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Effect of *Arthrospira platensis* on the Shelf Life, Sensorial and Rheological Properties of strudel

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Abstract

Arthrospira platensis microalga is widely used in the food industry due to its nutritional value such as having high protein content, vitamins, essential amino acids, minerals and antimicrobial properties that inhibit the growth of mold and yeast. This study aimed to evaluate the effect of the addition of dried microalga at different levels (0, 0.5, 1 and 1.5% w/w) on the technological, sensorial, and rheological properties (texture and color), as well as on the stability and the nutritional value of strudel. Results showed that the protein content of the enriched strudel was higher than control ($p< 0.05$) while its peroxide value reduced ($p<0.01$). Colorimetric analysis also showed that within 45 days, the color stability of enriched strudel samples was higher than control ($p<0.05$). Results from sensorial analysis done by 10 panelists indicated that addition of powdered Arthrospira results in a brittle strudel and 0.5 and 1% fortification achieved the most popular preferences. The overall acceptance results showed that the best strudel can be obtained by adding 0.5 to 1 % Arthrospira platensis, which in addition to the improvement of the sensorial and rheological properties, also has antimicrobial properties that inhibit the growth of yeasts and molds.

Keywords: *Arthrospira platensis, Microalga, Enrichment, Strudel*

Introduction

Arthrospira platensis (*A. platensis*), formerly named *Spirulina platensis*, a health-promoting food and/or food additive/supplement has been used as a food for humans and are known as the superior food in the World Health Organization (**WHO**) (A. BELAY [1]). The consumption of *Arthrospira* and its addition to foods is mainly due to its high content of protein (60–70% by weight), vitamins, especially vitamin B_{12}, essential amino acids, minerals, especially iron, essential fatty acids, particularly Hγ-linoleic acid, phycocyanin, fiber, and other micro nutrients (A. BELAY [1], A. BELAY & al. [2], D. BHOWMIK & al. [3], N.P. MINH [4], P. SPOLAORE & al. [5]). Furthermore, the presence of *Arthrospira* in food can have unique therapeutic effects such as immune-modulation, anti-cancerous, antioxidant, antiviral and antibacterial, metallic protection (S.M. HOSEINI & al. [6, 7]). *A. platensis* is the most commonly available and therefore most commonly used genus, which has been the subject of many studies in the food industry and medicine (H. BEHESHTIPOUR & al. [8]). Recently, a large number of studies using microalgae biomass in foods (e.g., dairy products, pastas and cereals) have been carried out in order to increase its nutritional properties (A. AKALIN & al. [9], V. FADAEI & al. [10], M. FRADIQUE [11], M. SELMO & al. [12]). Despite the development of this strategy, enrichment of strudel with *A. platensis* has never been thoroughly investigated.

Strudel, a fermented product, is widely consumed and can be useful as a carrier for important health nutrients (V. FADAEI & al. [10]). Strudel is traditionally manufactured with flour, sugar, oil, improving agents and essence and therefore its nutritional value is not very high. It is assumed that the nutritional properties and health benefits of strudel can be improved using microalgae as it was shown by Gouveia *et al*. for vegetable gelled desserts (L. GOUVEIA & al. [13]) and biscuits (L. GOUVEIA & al. [14]).

The purpose of the present study was to produce strudel with healthier nutrients, with longer shelf time and for the strudel to be more attractive. Therefore, strudels were enriched with *A. platensis* biomass with four different concentrations (0,0.5, 1 and 1.5% w/w) to investigate the technological, rheological and nutritional quality of this product. The main focus of this study was to investigate the effect of *A. platensis* on strudel texture, peroxide value, protein content, moisture, color and sensorial properties.

Materials and methods

1. Materials

A. platensis powder was provided by an Iranian microalgae production company (Riz Jolbak Gheshm). The biomass was protected from light and stored in dry and cool conditions. All the reagents to perform the analysis, such as hydrochloric acid 37%, sulfuric acid, sulfate cupper, sulfate potassium, methanol, potassium hydroxide, sodium hydroxide (40% w/v), Sodium thiosulfate (0.01 N) boric acid (4% w/v) and sulfuric acid (0.1 N) were purchased from Merck (Germany).

2. Strudel preparation process

The strudels were prepared using flour, 6.1% sugar, 1.8% salt, 52.2% water, 6.5% whey powder, and 50–57% layered margarine. Shortening, leaven, vanilla, egg, improving agent, and *Arthrospira* powder at varying concentrations of 0, 0.5, 1, 1.5% (w/w), were added to the mixture, according to Gouveia et al (L. GOUVEIA & al. [14, 15]) .A control strudel, without any microalga biomass was also prepared. In order to prepare strudel with 0.5, 1 and 1.5% (w/w) of *A. platensis,* 30, 60 and 90 g of *A. platensis* powder respectively, and accurately weighed, was homogenously mixed with 7 Kg of flour. Then other ingredients were added and mixed which resulted in a mixture to then obtain homogenous dough. The strudel cream was injected in the cookie after the baking process. The strudels were baked in an oven at 220±10°C for 20 min. The baked strudels were cooled down and kept in two layer nylon freezer bags (at 20±5°C) protected from light and humidity.

3. Analyses

3.1. Protein

Protein was measured using the micro Kjeldahl method (Foss, Germany) and the percentage of protein content was calculated by using a 6.25 conversion factor (ISO20483 [16]).

3.2. Moisture

Cooked strudel samples were analyzed for their moisture level according to ISO712 (ISO712 [17]).

3.3. Texture

The strudel texture was measured objectively using a texturometer (Hounsfield H5ks, UK) in penetration mode with a cylinder which had a 3.2 mm diameter probe at 60 mm min−1.The resistance to penetration was measured by the maximum force (N) showed on the texturogram peak which corresponds to the firmness value. Measurements were replicated three times at room temperature (20°C).

3.4. Color

The color of the strudel samples was measured instrumentally using a Hunter lab colorimeter (Hunter lab D25-DP9000, Germany). The results were expressed in accordance with the CIELAB uniform color system in terms of L∗, lightness (values increase from 0 to 100%); a∗, redness to

greenness (positive to negative values, respectively); b*, yellowness to blueness (positive to negative values, respectively). The total color difference between the control and enriched samples with microalgae was calculated by ΔE = [(ΔL*)2 + (Δa*)2 + (Δb*)2] 1/2. The measurements were done at 20±5°C under constant light conditions and replicated 3 times, after storage for 1 day and 1, 2, 4 and 6 weeks (E-S.A. ATTIA & al. [18]).

3.5. Peroxide

The peroxide values were determined through the extracted oil where the following method was performed: ISO 3960(ISO3960 [19]). Briefly, 5 g of extracted oil from strudel was weighed into a 100 mL Erlenmeyer flask and the weight was recorded. Followed by 30 mL of the acetic acid/chloroform solution (3/2: v/v) being added using a graduated cylinder. After that, 0.5 mL of saturated potassium iodide solution was added to the solution, and then, the reaction allowed to process for exactly 1 min in the dark. 30 mL of distilled water was then immediately added, and the mixture shaken vigorously to liberate the iodine from the chloroform layer. Using a dispensing device, 1 mL of starch solution was added as an indicator. Finally, the solution was titrated with sodium thiosulfate at 0.01N, until the blue grey color disappeared in the aqueous. The peroxide value of samples, were obtained as follows:

$$\text{Peroxide value} = \frac{A \times 10}{W}$$

Where A is sodium thiosulfate (g) consumed and W is sample weight (g).

4. Sensorial evaluation

Sensorial analysis was carried out according to the 5 point hedonic methodology by 10 trained panelists using semi-structured scales scoring 0 (lowest) to 4 (highest). The attributes evaluated were color, flavor, aroma, mouth feel and texture. The average of the judges' responses was calculated for each one of the attributes. Each sample formulation (samples with the incorporation of 0, 0.5, 1 and 1.5% of *A. platensis* biomass) was cooked and served randomly to the judges who were asked to taste the samples and rate the attributes from 'dislike extremely' (score 0) to 'like extremely' (score 4). Drinking water was provided for palate cleansing between each test. Randomized complete block design was used to analyze the results obtained from the judges (M. FRADIQUE & al. [11]).

5. Microbiological analysis

5.1. Enumeration of yeasts and molds

A count was made of the yeasts and molds using APHA method in three replicates for each treatment in five different storage time. Briefly, the culture media (Dextrose chloramphenicol agar, YGC, and sabouraud Dextrose agar (SDA)) were put on to 4 plates.

Lids were then placed on the plates to close and incubate them for 3–5 days at 4–26°C. Colony counts were performed (triplicated) based on average plate counts multiplying by the dilution ratio and the inverse accuracy.

6. Statistical analysis

Results of the chemical, physical, microbiological and sensorial analyses were evaluated in a complete random design. The Duncan analysis was incorporated in order to determine the difference between the averages of the data values for the 3 iterations. Statistical analysis was performed using SPSS.

Results and discussion

1. Protein content

The protein content of the *Arthrospira* powder is 60–70% (w/w). Thus, the replacement of a small amount of flour by *A. platensis* biomass resulted in an increase in the protein content of the strudel ($p<0.05$), due to the high protein content of *Arthrospira* (E.D.G. DANESI & al. [20]).

Table 1 indicates that the protein content of the strudel samples was significantly influenced by the addition of the *A. platensis* microalga powder. These results are in line with those obtained by Danesi et al (E.D.G. DANESI & al. [20]) related to the protein enrichment based on Cassava. *A. platensis* is also a good source of essential amino acids, and very easy to digest because of the lack of cell membrane cellulose walls (S.M. HOSEINI & al. [6]).

The same result was obtained by Mamatha et al (B. MAMATHA & al. [21]). They used seaweeds (*Enteromorpha compressa*) as an ingredient in the preparation of snack. Their results showed an increase in iron and calcium contents, and a significant increase in dietary fiber, protein and vitamin contents (B. MAMATHA & al. [21]). The results obtained in this study are also in agreement with those reported by Nakhost and Karel (Z. NAKHOST, M. KAREL [22]) using the green alga *Scenedesmus obliquus* as an enrichment source of protein for food production such as bran muffins, chocolate chip cookies and spinach noodle imitation.

Table 1. Protein, moisture, hardness, color, and peroxide content of samples enriched with different concentrations of *Arthrospira platensis* (0, 0.5, 1.0, 1.5 % w/w) over different storage times (producing day, 1, 2, 4 and 6 weeks)

Treatments	Protein (%w/w) (SD=0.056)	Moisture (%w/w) (SD=0.075)	Hardness (Pas) (SD=0.010)	ΔE^* (SD=0.152)	b (SD=0.659)	a* (SD=28.56)	L^* (SD=1.37)	Peroxide (meq/Kg oil) (SD=0.05)
W_0C_0	11.033^{ab}	18.117^{bd}	0.687^{ab}	0.470^{ac}	34.757^{a}	3.040^{a}	77.863^{a}	0.127^{ab}
$W_0C_{0.5}$	11.200^{ac}	17.950^{bd}	0.627^{a}	0.450^{c}	29.153^{ab}	-3.020^{a}	62.440^{ab}	0.127^{b}
W_0C_1	11.250^{a}	17.993^{ad}	0.640^{ac}	0.733^{bc}	21.817^{ac}	-12.573^{a}	54.270^{ac}	0.123^{ab}
$W_0C_{1.5}$	11.217^{ab}	17.903^{cd}	0.683^{ab}	1.603^{c}	20.940^{ac}	-11.647^{a}	53.537^{ac}	0.130^{ab}
W_1C_0	11.173^{abd}	17.907^{b}	0.680^{b}	6.555^{a}	36.370^{ab}	-7.167^{a}	77.533^{a}	0.133^{ad}
$W_1C_{0.5}$	10.367^{ab}	18.367^{b}	0.687^{ab}	2.443^{ac}	27.443^{b}	-3.407^{a}	61.717^{ab}	0.070^{bd}
W_1C_1	10.417^{ad}	18.583^{ab}	0.650^{bc}	3.742^{ab}	19.513^{bc}	-10.360^{a}	53.793^{ac}	0.080^{ad}
$W_1C_{1.5}$	10.810^{abc}	18.567^{bc}	0.640^{b}	2.750^{ac}	18.650^{bc}	-11.433^{a}	53.527^{ac}	0.090^{ad}
W_2C_0	10.383^{abc}	18.550^{ab}	0.667^{bc}	4.178^{ab}	37.143^{a}	-7.200^{a}	80.073^{a}	0.080^{ac}
$W_2C_{0.5}$	10.382^{c}	18.573^{ab}	0.670^{ac}	1.533^{bc}	26.713^{ab}	-3.38^{a}	62.377^{ab}	0.081^{bc}
W_2C_1	11.133^{ac}	18.813^{a}	0.693^{c}	2.795^{b}	21.570^{ac}	-6.830^{a}	54.807^{ac}	0.123^{ac}
$W_2C_{1.5}$	11.133^{cb}	18.750^{ac}	0.683^{bc}	0.402^{ac}	20.757^{ac}	-7.073^{a}	54.570^{ac}	0.130^{ac}
W_3C_0	11.190^{ab}	18.717^{bc}	0.617^{bd}	3.549^{ab}	38.163^{a}	-5.127^{a}	80.220^{a}	0.127^{ab}
$W_3C_{0.5}$	11.133^{bc}	18.823^{bc}	0.610^{ad}	2.577^{bc}	25.273^{ab}	-11.143^{a}	62.140^{ab}	0.123^{b}
W_3C_1	11.110^{ab}	18.733^{ac}	0.650^{cd}	2.701^{b}	21.307^{ac}	-10.143^{a}	53.403^{ac}	0.123^{ab}
$W_3C_{1.5}$	10.800^{b}	16.667^{c}	0.677^{bd}	1.670^{bc}	21.227^{ac}	-13.523^{a}	53.523^{ac}	0.137^{ab}
W_4C_0	10.817^{abc}	16.727^{be}	0.647^{ab}	5.426^{ab}	35.930^{ab}	-4.230^{a}	78.190^{a}	0.140^{a}
$W_4C_{0.5}$	10.820^{c}	16.633^{be}	0.707^{a}	2.693^{bc}	27.093^{b}	-1.533^{a}	62.003^{ab}	0.133^{ab}
W_4C_1	10.847^{ac}	16.767^{ae}	0.610^{ac}	1.510^{b}	21.560^{bc}	-9.020^{a}	53.263^{ac}	0.130^{a}
$W_4C_{1.5}$	11.368^{cd}	16.683^{ce}	0.647^{ab}	1.330^{bc}	20.043^{bc}	-10.650^{a}	52.520^{ac}	0.137^{a}

Means in the same column shown with different letters are significantly different ($p<0.01$)

W= Week of storage, W_0, W_1, W_2, W_4 and W_6 belong to the production day and first, second, fourth and sixth weeks, respectively

C= Concentration of *Arthrospira platensis* powder, C_0, $C_{0.5}$, C_1, and $C_{1.5}$ belong to sample enriched with 0, 0.5, 1 and 1.5% of *Arthrospira platensis*, respectively

2. Moisture

As shown in Table 1, the moisture content of strudels is independently affected by the microalgae powder concentration and storage time. The moisture content of the control and enriched samples was significantly different ($p<0.01$). However, during storage, the moisture content for the enriched samples was reduced by increasing the *Arthrospira* powder content which was not the case for the control samples. These results are in agreement with those reported by Batista et al (A.P. BATISTA & al. [23]).They reported that the absence of membrane could allow the absorption of water by the hydrocolloids (proteins) resulting in an increase in the moisture content and a reduction in the dehydration rate (A.P. BATISTA & al. [23]).

3. Hardness of Texture

The hardness evaluation of the samples (Table 1) revealed that the microalga powder concentration and storage time did not cause any impact on the sample hardness ($p\geq0.01$). The present results showed that the sample hardness decreases with an increase in the microalga powder content. The lowest hardness was observed in the samples incorporated with 1.5% of microalga (The changes are not significant $p\geq0.01$). Storage time had no significant effect on the hardness of the sample with 1.5% of microalga powder. It was observed that the incorporation of microalga had a beneficial effect on the stability of the strudel texture resulting in the enhancement of shelf life, which has a positive commercial value.

The *A. platensis* hydrocolloid (proteins) content can also impact the water absorption process (L. GOUVEIA & al. [15]). This can result in a reduction in the strudel dehydration rate and moisture removal. In addition, *A. platensis* proteins reduce the strudel's hardness (A.P. BATISTA & al. [23]). These observations are in agreement with the previous findings of Guarda et al (A. GUADRA & al. [24]) who described the effect of hydrocolloids (sodium alginate, xanthan, k-carrageenan and hydroxy propyl methylcellulose) on fresh bread quality and its impact on bread staling.

4. Sensorial analysis

The sensorial evaluation (color, flavor, aroma, mouth feel, texture and overall acceptability) of the strudels containing *A. platensis* was performed by 10 panelists (Table 2). In terms of color appreciation, the panelists clearly did not prefer the microalgae strudel, particularly those with the higher microalgae content (1.5%), in comparison with the control samples (without any microalga powder addition). It was observed that some panelists did not like to include *A. platensis* into strudels due to its green color. The same results were reported by Beheshtipour et al (H. BEHESHTIPOUR & al. [8]) on yogurt. The aroma and flavor attributes reported by the panelists have significantly decreased in enriched samples compared to the control ones. In addition, the use of a high concentration of microalga (1.5%) had a negative effect on the texture and mouth feel of the strudels. The result of the sensorial evaluation was calculated as the sum of the rankings obtained from the judges for each sample. Based on data presented in Table 2, the control sample is in the "like extremely "group, strudels 0.5% and 1% of *A. platensis* are in the "like group" and 1.5% of *A. platensis* is in the "dislike "group. Therefore, in terms of overall acceptability, no samples gained a high acceptance by panelists and it was obvious that the strudels without *Arthrospira* were preferred ($p<0.05$).

Table2. Sensorial analysis of the strudel containing different amounts of *Arthrospira platensis*

	Parameters				
Arthrospira platensis (%w/w)	Color ±0.354	Flavor ±0.274	Aroma ±0.296	Texture ±0.296	Mouth feel ±0.354
0	3.00^{a}	3.500^{a}	4.00^{a}	3.00^{a}	3.00^{a}
0.5	2.00^{ab}	2.00^{ac}	2.00^{ac}	3.00^{a}	3.00^{a}
1	2.00^{ab}	2.00^{ab}	1.50^{ab}	$3{:}00^{a}$	3.00^{a}
1.5	1.50^{ac}	1.00^{ad}	1.00^{ad}	2.50^{ab}	2.00^{ab}

Means in the same column shown with different letters are significantly different ($p<0.01$)

5. Color evaluation

Color is a major factor to determine the food product quality. The color of strudel samples was measured using a Hunterlab colorimeter on the first day and first, second, fourth and sixth weeks, for all experiments and replicated three times (E-S.A. ATTIA & al. [18]). From the instrumental color measurements, an increase in the green color of the enriched strudels was observed with the addition of microalga biomass, compared to the control strudel. Therefore, the strudels containing 0.5, 1 and 1.5% of *Arthrospira* showed significant differences with the control sample. The analysis of lightness (L^*) (Table 1) showed that lightness is significantly affected by microalga content ($p<0.01$). Meanwhile, the storage time had no significant effect on the lightness (L^*) of the samples ($p>0.01$). Results showed that the strudels with the highest and lowest microalga contents had the lowest and highest L* value, respectively. A significant decrease in L^* was observed with the addition of microalga ($p<0.05$). The chlorophyll and phycocyanin content (green and green/blue hues) of this microalga causes the reduction in the strudel's lightness.

As shown in Table 1, the addition of *Arthrospira* resulted in strudels with a negative a*. However, there is no significant difference in the a* values between the control and enriched samples ($p>0.01$). The highest a*was also observed in the control samples. As expected, the higher *Arthrospira* content significantly ($p<0.01$) increased the strudels' green color (negative a* values). Based on the colorimeter measurement data, significant ($p<0.05$) reduction in the b∗ value was observed, when A. platensis was added to the enriched strudels (Table 1). The control strudel presented a dominant yellow hue (highest positive b∗), while the strudel enriched with 1.5% *Arthrospira* presented the lowest b*. The strudel's color parameters, L*, a∗ and b*, remained very stable ($p<0.01$) during the storage time period of the present study, when *Arthrospira* was used.

As shown in Table 1, the total color differences (ΔE^*) underwent significant ($P<0.01$) reductions with increases in the microalgae (0.5, 1 and 1.5%) during the period of storage. The maximum variation in the strudel color was observed at the end of the storage period. It seems that the main reason for the color stabilization in the enriched strudels is that they are associated with low degradation and oxidation of the microalga pigments due to the antioxidant components that exist in the microalga (L. GOUVEIA & al. [14]). Therefore, the colorimetric parameters of the strudels enriched with microalga are significantly more stable than those of the control samples ($p<0.01$). The present results are in agreement with the results obtained by Gouveia et al (L. GOUVEIA & al. [14, 15]) who observed that the color of samples enriched with microalgae are more stable compared to the color of control samples.

6. Peroxide value

The peroxide value, which indicated the initial occurrence of the primary oxidation compounds for the different treatments was estimated in the present study according to ISO3960 for extracted oil (Table 1) (ISO3960 [19]). The results showed that the addition of microalga biomass to the strudel yielded significantly lower values for the primary oxidation products ($p<0.01$). Furthermore, the sample with the 0.5% of *Arthrospira* microalga showed the lowest peroxide value. As shown in Table 1, enriched strudels had a higher quality as well as a reduced oxidation rate. Therefore the enriched strudels show higher oxidation stability over time, compared to none for the enriched ones. This observation is similar to those reported by Gouveia et al (L. GOUVEIA & al. [25]). The authors showed that the addition of microalgae (*Haematococcus pluvialis* and *Chlorella vulgaris*) presents a positive effect on the emulsion's peroxide value and p-anisidine value (L. GOUVEIA & al. [25]). It is therefore estimated that the protective effect of the polar phenolic compounds and the phycocyanin content of *Arthrospira* prevent lipid peroxidation by free radical scavengers and metal

chelating such as iron (A. BELAY [1], H.H.A. EL-BAKY & al. [26]). Similarly, Prabhasankar et al (P. PRABHASANKAR & al. [27]) reported an increase in 2-2-diphenyl-1-picrylhydrazyl free radical scavenging and metal chelating activity when using seaweed (*Sargassum marginatum*). It is shown by Manoj et al (G. MANOJ & al. [28]) that the lipid peroxidation is prevented more significantly by the alcohol extract of *Arthrospira* than by the chemical antioxidants such as α-tocopherol (35%), BHA (45%), and β-carotene (48%). It is also shown that the water extract of *Arthrospira* has more antioxidant effects (76%) than gallic acid (54%) and chlorogenic acid (56%) (G. MANOJ & al. [28]). A major cause for quality loss in food is lipid oxidation due to the formation of undesirable volatile compounds and off - flavor (rancidity) (L. GOUVEIA & al. [25]). Based on the results, the incorporation of *Arthrospira* powder in strudels can significantly retard lipid oxidation.

7. *Microbiological analysis*

As shown in Table 3, a significant difference was observed between the mold count of the enriched strudels and those of the control samples ($p<0.05$). The strudel containing 1.5% of *A. platensis* is efficiently protected from the microbiological attachments, so that the maximum mold count was found in the control sample. In addition, the present results showed that the storage time and *A. platensis* concentration have opposite effects on the mold count of strudels.

Table 3. Effect of different concentrations *of Arthrospira platensis* and storage time on mold and yeast numbers

Treatment	Yeast numbers (SD=0.001)	Mold numbers (mean±SD)
W_0C_0	14.00^{a}	10.00 ± 1.94^{ac}
$W_1C_{0.5}$	10.00^{a}	10.00 ± 1.94^{ac}
W_1C_1	14.00^{a}	10.00 ± 1.94^{bc}
$W_1C_{1.5}$	12.00^{a}	10.00 ± 1.94^{ac}
W_2C_0	12.00^{a}	10.00 ± 1.94^{abc}
$W_2C_{0.5}$	10.00^{a}	55.00 ± 5.44^{abc}
W_2C_1	10.00^{a}	10.00 ± 1.94^{bc}
$W_2C_{1.5}$	10.00^{a}	10.00 ± 1.94^{abc}
W_3C_0	11.00^{a}	10.00 ± 1.94^{a}
$W_3C_{0.5}$	40.00^{a}	75.00 ± 5.44^{a}
W_3C_1	10.00^{a}	10.00 ± 1.94^{ab}
$W_3C_{1.5}$	10.00^{a}	75.00 ± 5.44^{a}
W_4C_0	150.00^{a}	53.33 ± 5.44^{abc}
$W_4C_{0.5}$	10.00^{a}	10.00 ± 1.94^{abc}
W_4C_1	11.00^{a}	10.00 ± 1.94^{bc}
$W_4C_{1.5}$	10.00^{a}	10.00 ± 1.94^{abc}
W_5C_0	50.00^{a}	75.00 ± 1.94^{ab}
$W_5C_{0.5}$	13.00^{a}	10.00 ± 1.94^{ab}
W_5C_1	10.00^{a}	10.00 ± 1.94^{b}
$W_5C_{1.5}$	11.00^{a}	10.00 ± 1.94^{ab}

Values shown with different letters are significantly different ($p<0.01$)
W= Week of storage, W_0, W_1, W_2, W_4 and W_6 belong to the production day, first, second, fourth and sixth weeks, respectively
C= Concentration of *Arthrospira platensis* powder, C_0, $C_{0.5}$, C_1, and $C_{1.5}$ belong to sample enriched with 0, 0.5, 1 and 1.5% of *Arthrospira platensis*, respectively.

According to Table 3, *A. platensis* concentration and storage time significantly affected the yeast number in opposite ways ($p<0.01$). It is observed that strudels with higher *A. platensis* content have a lower yeast number compared to the control sample which has a much higher one. Similar results were also demonstrated by Bhowmik et al (D. BHOWMIK & al. [3]) who reported the inhibition effect of *A. platensis* on the growth of certain human pathogenic bacteria. Generally, this antibacterial activity has minor effects on the Gram-negative bacteria compared to Gram positive ones due to their more complex cell membrane, which makes it more difficult for the active compound to penetrate (V. ÖRDÖG & al. [29]). The antibacterial activity of *A. platensis* is due to the production of certain biologically active substances, both intracellular and extra cellular secondary metabolites (D. BHOWMIK & al. [3]).

Conclusion

Arthrospira microalga, a natural ingredient, have been consumed as a food supplement due their nutritional well-balanced proteins, amino acids, lipids, vitamins, minerals, carbohydrates and natural pigments (D. BHOWMIK & al. [3]).The effect of adding *A. platensis* on the quality of strudels was investigated in the present study. The use of this microalga caused increased color and texture stability, high shelf life and reduced oxidation process in enriched strudels. The present results revealed that the enrichment of strudels with *A. platensis* (at most concentration) reduces the number of yeast and mold. It was also concluded that an *A. platensis* concentration of 1 and 1.5% were preferred for the enrichment of strudels because of the higher quality, shelf life and protein content and reduction of oxidation. But, it is not sufficient selecting the best concentration only by evaluating the above parameters. The preparation of strudel with 1.5% of *A. platensis* causes an increase in the costs for large-scale production. In addition, this concentration of *A. platensis* was not preferred by the panelists. Thus, strudels can be healthy and very attractive food when enriched with *A. platensis* where 1% of microalga addition is the suggested concentration to enrich the strudel.

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