكوكيز على محتوى رطوبي وكربوهيدرات أقل بصورة معنوية عن عينة المقارنة. أدي الاستبدال الجزئي لدقيق القمح بتركيزات مختلفة من مزيج الاسبيريولينا والمورينجا بصورة معنوية إلى زيادة كل المغذيات في الكوكيز المصنع ويشمل ذلك الرماد ، البروتين ، الليبيدات ، الالياف الخام والعناصر المعدنية وذلك بزيادة نسبة الاستبدال مقارنة بعينة المقارنة. لم يوجد احصائيا اختلافات معنوية بين عينة الكوكيز المقارنة وعينات الكوكيز T، T_2 بالنسبة لكل الخصائص الحسية. القيم الحسية لعينة الكويز T_1 مساوية تقريبا لعينة المقارنة. ولكن ، حصلت العينة T_3 على أقل قيم للمظهر ، اللون ، الطعم والقبول. ومع ذلك ، كل العينات كانت مقبولة حسيا. ازدادت قيم المحتوى الكلي من الفينولات والفلافونويدات والقدرة على كسح الشقوق الحرة بصورة معنوية لعينات الكوكيز المصنعة بزيادة نسب الاستبدال بمزيج الاسبيريولينا والمورينجا. باختصار ، بينت النتائج المتحصل عليها إمكانية التدعيم بنسبة ٦% من الكتلة الحيوية الجافة لطحلب الاسبيريولينا و ٩% من مسحوق أوراق المورينجا في إنتاج الكوكيز وذلك لتحسين الخصائص التغذوية والمضادة للأكسدة للكوكيز المنتجة.