CHEMICAL AND NUTRITIONAL EVALUATION OF FORTIFIED BISCUITS WITH DRIED SPIRULINA ALGAE

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ABSTRACT

The cyanobacterium Spirulina, a multicellular and filamentous blue green microalgae, is used in many countries of world including Egypt as human safe food. This research aims to study the nutritional values of dried Spirulina algae and prepare healthy and high nutritive values biscuits blends fortified by Spirulina algae. This study revealed that Spirulina algae contained high level of protein 67.0±5.2% as dry weight and interesting amounts of bioactive compounds with antioxidative activity such as phycocyanin (1254±23mg /100g) and β-carotene (85±5 mg/100g). Spirulina algae was rich in minerals such as Na (859 mg/100g), K (1399 mg/100g), Ca (689 mg/100g), P (960 mg/100g), Mg (400 mg/100g) and Fe (122 mg/100g) as average. Results indicated that biscuit blends fortified with dried Spirulina algae as 0.5, 1, 2 and 3, % lead to improve the organoleptic, chemical and nutritional properties for it. Biscuit blends were organoleptically accepted for panel test as soon as demonstrated high nutritional values, bioactive, protein and mineral content when compared with fortified biscuit samples (control).

INTRODUCTION

The cyanobacterium Spirulina, a multicellular and filamentous blue green microalgae, is used in many countries of world as human safe food collected from water, at the same time in many regions of Asia it is used as human health function food (Habib et al., 2008). The food potential of these algae, as source of relative complete proteins (60–70% w/w), unsaturated fatty acids and various minerals, has been reported (Belay, 2002). Apart from chlorophyll a, Spirulina contains Phycocyanin which is a blue pigment known to have an important antioxidative power (Chen and Wong, 2008). Many clinical studies suggest several therapeutic effects ranging from reduction of cholesterol, cardio-vascular diseases and cancers to enhancement of the immune system, an increase in intestinal lactobacilli, nephrotoxicity (Mohan et al., 2006), Hernandez and Olguín (2002) reported that two different species of Spirulina contained a high percentage of protein (68.95 ± 0.30 and 63.73 ± 0.25%) as a result of being cultivated in Zarrouk medium. Results obtained by Aly and Gad (2010) revealed the Spirulina isolated from Egypt high crude protein content which amounted 64.00% (w/w) on Zarrouk medium.

As a result, there are many applications of Spirulina in human healthy food: instantaneous noodles for children (Xu, 1993), beverages (Zeng and Liang 1995) tablets (Yamaguchi, 1997), development of Spirulina based biscuits (Gouveia et al., 2007, 2008a; Sharma and Dunkwal 2012), Spirulina enriched pasta (Fradique et al., 2010; Zouari et al., 2011), puddings/ gelled desserts and mayonnaises/salad dressings (Batista et al., 2008; Gouveia et al., 2008, b) and low fat and high protein frozen yoghurt enriched with papaya fruit and Spirulina (Dubey and Kumari 2011). Biscuits are popular and convenient food products, appreciated for their accepted taste, versatility, conservation, convenience, texture and appearance. The use of natural ingredients, exhibiting functional properties and providing specific health benefits beyond traditional nutrients, is a very attractive way to design new food products, with an important market.

The present research was aimed to study the following point:
- Determination of proximate chemical composition, minerals content and bioactive compounds of dried Spirulina algae.
- Prepare biscuits blends fortified with different levels of dried Spirulina algae as a natural source of protein, some minerals and bioactive compounds. The effect of this incorporation on the organoleptic properties and nutritional value of the biscuit blends was also evaluated.

MATERIALS AND METHODS

MATERIALS:

Egyptian Spirulina platensis algae strain was kindly obtained from Dr. Diaa Gab Allah, National Research Center, Egypt. Wheat flour (Triticum vulgare), sugar, vanilla, baking powder, corn oil and salt were obtained from local market in Kafr El-Sheikh City, Egypt. Chemicals used in this study were purchased from El-Gomhoria Company for Chemicals and Drugs, Tanta, Egypt.

METHODS:

Growing Spirulina algae in lab conditions.

Spirulina algae isolate was maintained in Zarrouk’s modified medium synthetic medium. Spirulina was carried out in continues Illumination at 30±4°C temperature, each further shaking of culture were carried out manually thrice a day (Mühling, 2000). To avoid bacterial contamination of axenic cultures, all media and materials used for handling cultures were autoclaved at 15 lb in2 for 20 minutes.

Preparation of Spirulina algae powder:

Spirulina algae was filtered under vacuum using filter paper (Whatman No.1) and washed several time with sterilized and distilled water. Then, the algae cells biomass were dried in thin layers 2 mm under warm air at 40°C and the air velocity was fixed at 1 m/s for 12 hrs. Dried Spirulina algae grounded in electric mill and
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passed through 120 mesh sieve screen to produce a fine algae powder and kept in polyethylene bags at low temperature (5 °C) until used. All samples were analyzed in triplicate (Yamarsaeng and Bualuang, 2010).

Preparation of biscuit blends fortified with dried Spirulina algae:

Biscuit blends were prepared by adding powder sugar (253 g), egg (150 ml) and vanilla (0.7 g) and mechanically beaten for 5 min until they creamed. Then unsalted butter (506 g) and dough were added thoroughly and mixed with wheat flour (800 g) for 2 min. Then, 15 g baking powder was added and mixed. Spirulina algae powder was substituted with wheat flour at ratios 0.5, 1, 2, 3, 4, and 5% (w/w) and the blended biscuits take ovoid shape. Then, backed in an oven at 160 °C for 15 min. After cooling for one hour, biscuit blends packed in polyethylene bags. The samples were used to evaluate organoleptic properties, chemical composition and nutritive values.

Organoleptic properties of biscuit blends:

A trained twenty-member panel consisting of students and staff members (both male and female) of the Home Economics Department, Faculty of Specific Education, Kafrelsheikh University, Egypt was selected based on their experience and familiarity with blends of biscuit for the organoleptic properties evaluation. The tests were performed under fluorescent lighting in organoleptic properties laboratory. Tap water was provided to rinse the mouth between evaluations. The judges evaluated the samples for taste, colour, odour, texture and overall acceptability. Each organoleptic properties attribute was rated on a 10-point hedonic scale (Abo, et. al., 2014).

Chemical analysis:

Gross chemical composition:

Moisture, ash, crude protein, crude fibers and ether extract were determined according to the method of AOAC, (2000). Carbohydrates were calculated by subtracting the total ether extract, ash, crude fibers and protein contents from 100%.

Energy or caloric values

Total energy contents were determined by multiplying the values obtained for crude protein, total carbohydrates, and total lipids by factors as 4, 4, and 9kcal/g, respectively, and summing the results (Fuentes et. al., 2000).

Minerals:

The minerals content of samples were determined using the method of Santos et. al., (2006).

Amino acids analysis

Amino acids content of biscuit blends were determined according to the methods of AOAC, (2000).

Amino Acid Scores (A.A.S.):

Amino acid scores (AAS) were calculated for indispensible amino acids according to the FAO/WHO/UNU (1985) procedure using the following equation:

\[ \text{AAS} = \frac{\text{Mg of indispensable amino acids in 1gm of tested protein}}{\text{mg of amino acids in 1gm reference protein}} \times 100 \]

Bioactive compounds:

Total phenolic contents:

Total phenolic compounds in Spirulina extracts were spectrophotometrically determined using Folin-Ciocalteu reagent following the method of Lim et al., (2002).

Determination of chlorophyll a:

Four grams of algae samples were homogenized in acetone (80 ml, 80%) and allowed to stand overnight in dark at 4°C for complete extraction followed by centrifugation at 10,000 xg for 5 min. Chlorophyll_a in the supernatant was spectrophotometrically determined according to Lichtenthaler (1987) method.

Extraction and determination of phycocyanin:

Phycocyanin was extracted by repeated freezing, sonication and thawing of samples in 50 mM phosphate buffer pH 6.8, followed by centrifugation at 4000 rpm for 20 min. The concentration of total blue pigment phycocyanin was spectrophotometrically determined in the supernatant at 615 and 652 nm; respectively, as reported by Silverira et al. (2007). Phycocyanin concentration = OD_{615} - 0.474 (OD_{652}) / 5.34 mg ml^{-1}.

Determination of total carotenoids:

The total carotenoids in samples were spectrophotometrically determined at 450 nm according to standard methods A.O.A.C. (1995). β-carotene, as a standard compound was used for preparation of the calibration curve.

Determination of β-carotene:

About 5 mg of algae sample with glass beads were placed alternately in an ice bath and in a vortex with portions of 5 ml acetone. The extracts were centrifuged at 3500 rpm for 5 min and collected. The procedure was repeated three times, until both precipitate residue and supernatant become colorless. The extracts were also analyzed by reversed-phase high performance liquid chromatography (HPLC), with a C18 column (250/4.6 mm) and a UV/VIS detector, with methanol : acetonitrile (75:25 v/v) as eluent. β-carotene was eluted over 30 min with a flow rate of 1 ml/min. Peak was compared with retention time of standard β-carotene solution in acetone (AOAC, 2000).

Statistical analysis:

All the obtained data were statistically analyzed by SPSS computer software. The calculated occurred by analysis of variance ANOVA and follow up Duncan's multiple range tests by SPSS computer software. The calculated occurred by factors as 4, 4, and 9kcal/g, respectively, and summing the results (Fuentes et. al., 2000).

RESULTS AND DISCUSSION

Evaluation of nutritional value of Spirulina algae.

Gross chemical composition of dried Spirulina:

Data in Table (1) showed the chemical composition and caloric values of dried Spirulina algae. Results indicated that protein content of Spirulina is especially high, 67.0%, and comprises almost all amino acids, including the essential ones. However, it should be noted that a reasonable daily consumption of Spirulina cannot provide more than about 15 grams of proteins. Depending to many literatures Spirulina has the highest crude protein concentration (60-70% of its dry weight) in the range of our results (Hernandez and Olguín, 2002; Aly and Gad, 2010)
Table (1): Gross chemical composition (g/100g) and caloric values (k.cal/100g) of dried Spirulina algae (on dry weight basis).

<table>
<thead>
<tr>
<th>Components</th>
<th>Moisture</th>
<th>Crude Protein</th>
<th>Ether extract</th>
<th>Ash</th>
<th>Crude fiber</th>
<th>Carbohydrates</th>
<th>Total caloric values (k.cal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried Spirulina</td>
<td>5.5 ±0.5</td>
<td>67.0±5.2</td>
<td>7.2±0.52</td>
<td>6.8±0.53</td>
<td>3.8±0.31</td>
<td>15.2±0.68</td>
<td>393.6</td>
</tr>
</tbody>
</table>

Each value is the mean of three determination ±SD.

Nevertheless, in the case of children suffering malnutrition, it would be realistic to incorporate up to 10 g of Spirulina in the daily ration. Depending on the weight of the child, this can amount to more than 50% of the recommended protein intake. Data in Table (1) confirmed that ether extract of Spirulina represented 7.2% of the dry matter. Literature reports fat contents normally lower than 8% for Spirulina algae (Ogbonda et al., 2007; Tokusoglu and Ünal 2003; Gouveia and Oliveira, 2009) while Batista et al., 2013 found that Spirulina presented relative low fat value (4%). The wide variations reported in the literature indicated that there may have been striking differences in medium of cultivation or in the procedures for the extraction or the estimation of the lipid content (Ciferri, 1983).

Carbohydrates in Table (1), accounted for slightly lower value (15.2%) of the dry weight of Spirulina algae. These results considered acceptable as others reviewers reported that Spirulina carbohydrates were accounted for 15 to 20% of the dry weight (Batista et al., 2013).

That carbohydrates represented in Spirulina essentially by a branched polysaccharides, composed of only glucose and structurally similar to glycogen Spirulina uses glycogen as storage product and has thin and fragile peptidoglycan cell walls (Becker, 2004). Small percentage of crude fibers and ash were recorded as 3.8 and 6.8%, respectively, of studied Spirulina algae, while total caloric values were 393.6 k.cal/100g on dry weight basis. Tokusoglu and Ünal, (2003) reported similar results in Spirulina ash as 7.43-10.38%.

Minerals content:

Minerals content of dried Spirulina algae (mg/100g) is given in Table (2). Spirulina sample was rich in Na (859 mg), K (1399 mg), Ca (689 mg), P (960 mg), Mg (400 mg) and Fe (122 mg) as average. These data are in harmony with others obtained by Tokusoglu and Ünal, (2003) who found that minerals content in Spirulina were as follow; Na (929.4 mg), K (1412.9 mg), Ca (826.3 mg), P (750.7 mg), Mg (388.9 mg) and Fe (95.37 mg) as average.

Bioactive compounds:

Data in Table (3) showed some bioactive compounds of Spirulina algae. The most important compound in Spirulina algae was Phycocyanin for its health benefits and as antioxidant. Despite its low content in lipophilic pigments Spirulina is very rich in blue phycobiliprotein aqueous pigments, with 1254 mg/100g of Phycocyanin, which is in agreement with results of other authors (Batista et al., 2013; Ciferri, 1983), Saranraj and Sivasakthi (2014), reported that Spirulina and other blue-green algae contain c-phycocyanin, which acts as an accessory pigment when light energy is captured and transferred to chlorophyll a. This is a spectrophotometry method adapted to extract and quantify a relatively pure c-phycocyanin fraction from Spirulina. Among the pigments, the most abundant was chlorophyll, accounts in other studies for 0.8 to 1.5% of the dry weight in Spirulina (Batista et al., 2013; Gouveia et al. 2008c) comparing with these results which presented percentage close to 1010 mg/100g Spirulina algae. The conventional sources of chlorophyll are spinach and alfalfa, with approximately 0.5% (w/v) chlorophyll (Lemes, 2012). However, the Spirulina biomass could be an alternative source.

Table (2): Minerals content of Spirulina algae (mg/100g on dry weight basis) and required adult daily dose (RAD) as mg/day*

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Sodium (Na)</th>
<th>Potassium (K)</th>
<th>Calcium (Ca)</th>
<th>Phosphorous (P)</th>
<th>Magnesium (Mg)</th>
<th>Iron (Fe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spirulina algae</td>
<td>859±25</td>
<td>1399±19</td>
<td>689±10</td>
<td>960±16</td>
<td>400±28</td>
<td>122±8</td>
</tr>
<tr>
<td>RAD</td>
<td>500</td>
<td>3500</td>
<td>1200</td>
<td>1000</td>
<td>250-350</td>
<td>18</td>
</tr>
</tbody>
</table>

* As USA National Research council (1980)
** Each value is the mean of three determination ±SD.

Table (3): Some bioactive compounds of Spirulina algae (mg/100g on dry weight basis)*

<table>
<thead>
<tr>
<th>Bioactive compounds</th>
<th>(mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phycocyanin</td>
<td>1254±23</td>
</tr>
<tr>
<td>Chlorophyll-a</td>
<td>1010±19</td>
</tr>
<tr>
<td>Carotenoids</td>
<td>310±9</td>
</tr>
<tr>
<td>β-Carotene</td>
<td>85±5</td>
</tr>
<tr>
<td>Phenolic compounds (as gallic acid)</td>
<td>800±9.20</td>
</tr>
</tbody>
</table>

* Each value is the mean of three determination ±SD.
Carotenoids and Beta-carotene represented 310 and 85 mg/100g; respectively. Beta-carotene is the major carotenoids, their content represented in many literatures approximately 0.2 to 0.4% of the dry weight. Spirulina is claimed to be the richest whole-food source of β-carotene (Christaki et al., 2012; Sotiroudis and Sotiroudis, 2013). Our finding represented that the amount of Beta-carotene in Spirulina algae was 85±4 mg/100g. Habib et al., (2008) reported that, an intake of 6.0 mg β-carotene daily may be effective in minimizing the risk of cancer. So, anybody takes around 7.0 g of studied Spirulina daily that is sufficient to get 6 mg β-carotene. Spirulina also contains phenolic compounds which can act as natural antioxidant. Total phenolic compounds presented in Table (3) were 800 mg of gallic acid/100 g dry weight of Spirulina. Those results were in harmony with the results reported by Agustini et al., (2015).

**Evaluation of nutritional value for biscuit blends:**

**Organoleptic properties of biscuit blends fortified with different levels of dried Spirulina algae:**

As the organoleptic properties of foods are of decisive importance in their acceptance, their modification resulted through adding or replacing components should be carefully studied to access the consumer’s reaction to the alterations in taste, texture and colour of the products. Organoleptic properties of the prepared biscuit blends fortified with different levels of dried Spirulina algae were considered the important tests affecting on a large extent, their acceptable qualities of the prepared diets. This study was undertaken to determine the effects of adding dried Spirulina as a function ingredient in traditional biscuits. Fortified biscuits were prepared using dried Spirulina algae with percentage 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 %. It was noticed that biscuit scored more points than the control of each of them in most of organoleptic characteristics that may be due to crisp texture which happened of difference levels of dried Spirulina used. Ismail (2007) observed that the fresh baked biscuits characterized by firm and crisp texture and received high score values. This crisp texture of biscuit was related to the used substitute materials and the moisture content of baked products. These observations are in harmony with those of Joanna et al., (1990).

**Table: (4). Organoleptic properties of biscuit blends fortified with different levels of dried Spirulina algae.**

<table>
<thead>
<tr>
<th>Biscuit blends</th>
<th>Taste</th>
<th>Colour</th>
<th>Odour</th>
<th>Texture</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>9.20(a)</td>
<td>10.00(a)</td>
<td>9.70(a)</td>
<td>9.48(a)</td>
<td>9.50(a)</td>
</tr>
<tr>
<td>Biscuit 1</td>
<td>9.30(a)</td>
<td>8.00(b)</td>
<td>9.50(a)</td>
<td>9.49(a)</td>
<td>9.40(ab)</td>
</tr>
<tr>
<td>Biscuit 2</td>
<td>8.50(b)</td>
<td>7.40(bc)</td>
<td>9.10(a)</td>
<td>9.49(a)</td>
<td>8.50(b)</td>
</tr>
<tr>
<td>Biscuit 3</td>
<td>8.50(b)</td>
<td>6.10(c)</td>
<td>6.50(b)</td>
<td>9.50(a)</td>
<td>8.50(b)</td>
</tr>
<tr>
<td>Biscuit 4</td>
<td>7.10(c)</td>
<td>5.60(c)</td>
<td>5.20(c)</td>
<td>9.50(a)</td>
<td>7.40(b)</td>
</tr>
<tr>
<td>Biscuit 5</td>
<td>3.30(d)</td>
<td>3.50(d)</td>
<td>4.30(d)</td>
<td>9.54(b)</td>
<td>4.40(d)</td>
</tr>
<tr>
<td>Biscuit 6</td>
<td>3.20(d)</td>
<td>1.10(d)</td>
<td>3.10(e)</td>
<td>9.55(b)</td>
<td>3.50(e)</td>
</tr>
</tbody>
</table>

Where: Control: Biscuit without dried Spirulina algae.
Biscuit 1: Fortified with 0.5% dried Spirulina algae.
Biscuit 2: Fortified with 1.0% dried Spirulina algae.
Biscuit 3: Fortified with 2.0% dried Spirulina algae.
Biscuit 4: Fortified with 3.0% dried Spirulina algae.
Biscuit 5: Fortified with 4.0% dried Spirulina algae.
Biscuit 6: Fortified with 5.0% dried Spirulina algae.

Mean values in each column designated by the same letter are not significantly different at 5.0% level using Duncan’s multiple range tests.

Data in Table (4) and Fig (1) revealed that biscuit blends fortified with high levels of dried Spirulina algae had not accepted especially in taste, colour, odour, texture and overall acceptability. The organoleptic quality start dramatically decreased in biscuit 5 and biscuit 6 with lowest values (less than 5) which we eliminated in further studies. For a product to be considered approved in relation to its organoleptic properties, it is necessary that the acceptability index be at least 70%, adequate for consumption, with a good marketability (Santos et al., 2011) so we decided the above decisions. In otherwise, those results not agreed with Sharma and Dunkwal (2012) who prepared biscuits with 10 % dried Spirulina algae in India. They found that mean score for overall acceptability of value added biscuit was 7.5 against the control sample, 7.9 on nine point hedonic ranking scale. Accepted high percentage (10% dried Spirulina algae) in the Indian study and unaccepted even half of it (4% dried Spirulina algae) in the Egyptian study could be attributed for panel members food culture and habit. The eating habits of an individual are acquired depending on one’s environment or family experiences.
Fig (1): Prepared biscuit blends fortified with different percentage of Spirulina algae.
Where Control: Biscuit without dried Spirulina algae.
Biscuit 1: Fortified with 0.5% dried Spirulina algae.
Biscuit 2: Fortified with 1.0% dried Spirulina algae.
Biscuit 3: Fortified with 2.0% dried Spirulina algae.
Biscuit 4: Fortified with 3.0% dried Spirulina algae.
Biscuit 5: Fortified with 4.0% dried Spirulina algae.
Biscuit 6: Fortified with 5.0% dried Spirulina algae.

Traditionally, biscuits exhibit light yellow colorations, derived from its tradition ingredients. So, Egyptian people not accepted the green colour especially with high tone in the high concentration of Spirulina algae. Colour factor was the crucial variable in the organoleptic properties evaluation. In other hand, the texture of the biscuit blends in Table (4), was also evaluated, and a significant increase of their firmness was evidenced with an increase of added dried Spirulina algae. These results evidence the positive effect of the algae in the biscuit structure, reinforcing the short dough system. Biscuits are considered solid emulsions of sucrose, lipids and non-gelatinized starch, being this morphology is responsible for the biscuits structure and texture. The main factor affecting these properties is the moisture content and water mobility, which are highly affected by the interaction with hydroxyl groups present in the matrix. The replacement of a small amount of flour by dried Spirulina algae resulted in the inclusion of a complex biomaterial, rich in different proteins and polysaccharides. These molecules have an important role on the water absorption process, which promote the increase of biscuits firmness, resulting in more compact structures (Gouveia et. al., 2008c).

Chemical composition of biscuit blends:
Biscuits are the most popular bakery products consumed nearly by all sections of the society in Egypt. Some of the reasons for such wide popularity are low cost as
comparing with other processed foods affordable cost, good nutritional quality and availability in different forms, varied taste and longer shelf life. Bakery products are sometimes used as a vehicle for incorporation of different nutritionally rich ingredients (Sudha et. al., 2007 and Zedan, 2012). Data given in Table (5) showed the centesimal chemical composition of biscuits fortified with different levels of dried *Spirulina* algae, it could be noticed that the moisture content for biscuits fortified with dried *Spirulina* algae was less than biscuits without dried *Spirulina* (control). Moisture content is measured for a number of reasons including legal and label requirements, economic importance, food quality better processing operations and storage stability considerations. The moisture content in biscuits was ranged between (3.90 to 4.90%), the highest value was in control biscuit and the lowest in biscuit 4 fortified with 3.0% dried *Spirulina* algae. Moisture content showed slight and gradually decreased in all biscuit blends as comparing with control samples, but it was not significant increase P< 0.05. For protein content, the results cleared that the percentage of crude protein was increased in a noticed degree by adding dried *Spirulina* algae. Crude protein content in biscuits was ranged from (6.8 to 7.8 %). The highest crude protein content was found in Biscuit 4 followed by Biscuit 3, Biscuit 2 and Biscuit 1 as (7.8, 7.4, 7.2, and 6.9 %), respectively. Crude protein showed significant increase (P< 0.05) in all biscuit blends except with Biscuit 1 as comparing with control biscuits. Fat, ash, crude fibers and carbohydrates in both control biscuits and biscuits blended with dried *Spirulina* algae were similar and there were no significance differences between them.

Table (5): Chemical composition of biscuit blends fortified with different levels of dried *Spirulina* algae (g/100g dry weight basis).

<table>
<thead>
<tr>
<th>Biscuit blends</th>
<th>Moisture</th>
<th>Crude Protein</th>
<th>Fat</th>
<th>Ash</th>
<th>Crude fibers</th>
<th>Carbohydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4.90a</td>
<td>6.80a</td>
<td>24.94ab</td>
<td>0.55a</td>
<td>·A1ab</td>
<td>66.87a</td>
</tr>
<tr>
<td>Biscuit 1</td>
<td>4.70a</td>
<td>6.90abc</td>
<td>26.16a</td>
<td>0.61a</td>
<td>·A2ab</td>
<td>65.73a</td>
</tr>
<tr>
<td>Biscuit 2</td>
<td>4.10ab</td>
<td>7.20b</td>
<td>20.8b</td>
<td>0.62a</td>
<td>·A4ab</td>
<td>70.59a</td>
</tr>
<tr>
<td>Biscuit 3</td>
<td>3.91ab</td>
<td>7.40ab</td>
<td>22.58ab</td>
<td>0.59a</td>
<td>·A5a</td>
<td>68.09a</td>
</tr>
<tr>
<td>Biscuit 4</td>
<td>3.90ab</td>
<td>7.80a</td>
<td>24.74ab</td>
<td>0.45a</td>
<td>·A1ab</td>
<td>66.20a</td>
</tr>
</tbody>
</table>

Where: Control: Biscuit without dried *Spirulina* algae.
Biscuit 1: Fortified with 0.5% dried *Spirulina* algae.
Biscuit 2: Fortified with 1.0% dried *Spirulina* algae.
Biscuit 3: Fortified with 2.0% dried *Spirulina* algae.
Biscuit 4: Fortified with 3.0% dried *Spirulina* algae.

Mean values in each column designated by the same letter are not significantly different at 5.0% level using Duncan's multiple range tests.

Carbohydrates mean values in studied biscuits were ranged from 66, 20 to 70.59%. The highest carbohydrates content of biscuits may be due to high content of wheat flour and this agree with that reported by Arafa, (2009) and Ahmed (2012), who mentioned that wheat flour at extraction ratio 72% involves high amount of total carbohydrates. The increase in crude protein of biscuits fortified with dried *Spirulina* can be attributed to the high content of ingredient in *Spirulina* algae. These results are confirmed with the results of Hooda and Jood (2005) and Eissa et. al. (2007) they reported that high protein content of biscuits prepared from blends of wheat-raw and germinated leguminous flour. Our results in general were in the same line of others obtained by Sharma and Dunkwal (2012) who prepared biscuits with 10% dried *Spirulina* algae. The developed value added biscuit contained 2.9% moisture, 19.6g protein, 26.71g fat, 2.08g crude fiber, 1.83g ash, 46.83 g carbohydrates and 506.11 kcal energy/100g on dry weight basis. And also with results obtained by Singh et. al., 2015 who found that addition of *Spirulina* powder in biscuit increased its protein as well as antioxidant potential in proportion to the level of *Spirulina* powder added.

**Caloric values of biscuit blends:**

Data in Table (6) showed the caloric values of biscuits fortified with different levels of *Spirulina* algae according to nutrient sources. It is noticed the calories become from the protein as a source increased with the increasing of the percentage of dried *Spirulina* algae in biscuits blends. It start from 27.2 in control biscuit and reached to 31.2 in biscuit 4 which contain 3% dried *Spirulina* algae. In other wise, it were clear that both fat or carbohydrates not play an important role as results not correlate with the percentage of algae.

Table (6): Caloric values of biscuit blends fortified with different levels of *Spirulina* algae (kcal. /100 g of biscuit blends).

<table>
<thead>
<tr>
<th>Biscuit blends</th>
<th>Sources of calories (kcal.)</th>
<th>Carbohydrates</th>
<th>Total caloric values (kcal./100 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>27.2a</td>
<td>224.46a</td>
<td>267.48a</td>
</tr>
<tr>
<td>Biscuit 1</td>
<td>27.6b</td>
<td>235.44a</td>
<td>262.92a</td>
</tr>
<tr>
<td>Biscuit 2</td>
<td>28.8ab</td>
<td>187.2a</td>
<td>282.36a</td>
</tr>
<tr>
<td>Biscuit 3</td>
<td>29.6ab</td>
<td>203.22a</td>
<td>272.36a</td>
</tr>
<tr>
<td>Biscuit 4</td>
<td>31.2a</td>
<td>222.66a</td>
<td>264.81a</td>
</tr>
</tbody>
</table>

Where: Control: Biscuit without dried *Spirulina* algae.
Biscuit 1: Fortified with 0.5% dried *Spirulina* algae.
Biscuit 2: Fortified with 1.0% dried *Spirulina* algae.
Biscuit 3: Fortified with 2.0% dried *Spirulina* algae.
Biscuit 4: Fortified with 3.0% dried *Spirulina* algae.

Mean values in each column designated by the same letter are not significantly different at 5.0% level using Duncan's multiple range tests.
Ingredients used for making biscuits are considered of low nutritive and biological values, for example soft wheat flour is deficient in several nutrients including some vitamins, minerals and dietary fibre and contains only 7 to 10 % of protein. Besides, wheat flour lacks certain essential amino acids such as lysine, tryptophan and threonine (Erben et al., 2014).

**Amino acids composition of biscuit blends.**

Amino acids composition of biscuit blends fortified with different levels of dried *Spirulina* algae are shown in Table (7). The biscuits samples contained all indispensable amino acids. It could be noticed that, all indispensable amino acids contents of tested biscuits were found to be higher than that of reference protein recommended by FAO/WHO/UNU (1985). It could be observed that, biscuits blends fortified with different levels of dried *Spirulina* had the highest amount of indispensable amino acids (individual and total) than control biscuit.

It was clear that leucine was the highest amino acids in control biscuit (6.85), followed by phenylalanine (5.75), while lysine was the lowest value (2.65) of essential amino acids. Biscuit 2 recorded total indispensable A.A. (39.82) as the highest biscuit blends compared with the lowest one which was the biscuit control (35.91).

All biscuits blends samples contained more amounts of dispensable amino acids than indispensable amino acids.

The nutritive value of dietary protein depends on its indispensable amino acids composition. The amino acids scores can be considered as an imperfect indicator of protein quality, but it still the best one based on amino acids. The nutritive value of a protein depends primarily on its efficiency to satisfy the requirements for essential amino acids. Thus, the amino acids requirements are the logical yardstick by which protein quality can be measured (Abdou, 2004 and Zedan, 2012). This is due to the fact that protein quality as determined by biological procedures depends on the limiting indispensable amino acids. The amino acid scores were calculated to throw light on the quality of bakery products as affected by dried *Spirulina* additives.

### Table (7): Amino acids composition of biscuit blends (g/100g protein).

<table>
<thead>
<tr>
<th>Amino acids</th>
<th>Control</th>
<th>Biscuit 1</th>
<th>Biscuit 2</th>
<th>Biscuit 3</th>
<th>Biscuit 4</th>
<th>FAO/WHO/UNU pattern (1985)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total indispensable A.A</td>
<td>35.91&lt;sup&gt;b&lt;/sup&gt;</td>
<td>36.72&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>39.82&lt;sup&gt;a&lt;/sup&gt;</td>
<td>39.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.18&lt;sup&gt;ab&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>5.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.78&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>6.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.98&lt;sup&gt;ab&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>26.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Serine</td>
<td>4.97&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.71&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Glycine</td>
<td>3.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.64&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.96&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Arginine</td>
<td>4.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.28&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.82&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Alanine</td>
<td>3.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.96&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.76&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Proline</td>
<td>5.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.85&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Total dispensable A.A</td>
<td>52.59&lt;sup&gt;b&lt;/sup&gt;</td>
<td>56.75&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>59.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>55.02&lt;sup&gt;ab&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Total A.A</td>
<td>88.51&lt;sup&gt;b&lt;/sup&gt;</td>
<td>93.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>99.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>98.85&lt;sup&gt;a&lt;/sup&gt;</td>
<td>91.22&lt;sup&gt;ab&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Where: Control: Biscuit without dried *Spirulina* algae.
Biscuit 1: Fortified with 0.5% dried *Spirulina* algae.
Biscuit 2: Fortified with 1.0% dried *Spirulina* algae.
Biscuit 3: Fortified with 2.0% dried *Spirulina* algae.
Biscuit 4: Fortified with 3.0% dried *Spirulina* algae.

Mean values in each column designated by the same letter are not significantly different at 5.0% level using Duncan’s multiple range tests.

**Amino acids score of biscuit blends**

The amino acids scores (AAS) of the indispensable amino acids in control biscuit was ranged from 1.52 to 5.18, the highest value was detected in phenylalanine + tyrosine followed by leucine (3.61) and the lowest value was presented in histidine. Biscuit blends fortified with dried *Spirulina* algae showed increase in A.A.S., it ranged between 1.45 to 5.38. The highest values were in phenylalanine +tyrosine in biscuit 2 followed by leucine (4.08) in biscuit 3 and the lowest value was presented in histidine in biscuit 4 (Table 8).

The first limiting amino acids in all biscuit blends was the histidine, while lysine was the second limiting amino acids. The AAS of threonine, valine, methionine + cystine, leucine, Histidine and lysine in all biscuit blends fortified with (0.5-3.0%) dried *Spirulina*, showed some improvement.
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Table (8): Amino acids scores* (A.A.S.) of biscuit blends fortified with different levels of dried Spirulina alga.

<table>
<thead>
<tr>
<th>Amino acids</th>
<th>Control</th>
<th>Biscuit 1</th>
<th>Biscuit 2</th>
<th>Biscuit 3</th>
<th>Biscuit 4</th>
<th>FAO/WHO/UNU pattern (1985)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threonine</td>
<td>3.44</td>
<td>3.57</td>
<td>3.54</td>
<td>3.84</td>
<td>3.54</td>
<td>0.90</td>
</tr>
<tr>
<td>Valine</td>
<td>3.23</td>
<td>3.38</td>
<td>3.89</td>
<td>3.87</td>
<td>3.64</td>
<td>1.30</td>
</tr>
<tr>
<td>Methionine + Cystine</td>
<td>1.95</td>
<td>2.14</td>
<td>2.26</td>
<td>2.03</td>
<td>2.04</td>
<td>1.70</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>2.72</td>
<td>2.72</td>
<td>3.13</td>
<td>3.06</td>
<td>2.82</td>
<td>1.30</td>
</tr>
<tr>
<td>Leucine</td>
<td>3.61</td>
<td>3.72</td>
<td>4.05</td>
<td>4.08</td>
<td>3.91</td>
<td>1.90</td>
</tr>
<tr>
<td>Histidine</td>
<td>1.52</td>
<td>1.54</td>
<td>1.72</td>
<td>1.64</td>
<td>1.45</td>
<td>1.60</td>
</tr>
<tr>
<td>Phenylalanine + Tyrosine</td>
<td>5.18</td>
<td>5.07</td>
<td>5.38</td>
<td>5.35</td>
<td>4.88</td>
<td>1.90</td>
</tr>
<tr>
<td>Lysine</td>
<td>1.66</td>
<td>1.74</td>
<td>1.86</td>
<td>1.83</td>
<td>1.69</td>
<td>1.60</td>
</tr>
</tbody>
</table>

Where: Control: Biscuit without dried Spirulina algae.
Biscuit 1: Fortified with 0.5% dried Spirulina algae.
Biscuit 2: Fortified with 1.0% dried Spirulina algae.
Biscuit 3: Fortified with 2.0% dried Spirulina algae.
Biscuit 4: Fortified with 3.0% dried Spirulina algae.

*Chemical scores were calculated as amino acid ratio of food protein to reference protein FAO/WHO/UNU (1985)

Minerals content of biscuit blends:

Data in Table (9) illustrated minerals content of biscuit blends fortified with different levels of dried Spirulina alga, including sodium, potassium, calcium, phosphorus, magnesium and iron. Generally, adding dried Spirulina alga to biscuit blends with all added percentages (0.5 to 3.0%) increased minerals content of all samples. It was noticed that there were significant difference between all biscuits blends and the control in all studied minerals except for phosphorus. Sodium values showed significantly different among all biscuit blends. Biscuit 4 showed the highest sodium content (150 mg/100g), followed by Biscuit 3 (131.10 mg/100g), and control biscuit (162.35 mg/100g). Sodium content was recorded in control biscuit (162.35 mg/100g). Regarding phosphorus content, there were not significant differences among control biscuit, Biscuit 1 and Biscuit 2 without trend of increase. However, phosphorus contents start to be significant more than control in Biscuit 3 and Biscuit 4 (0.26 and 0.27 mg/100g). Magnesium content increased slowly as a function of the increase of add dried algae percentage. There were significant differences between biscuit blends (3 and 4) and biscuit blends (1, 2 and control). The highest value was detected in Biscuit 4 (196.8 mg/100g) which record to be 1.3 fold in magnesium content more than the biscuit control. Iron content differed significantly in biscuit blends fortified with dried algae comparing with biscuit control. However, there were no significant differences among those biscuit blends. But as others studied elements, Biscuit 4 recorded the maximum contents of iron (31.4 mg/100g). The obtained results recorded iron content much more than that reported by Sharma and Dunkwal (2012) who found potassium content in fortified biscuits was 292 mg/100g.

Table (9): Minerals contents of biscuit blends fortified with different levels of dried Spirulina alga (mg/100g, dry weight basis)

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Sodium (Na)</th>
<th>Potassium (K)</th>
<th>Calcium (Ca)</th>
<th>Phosphorus (P)</th>
<th>Magnesium (Mn)</th>
<th>Iron (Fe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>47.20^a</td>
<td>84.90^b</td>
<td>162.35^c</td>
<td>0.22^d</td>
<td>154.70^a</td>
<td>22.10^b</td>
</tr>
<tr>
<td>Biscuit 1</td>
<td>72.00^b</td>
<td>878.00^c</td>
<td>194.80^c</td>
<td>0.23^d</td>
<td>167.70^b</td>
<td>26.34^c</td>
</tr>
<tr>
<td>Biscuit 2</td>
<td>95.90^b</td>
<td>1007.00^d</td>
<td>182.70^c</td>
<td>0.12^e</td>
<td>168.80^b</td>
<td>31.72^c</td>
</tr>
<tr>
<td>Biscuit 3</td>
<td>131.10^b</td>
<td>1046.00^d</td>
<td>234.80^c</td>
<td>0.26^e</td>
<td>188.10^c</td>
<td>26.58^c</td>
</tr>
<tr>
<td>Biscuit 4</td>
<td>150.00^c</td>
<td>1149.00^e</td>
<td>277.20^c</td>
<td>0.27^f</td>
<td>196.80^c</td>
<td>31.40^c</td>
</tr>
</tbody>
</table>

Where: Control: Biscuit without dried Spirulina algae.
Biscuit 1: Fortified with 0.5% dried Spirulina algae.
Biscuit 2: Fortified with 1.0% dried Spirulina algae.
Biscuit 3: Fortified with 2.0% dried Spirulina algae.
Biscuit 4: Fortified with 3.0% dried Spirulina algae.

Mean values in each column designated by the same letter are not significantly different at 5.0% level using Duncan’s multiple range tests.

Both of Biscuit 3 and Biscuit 4 were very important sources of calcium as (234.8 and 277.2 mg/100g); respectively, with being not significant difference between all of them. The lowest calcium content was recorded in control biscuit (162.35 mg/100g). Regarding phosphorus content, there were not significant differences among control biscuit, Biscuit 1 and Biscuit 2 without trend of increase. However, phosphorus contents start to be significant more than control in Biscuit 3 and Biscuit 4 (0.26 and 0.27 mg/100g). Magnesium content increased slowly as a function of the increase of add dried algae percentage. There were significant differences between biscuit blends (3 and 4) and biscuit blends (1, 2 and control). The highest value was detected in Biscuit 4 (196.8 mg/100g) which record to be 1.3 fold in magnesium content more than the biscuit control. Iron content differed significantly in biscuit blends fortified with dried algae comparing with biscuit control. However, there were no significant differences among those biscuit blends. But as others studied elements, Biscuit 4 recorded the maximum contents of iron (31.4 mg/100g). The obtained results recorded iron content much more than that reported by Sharma and Dunkwal (2012) who prepared biscuits with 10% dried Spirulina alga and found that iron content recorded about 17.62 mg/100g.
It was cleared that biscuit blends containing dried *Spirulina* algae at different levels were a good source for sodium, potassium, calcium, phosphorus, magnesium and iron.

**Bioactive compounds of biscuit blends:**

Data in Table (10) showed total chlorophyll-a, total carotenoids, phycocyanin and total Phenolic compounds of biscuit blends fortified with different levels of dried *Spirulina* algae. Chlorophyll-a increased upon the increase of dried *Spirulina* algae levels. Results indicated that chlorophyll-a ranged between 0.0 and 46.1 µg g⁻¹. It is noticed that the lowest results were for control biscuit and highest values were for biscuit 4. Data revealed that there were high significance between control biscuit (0 of Chlorophyll-a) and others biscuit blends.

<table>
<thead>
<tr>
<th>Bioactive compounds</th>
<th>Chlorophyll-a (µg g⁻¹)</th>
<th>Total carotenoids</th>
<th>β-carotene</th>
<th>Phycocyanin (µg g⁻¹)</th>
<th>Total Phenolics (mg gallic acid/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.00⁷</td>
<td>29.3⁷</td>
<td>10.90⁷</td>
<td>0.00⁷</td>
<td>55.20⁷</td>
</tr>
<tr>
<td>Biscuit 1</td>
<td>31.70⁶</td>
<td>58.80⁶</td>
<td>21.40⁶</td>
<td>22.10⁶</td>
<td>61.20⁶</td>
</tr>
<tr>
<td>Biscuit 2</td>
<td>29.70⁶</td>
<td>63.90⁶</td>
<td>20.10⁶</td>
<td>23.90⁶</td>
<td>81.20⁶</td>
</tr>
<tr>
<td>Biscuit 3</td>
<td>39.40⁶</td>
<td>69.00⁶</td>
<td>29.10⁶</td>
<td>30.70⁶</td>
<td>96.30⁶</td>
</tr>
<tr>
<td>Biscuit 4</td>
<td>46.10⁶</td>
<td>72.00⁶</td>
<td>31.10⁶</td>
<td>35.00⁶</td>
<td>99.20⁶</td>
</tr>
</tbody>
</table>

Where: Control: Biscuit without dried *Spirulina* algae.
Biscuit 1: Fortified with 0.5% dried *Spirulina* algae.
Biscuit 2: Fortified with 1.0% dried *Spirulina* algae.
Biscuit 3: Fortified with 2.0% dried *Spirulina* algae.
Biscuit 4: Fortified with 3.0% dried *Spirulina* algae.

Mean values in each column designated by the same letter are not significantly different at 5.0% level using Duncan's multiple range tests.

In other compounds like carotenoids, results indicated that control biscuit have a little amount which considered lowest amount with significant different regarding others biscuit blends. Total carotenoids ranged between 29.3 in control biscuit and increase upon the increase of dried *Spirulina* algae level to reach the maximum with 3.0% in biscuit 4 as 72.0. β-carotene started also with small amount in control biscuit as 10.9 then increased to reach a 31.10 in biscuit 4. Those results were less than others obtained by Sharma and Dunkwal (2012) found that β-carotene in biscuits fortified with 10% dried *Spirulina* algae and contents was in the range of 349.75 µg/100g. The major differences in biochemical composition of studied biscuit blends were related to the present of phycocyanin and chlorophyll-a in *Spirulina* algae as markable compounds. Phycocyanin and chlorophyll amount in biscuit control were 0, whereas those amount increased upon the increase of dried *Spirulina* algae to reach the maximum as 80.9 and 35.00 µg g⁻¹, respectively, in Biscuit 4. Total phenolic increased slowly with no significant deference between control biscuit (55.2) and biscuit 1 (61.20), then increased with high ratio significantly to reach the maximum in biscuit 4 (99.2). Those results were agreed with Rodríguez De Marco *et. al.*, (2014) who reported that pasta with *Spirulina* exhibited high phenolic compounds content and antioxidant activity compared to control pasta, which could be used to enhance the nutritional profile of the product.

**REFERENCES**


Ekram H. Barakat et al.


Gouveia, L. and Oliveira A.C., (2009), Microalgae as a raw material for biofuels production, Journal of Industrial Microbiology and Biotechnology 36 269–274.


التقييم الكيميائي والغذائي للبسكويت المدعم بطلبب Spirulina platensis

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*قسم الاقتصاد المنزلي كلية التربية النوعية جامعة فركل الشيخ مصر

**قسم الصناعات الغذائية كلية الزراعة جامعة فركل الشيخ مصر

يستخدم طلب الباسيل فاي كمشروع أساسي للطلبة في العديد من الدول ومن بينها مصر هو من الطباق الخضرا المزرع في عديد المناخات.

يهدف هذا البحث لدراسة قيم الغذاء لطلح الباسيل والدوريون واعداد خلطات البسكويت المدعمة به ذات قيمة الغذائية المرتفعة.

حيث أن هذا الطلب يمكن أن يكون من الباسيل والدوريون على مرتبة من البروتين (22%) ومن الكربوهيدرات الفعالة والتي لها قدره عالية من محتوى الحديد، وقد تم إجراء الدراسات الأولى للطلب على طلب الكبسولات البلاستيكية (45 جم/100 جم) والبلاستيكية (50 جم/100 جم) والبلاستيكية (55 جم/100 جم) مكونة من مكونات مختلطة (40 جم/100 جم) مع الطلب على المحتوى البشري (40 جم/100 جم) لتمكينه.

كما أن هذا البحث القائم على خلطات طلبال الباسيل وفيتالا أوراوليا المدعمة بطلح الباسيل والدوريون بنسبة 6:4% لدي التحسينات الموضعية والكيميائية والغذائية لها حيث كالتخلخلات يجلبها حسب الدور الحيوية من المركبات الغذائية المفيدة والبروتينات والعناصر الغذائية.

البسكويت المدعوم بشكل بيتل بسلا سيرينا (الألكورول)