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Investigating the Effect of Spirulina Platensis Microalgae on Textural and Sensory Properties of Baguette Bread

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ABSTRACT

Background: *Spirulina platensis* is a photosynthetic microalgae with fibrous filamentous that belongs to the cyanobacteria family. In this study, we investigated the effects of ethanol and methanol extracts as well as the powder of *spirulina platensis* microelements on the sensory and texture properties of the bread. **Methods**: In order to determine the texture characteristics, we applied a texture analyser and conducted the Texture Profile Analysis test (Double-Density Compression). Sensory evaluation (hedonic scale 1−5) of the samples was performed by 10 trained panelists. **Results**: The results showed that use of spirulina microalgae in the formulation of bread altered the tissue properties significantly compared with the control sample. Addition of the spirulina decreased the hardness of the bread compared to the control sample. Moreover, addition of the methanol extract resulted in the highest adhesiveness, while addition of ethanol extract and spirulina microalgae powder led to the highest springiness rate among the samples. The highest and lowest amounts of gumminess were observed in bread samples containing spirulina microalgae powder and control treatments, respectively. The control sample received the highest score regarding all of the sensory features. Samples with spirulina powder received the lowest sensory properties. **Conclusion**: We can produce spirulina fortified bread with desirable nutritional and sensory characteristics.

Keywords: *Spirulina microalgae; Baguettes; Sensory properties; Texture*

Introduction

Bread as an excellent source of energy and protein has a vital role in feeding people throughout the world. Food agriculture organization (FAO) studies showed that people in the Middle East and the Near East provided about 70 percent of their daily needs' energy from bread and other wheat product (Payan, 2004, Rajabzadeh, 2013) .

Today, in order to improve the nutritional status of people, rich healthy foods with low calories are produced increasingly. In the early 1950s, a significant shortage of protein sources was observed in the diet of the world's population,

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which led scholars to search for other protein sources. To achieve this goal, the algal cell mass appeared to be the perfect choice at that time. Micro-algae are natural alternative nutrient sources that can be used to develop new foods. Biologically active compounds are naturally enclosed within the microalgae cells and are able to withstand severe technological conditions in food processes (Batista *et al.*, 2012) .The use of microalgae in food products is due to the availability of a wide range of bioactive compounds. They are new sources of nutritional and natural ingredients used to meet the growing demands of consumers for healthy food (Shahdadi *et al.*, 2015) .

Considering the world's population growth and the limited agricultural land, algae can be considered as the natural food sources. Algae and microalgae are potentially large sources of compounds that can be used to produce the pragmatic food ingredients. Microalgae are important biological resources for new products and applications because they have good balance in chemical composition. They also can be used as an improver and nutritional value enhancer for human food and animal feed. The use of microalgae bio-masses and their metabolites has created an interesting trend in improving the value of healthy food products such as bakery products (Selvam, 2002).

Among the well-known species of microalgae, *chlorella vulgaris* and *spirulina platensis* are the common microalgae used as food. The amino acid, carbohydrates, and fatty acids patterns found in microalgae are very similar to the proteins of other foods (Sousa *et al.*, 2008, Vyssoulis. G.P., 2001) .

Considering the functional and nutritional characteristics of spirulina platiensis microalgae, we should provide the basis for producing a product with better rheological and sensory properties. Therefore, the aim of this study was to investigate the effect of ethanol, methanol extracts, and powder of spirulina on the quality of bulk bread.

Materials and Methods

Raw materials: The materials used for the study included the Stars Flour with an extraction percentage of 82 percent, which was obtained from Golmakan Flour Company of Mashhad. We bought the dried spirulina from Sina Riz algae of Qeshm and stored it in vacuum at 4ºC until the trial. Active dry baking yeast was bought from Fariman Company and minor ingredients including oil, iodized salt, sugar, and improver used in the preparation of bread were purchased from reputable stores.

Extraction: We mixed 10 g spirulina dried powder with 100 mL methanol 80 percent and ethanol 50 percent solvents. Extraction was carried out at ambient temperature (25°C) for 24 h using a laboratory shaker. The ratio of methanol and water which lead to the highest yield of phenolic and flavonoids compounds during the preliminary trials were selected as the best ratio. Similar ratio of methanol to water was also used by (Shahdadi *et al.*, 2015). Later, each extract was filtered with whatman No. 1 filter paper. The obtained filtrate evaporated to dryness at 40°C in a rotary evaporator (Buchi Laborator). Then, all the extracts were stored at 4°C.

Bread production: The amount of flour used to prepare each batch was 1000 g. Considering 1000 g of flour, 10 g methanol extract, 10 g ethanol extract, and 10 g spirulina dried powder were separately added on the basis of flour weight. Furthermore, 10 g salt and 20 g yeast were added to the formulation and 610 mL water was also added. We used Star Flour, water (37-38°C), yeast, and salt to form the control samples.

The sourdough contained 100 parts flour, 61 parts water, 1.5 parts salt, and 2 parts yeast. After 4 hours of fermentation at ambient temperature (30°C), we added the sourdough gradually to the dough mixture during the treatment.

After mixing, the prepared dough was put aside at the ambient temperature so that the initial fermentation can be completed. This process, which is called leavening dough took about an hour and 30 minutes. After the initial fermentation period, the dough was divided into 250-g sections and placed inside the roller system to form the baguette. Moreover, we gave the rest to the shaped

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dough for 5 minutes; the mid-fermentation. Then, we put the shaped dough pieces in the oven (fermentation wagon) with relative humidity of 75 percent and temperature of 38°C for one hour and 30 minutes (final fermentation) (Rajabzadeh, 2013). The baking steps are shown in **Figure 1**.

The sensory properties of bread: Sensory test was performed using (Rajabzadeh, 2013) method. Panelists were selected from the trained people. The sensory characteristics of bread were shape (asymmetric shape, loss of bread part, presence of cavity or empty space), upper surface characteristics (burn, two scaling, abnormal color, wrinkles, and abnormal surface), lower surface characteristics (burns, wrinkles, and abnormal surface), porosity (abnormal porosity, high density, and compression), stiffness and softness of the tissue (abnormal softness, tightness, brittleness), chewability (dryness and rigidity of the bread, shaping bullet and tasting dough in the mouth, sticking to the teeth), odor, taste, and flavor (nasty taste, salty and alkaline taste, rancidity odor, or natural bread odor) (**Table 1**). These sensory properties were evaluated by 10 trained panelists. The attribute evaluation coefficient also ranged from very bad (1) to very good (5).

The texture characteristics: The bread stiffness was measured by Texture Profile Analysis test using texture analyser system (Brookfield-Model Ct3 10k) at ambient temperature. In this method a cylindrical piece of bread with a height of 3 cm and a diameter of 3 cm was placed under the device and compressed by the system probe. The force input was 5 kg, the probe speed was 100 mm/min, and the diameter of the probe was 50 mm. In this method, parameters such as hardness, gumminess, springiness, and cohesiveness of bread samples were investigated (Martin and Hoseney, 1991).

Data analysis: The tests were conducted in a completely randomized design with three replications. Data were analyzed by SPSS 19. To compare the means, Duncan's multi-dimensional test was used at the 5 percent significance level.

Results

Effect of adding ethanol, methanol extracts, and powder of spirulina on the sensory properties of baguette: As **Figure 2** represents, the control treatment samples received the highest scores for all sensory characteristics. The treatment with spirulina powder had the lowest sensory properties and most evaluators did not like the green color for bread.

According to **Figure 2**, we found that the color, taste, and texture scores of the breads enriched with ethanol, methanol extract, and powder of spirulina decreased significantly compared with the control sample. The breads containing spirulina ethanol and methanol extracts had the best color after the control sample and did not have a significant difference in their color scores ($P > 0.05$), whereas the bread containing the spirulina powder showed the lowest color scores. The decrease in the popularity of the breads containing spirulina powder was due to color changes of the bread surface. The green color resulted from addition of spirulina was not favoured by some panellists; whereas, some others considered this color a kind of variety and innovation and liked it more.

Effect of spirulina on the bread hardness: **Figure 3** shows the effect of ethanol and methanol extracts as well as the spirulina powder on the hardness of the studied breads. According this figure, spirulina in all three forms reduced the hardness of bread samples, but the most rate of hardness was related to the control sample. We observed no significant difference among treatments containing ethanol and methanol extracts as well as spirulina powder.

Effect of spirulina microalgae on bread cohesiveness: The highest cohesiveness of bread tissue was related to methanol extracts of spirulina. However, the lowest cohesiveness was observed in the ethanol extract, which showed no significant difference with the treatments containing spirulina powder ($P > 0.05$) (**Figure 4**).

Effect of spirulina microalgae on bread springiness: **Figure 5** indicates that the treatments affected the bread springiness significantly. The highest amount of springiness was observed for the spirulina powder (10.56 mm) that did not show any significant difference with the ethanol extract of spirulina powder (10.53 mm). The lowest springiness was observed in control treatment (8.43 mm).

Effect of spirulina microalgae on bread gumminess: The highest amount of gumminess was observed in the spirulina powder treatment (2.23 N). Treatments containing ethanol (1.24 nm) and methanol (1.13 nm) extracts did not show any significant difference regarding the gumminess property. The lowest gumminess was also related to the control treatment (0.84 N) (**Figure 6**).

Table 1. Sensory evaluation test form

Panellist name	**Date**	**Sample number**	
Bread characteristics	Quality grading (1-5)	Score ration	Obtained score
Softness (amount of force required to squeeze the sample between two fingers)	1: Soft 5: Hard	2	
Elasticity (speed with which the compressed sample goes back to the first position after pressing)	1: Low speed 5: High speed	3	
Chewability (the number of chews needed to soften the sample by saliva and prepare it to devour.	1: High chewability 5: Low chewability	2	
Bread color (crumb and crust)	1: Undesirable 5: Desirable	2	
Crumb porosity (number of porosity and uniformity)	1: Low porosity 5: High porosity	3	
Bread smell + taste	1: Undesirable 5:Desirable	4	
Bread odor (Sensing any rancid odour)	1: High rancid odor 5: Low rancid odor	3	
Total score			

Figure 1. Dough preparation and baking steps

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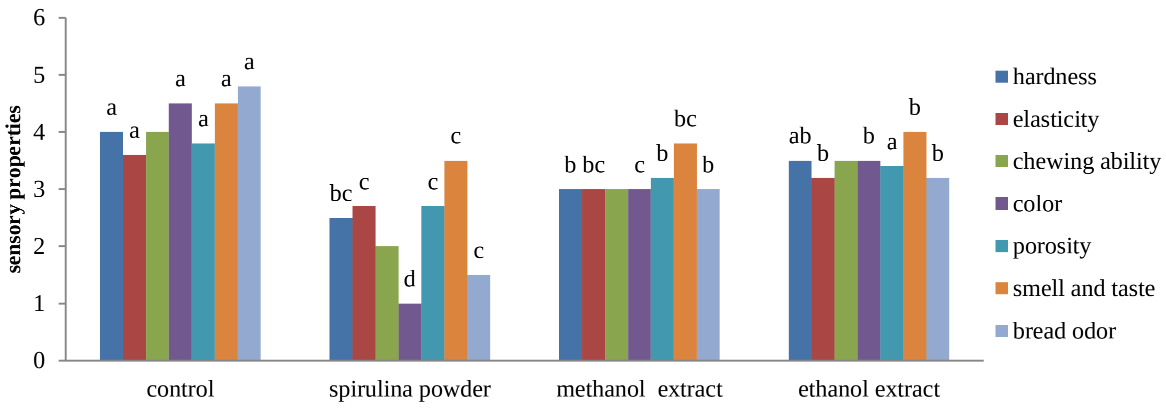

Figure 2. Effect of spirulina microalgae on bread sensory properties means with same superscripts had no significant difference with each other ($P > 0.05$)

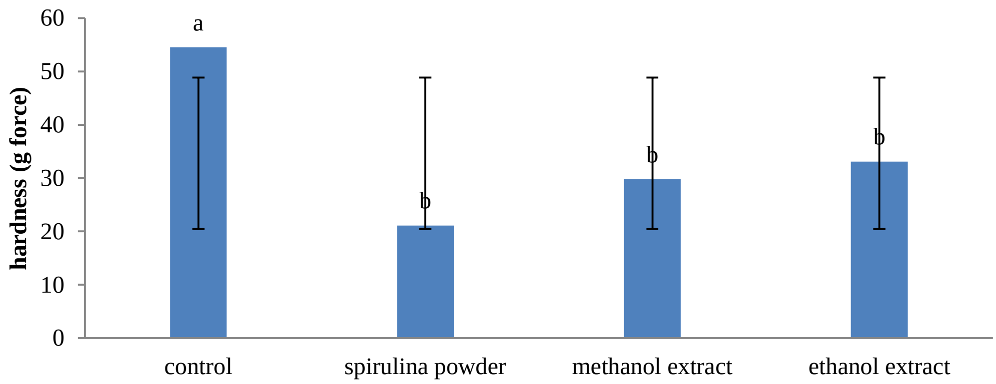

Figure 3. The effect of spirulina microalgae on the bread hardness means with same superscripts had no significant difference with each other ($P > 0.05$)

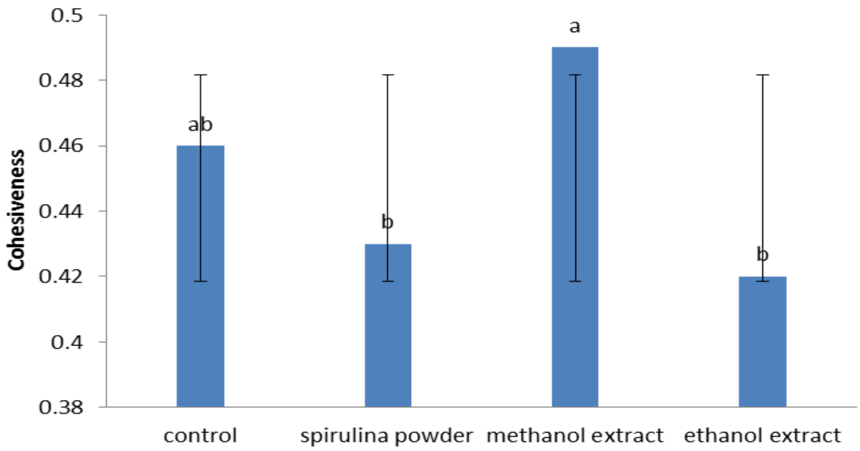

Figure 4. Effect of spirulina microalgae on bread cohesiveness means with same superscripts had no significant difference with each other ($P > 0.05$)

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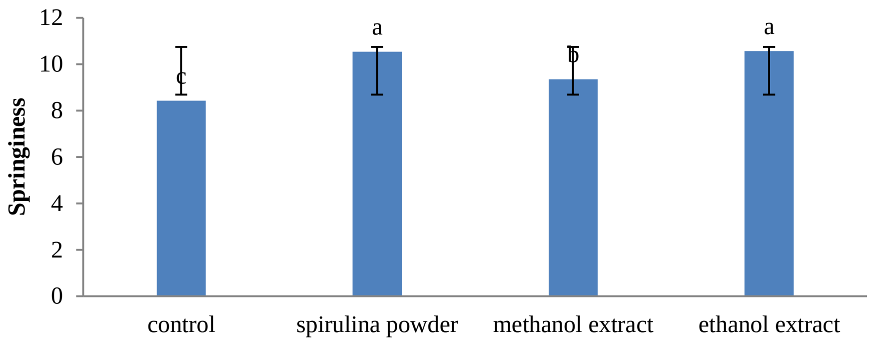

Figure 5. The effect of spirulina microalgae on bread springiness means with same superscripts had no significant difference with each other ($P > 0.05$)

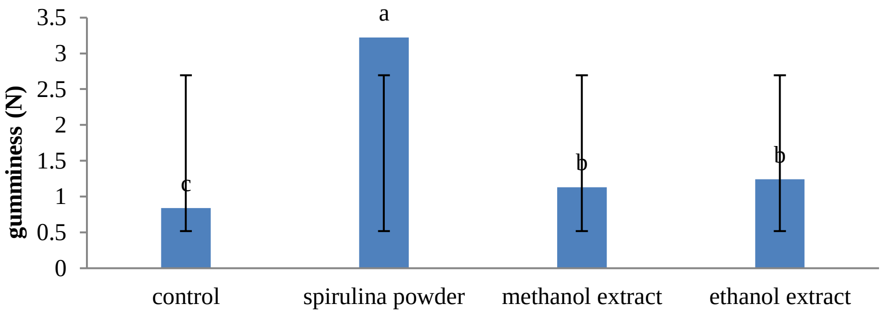

Figure 6. Effect of spirulina microalgae on bread gumminess means with same superscripts had no significant difference with each other ($P > 0.05$)

Discussion

The texture scores (stiffness, chewing ability, porosity, and elasticity) decreased significantly in samples with spirulina compared to the control sample. Homogeneity of tissue was influenced by visual factors. The taste scores in samples containing ethanol and methanol extracts of spirulina microalgae did not differ significantly.

It was investigated the possibility of using spirulina platensis powder in the production of industrial cookie. Their results indicated that the sensory scores decreased with increase of spirulina microalgae in the cookie formulation (Salehifar, 2012).

The effect of spirulina powder on the gumminess of the bread texture was significant and positive. Probably, the spirulina protein part, which accounted for about 60 percent of the structure, increased the hardness and resistance of the gel. In other words, the hydrogen bonding of the amide-hydroxyl and hydroxyl-carbonyl groups with the polar groups increased the bread hardness. In addition to the hydrogen bonds, the electrostatic interactions are possible between the charged proteins of spirulina and the charged part of the dough. These interactions also increased the strength of the sample structure. The results of Chronakis et al. showed that the elasticity of the dough improved by increasing the concentration of spirulina, which is due to electrostatic and hydrogen bonding during the formation of the gel (Chronakis, 2001).

Generally, the bread hardness depends on many factors, such as amylopectin and amylose retrogradation, alteration in the nature of protein, decreased moisture content, and formation of the bond between starch and protein (Nasehi, 2009) .Decrease in the hardness of the spirulina-containing samples compared to the control sample can be attributed to the fibre compositions. These compositions prevent from the release of moisture by absorbing water proportionally and this is one of the factors affecting the staleness and hardness of the bread. These compounds are also able to react with starch molecules and postpone the retrogradation process in the final product (Nikouzad, 2011) .

Conclusions

This study was conducted to investigate the effects of ethanol and methanol extracts as well as the powder of *spirulina platensis* microelements addition on the texture and sensory properties of bread. We found that use of spirulina microalgae in bread formulation altered the texture characteristics of the bread significantly in comparison with the control sample. Addition of the spirulina decreased the hardness of the bread compared to the control sample. Regarding cohesiveness, the highest cohesiveness was observed in the sample containing methanol extract. The highest springiness levels were also observed in samples with ethanol extract and spirulina microalgae powder. The highest and lowest levels of gumminess were observed in treatments containing spirulina microalgae powder and control samples, respectively. The results of sensory evaluation also showed that the control treatment received the highest scores on all sensory characteristics. The treatment with spirulina Powder had the least sensory properties and the most panelists did not like the green color for bread.

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Authors' contributions

All authors contributed with study design, data collection, data handling and manuscript preparation. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflict of interests.

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