الخواص الحسية و الكيميائية للمخبوزات المدعمه بطحلب الاسبيرولينا أثناءالتخزين

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ملخص البحث

تهدف الدراسة الى تقدير الخواص الحسية و الكيميائية لمخبوزات البسكويت خلال التخزين على درجة حرارة الغرفة (25 _+ 5م5) لمدة ثلاث شهور حيث أوضحت النتائج أن تدعيم خلطات البسكويت بطحلب الأسبيرولينا الجافة بنسب 5و،3،2،1% أدى الى تحسين الخواص الحسية و الفيزيائية حيث كانت الخلطات مقبولة لدى المحكمين لارتفاع محتواها من المركبات الحيوية الفعالة مقارنة بعينات البسكويت الغير مدعمة (الكنترول) . بينما حدث نقص فى رقم الحموضة لخلطات البسكويت المدعمة بالأسبيرولينا مقارنة بعينات الكنترول المخزنة لمدة ثلاث أشهر على درجة حرارة (25 +_ 5 م 5) وسجل رقم البيوكسيد أقل قيمة فى خلطات البسكويت المدعمة مع وجود فارق معنوى بينهم ولقد قاوم بسكويت رقم 4 زيادة رقم البيروكسيد خلال فترة الحفظ مقارنة بالكنترول . كما سجل حامض الثيوباربيوتيك قيم أقل فى خلطات البسكويت المخزنة لمدة ثلاث أشهر على درجة حرارة (25 _+ 5 م 5) . وأخيرا يمكن استخدام طحلب الأسبيرولينا كمدعم غذائى للمخبوزات نظرا لخصائصه الغذائية العالية .

الكلمات المفتاحية: الخواص الكيميائية ، طحلب الاسبيرولينا ، المخبوزات.

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Organoliptic and Chemical Properties of Biscuits Blends Lipids Supported with Dried *Spirulina* Algae during Torage

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Abstract:

Spirulina algae, is a multicellular filamentous blue-green microalgae, is used in many countries of world including Egypt as human safe food. *Spirulina* algae used to enhance the nutritional value of food such as bakery products, due to their well balanced chemical composition as well as source of highly fatty acid chlorophyll , carotenoid, phycobilins, sterols vitamins, and other biological active compounds .

The aim of the present study was evaluated of organoleptic and chemical properties of biscuits blends fortified with different levels of dried *Spirulina platensis* during storage period for 3 months at 25 ±5°C. The result indicated that biscuits blends fortified with dried *Spirulina platensis* as 0.5,1,2, and 3 % lead to improve the organoleptic physical properties fortified and chemical properties of biscuits blends when compared with unfortified biscuits sample (control). The chemical properties of biscuits blend lipid during storage revealed that acid value was decreasing upon the increasing *Spirulina platensis* in level biscuit blends than control. There were no significant difference in peroxide value between biscuit 1, biscuit 2 and control. Biscuit 3 and biscuit 4 recorded low increase of peroxide value during the storage time with significant difference after three months comparing with the control. The highest increase was recorded in biscuit control, while the lowest were in biscuit 4 with significant difference. Thiobarbituric acid (TBA) decreasing upon the increasing *Spirulina platensis* in level biscuit blends 1,2,3 and 4 than control while biscuit 2 and biscuit 4 recorded the lowest value.

Biscuits blends fortified supplemented with algae much more balance nutrient than control one. This supplementation also influences to acidity. Finally, using *Spirulina platensis* algae powder in the fortification of bakery products for its high nutritive value.

Keywords: *Spirulina platensis* , Chemical properties, Organoliptic, biscuits blends.

INTRODUCTION

Biscuit is a popular bakery product usually eaten for breakfast in many parts of the world. One of the most important algae types cultured today is *Spirulina platensis*. it is filamentous in nature and a microscopic blue-green alga type which is found intensively in alkaline waters, contains 60% to 70% protein, gamma linoleic acid, rich in vitamin B12 (193 µg/100 g), E and C, , source of calcium and iron (1043.62 and 338.76 mg/100 g), rich in chlorophyll a (1.472%) , phycocyanin (14.18%) pigments, and used as an essential nutrition support (Zarrouk 1966 , Morsy *et al*.2014 and Barak *et al*.2016). *Spirulina algae* is a protein resource which is low lipid, low-calorie, and cholesterol -free (Richmond, 2004). It is an energy supplement for elderly people. In Japan, 73% of people aged over 50 eat *Spirulina* where 10 grams of *Spirulina* contains only 36 calories (Seshadri and Jeeji Bai 1992). *Spirulina platensis* is digestible because 86% of its cell wall is composed of digestible polysaccharide (Li and Qi 1997) . *Spirulina* contains high amount of iron, which makes it important in anemia disease (Becker, 1994). Addition of *Spirulina platensis* resulted in protein content increase, ranging from 7.40% to 11.63%. While calcium, magnesium and iron contents of bread with *S. platensis* were 721.2, 336.6, 41.12ppm respectively. Conventional bread contained 261.7ppm calcium, 196 ppm magnesium, and 8.72ppm iron (Burcu, *et.al*. 2016). According to World Health Organization (WHO 1975) , an estimated 150 million individuals suffer from some type of anemia.

Spirulina algae had been shown to be an excellent source of high quality protein, bioactive compounds and minerals. Therefore, *Spirulina* algae had been designated an ideal food and dietary supplement for (Whitton, 2012). *Spirulina* is considered as an excellent food, lacking toxicity and have anticancer, antiviral, immunological properties and it also acts as a potent antioxidant. Hanaa *et al*., (2015) showed that functional products (FPs) a high oxidative stability during storage (30 days) periods (as assessed by antiradical scavenging activity of 2,2-diphenyl-1-picrylhydrazyl (DPPH) and Thiobarbituric acid (TBA) test), compared with that in untreated food products (control). Purpose of our research is to diversify biscuits and pizza blends fortified with more nutrients which are similar to functional food. *Spirulina platensis* can enhance oxidative stability and improve the shelf life of olive oil (Alavi and Golmakani 2017). Massoud *et al*., (2016) found that the *A. platensis* biomass enhanced the levels of biologically active substances (i.e. essential amino acids, chlorophyll, phycocyanin, carotenoids, minerals, vitamins, and essential fatty acids) in croissant samples. The present study was carried out to determination the chemical composition ,acid values, peroxide, thiobarbituric acid and organoleptic qualities of biscuits blends fortified with different levels of *Spirulina* algae after storage period at (25±5°C) for three months.

MATERIAL AND METHODS

Material

Spirulina algae strain was obtained kindly from The National Research Center, Giza, Egypt.

Wheat flour 76%, sugar, yeast, cheese, vanilla, baking powder, oils (corn oil) , salt, olive and vegetables like (tomato, pepper) were obtained from a supermarket in Kafrelsheikh City, Egypt. Chemicals used in this study were purchased from El-Gomhoria Campany for Trading Drugs Chemicals and Medical instituts, Tanta, Egypt.

Methods

Growing *Spirulina* algae in lab conditions.

Spirulina algae isolate was maintained in Zarrouk's modified synthetic medium **(Mühling, 2000)**. To avoid bacterial contaminations of axenic cultures, all media and materials used for handling cultures were autoclaved at 15 lb in^{-2} 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 passed through 120 mesh sieve screen to produce a fine algae powder and kept in polyethylene bags at low temperature (5°C) until used **(**Yamsaengsung and Bualuang, 2010).

Preparation of biscuit blends 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. 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 at least, biscuit blends were packed in polyethylene bags. The samples were used to evaluate organoleptic properties and chemical properties of it lipid during storage at 25±5 °C for three months.

Organoleptic properties of biscuits blends:

A trained twenty member panel consisting of students and staff members (both male and female) of the Home Economic Dept., Fac. Specific Education, Kafrelsheikh University, Egypt was selected . The test were performed under flouresscent lighting in organoleptic properties laporatory. Tap water was provided to rinse the mouth between evaluation . The judges evaluated the samples for taste, colour, odour, texture and overall acceptability. Each organoleptic properties attribute was rated on a 10 point hedomic scale (Abo, *et al*., 2014).

Physical characteriscs of prepared bakery products

Width and thickness

Width of biscuits was measured by laying six biscuits edge to edge with the help of a scale rotating those 90 and pre measuring the width of six cookies in cm and then taking average value. Thickness (T) or height of biscuits was measured by stacking six biscuits on top of one another and taking average thickness (T) of six biscuits in cm.

Spread ratio

Spread ratio was calculated according to A.A.C.C. (1983) by dividing the average value of width (W) by average value of thickness (T) of biscuits.

Specific density

The Specific volume was determined according to Penfield and Campbell, (1990) as shown in the following equation

Specific density(cm/g)=(weight of limited volume product/the same weight volume of water)X100

Colour

The colour was determined according to Attia *et al*. (1993) as following: one gm of grinded product samples was extracted with 5 ml acetone (80%) for 24h. at room temperature. The extract absorbance was measured spectrophotometerically at 420 nm.

Baking losses

Baking losses was accounted according to El-Nemer (1979).

Baking losses% = <u>Raw sample weight (g) – baking sample weight</u>

Raw sample weight (g) X 100

Chemical properties of biscuits lipids during storage

Baked biscuits blends were stored at room temperature (25±5°C) for three months. The samples were kept in polyethylene bags and they were analyzed every month .

Acid value and Peroxide value of biscuits blends were determined according to A.O.A.C. (2000). Thiobarbituric Acid (TBA) was determined according to the methods of Tarladgis *et al.*, (1966) .

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 ver.11 according to **Abo-Allam (2003)**.

RESULTS AND DISCUSSION

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 biscuit. The organoleptic characteristics of all blends were formed in biscuit. The obtained results were undertaken to determine the effects of substituted dried *Spirulina* algae as a function ingredient in traditional biscuit. Formulas of bakery products (biscuit) were prepared using dried *Spirulina* algae with percentage 0, 0.5,1,2,3,4, and 5% (Figure 1).

Fig (1):1,2,3,4and 5 Biscuit blends fortified with different percentage of *Spirulina* algae also Control Biscuit without dried *Spirulina* algae.

Choosing the highest organoleptic evaluated biscuit blends were happened comparing with the control sample for each them. Organoleptic evaluation as a final judgment of biscuit blends had been performed after baking. It was noticed that biscuit scored more points than the control biscuit 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 biscuit characterized by firm and crisp texture and received high score value. This crisp texture of biscuit was related to the used of substitute materials and the moisture content of baked products. These observations are in harmony with those of Joanna *et al.*, (1990) and Darani *et al.*,(2017) observed that using of this microalga caused increased color and texture stability, high shelf life and reduced oxidation process in enriched strudels and enrichment of strudels with *A. platensis* reduces the number of yeast and mold also higher quality, shelf life and protein content and reduction of oxidation.

Data in Table(1) showed organoleptic qualities of biscuit blends fortified with different levels of dried *Spirulina* algae. Data revealed that biscuit blends fortified with high levels of dried *Spirulina* algae become sensory not acceptable. The organoleptic quality start dramatically decreased in biscuit 5 and biscuit 6, which were eliminated in further studies. For a product to be considered approved in relation to its organoleptic characteristics, it is necessary that the acceptability index showed be at least 70%, adequate for consumption, with a good marketability (Santos *et al*., 2011) .

Table: (1). Organoleptic properties of biscuit blends fortified with different levels of dried *Spirulina* algae

Biscuit blends	Organoleptic properties				
	Taste	Colour	Odour	Texture	Overall Acceptability
Control	9.20^{a}	10.00^{a}	9.70^{a}	9.48^{a}	9.50^{a}
Biscuit 1	9.30^{a}	8.00^{b}	9.50^{a}	9.49^{a}	9.40^{ab}
Biscuit 2	8.50^{ab}	7.40^{bc}	9.10^{a}	9.49^{a}	8.50^{b}
Biscuit 3	8.50^{ab}	6.10^{c}	6.50^{b}	9.50^{a}	8.50^{b}
Biscuit 4	7.10^{b}	5.60^{c}	5.20^{c}	9.50^{a}	7.40^{b}
Biscuit 5	3.30^{cd}	3.50^{d}	4.30^{d}	9.54^{ab}	4.40^{c}
Biscuit 6	3.20^{cd}	1.10^{e}	3.10^{e}	9.55^{b}	3.50^{c}

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

In otherwise, these results not agreed with Sharma and Dunkwal (2012) who prepared biscuit 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 present study could be attributed for panel members food culture and habit. Also, Massoud *et al.*, (2016) showed that the use of *A. platensis* biomass for the production of fortified croissants improved the textural and organoleptic properties of the final products. *Spirulina* fortification also increased the protein and moisture levels and water-holding capacity, whereas it decreased the crumb firmness and lightness of croissants. Optimum sensory results were obtained when *Spirulina* was applied at a rate of 1%. The eating habits of an individual are acquired depending on one's environment or family experiences. The appearance of a food is, among others, a factor that defines its quality and the first impression the consumer gets directly from foods. Color, as one aspect of appearance, plays a major role on the acceptability of a food product, being a determinant of its identification, as an indicator of quality, freshness, conservation state, odour expectation and commercial value. Traditionally, biscuit exhibit light yellow colorations, derived from their tradition ingredients. So, Egyptian people not accepted the green color especially with high tone in the high concentration of S*pirulina* algae. Color factor was the crucial variable in the organoleptic properties evaluation.

On the other hand, the texture of the biscuit blends in Table (1), was also evaluated, and a significant increase of their firmness was evidenced with an increase of added dried *Spirulina* algae. These results proved the positive effect of the algae in the biscuit structure, reinforcing the short dough system. Biscuit are considered solid emulsions of sucrose, lipids and non-gelatinized starch, being this morphology is responsible for the biscuit 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 biscuit firmness, resulting in more compact structures (Gouveia *et al.*, 2008c**)**.

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

Results in Table (2) showed some physical properties of prepared biscuit blends fortified with different levels of dried *Spirulina* algae. It was noticed that the moisture percentage in all biscuit blends were in range 3.9 to 4.9%. It was clear that addition of *Spirulina* algae reduced the percentage of water in biscuit blends with *Spirulina*. Biscuit 3 and Biscuit 4 were significantly less than the control biscuit. Baking loss % and width didn't demonstrate a clear difference among studied biscuit blends while height, spread ratio and color recorded significant difference. Biscuit 4 recorded lowest height (0.71 cm) and biscuit 1 represented a low spread ratio (4.64). Color of biscuit increased by adding more dried *Spirulina* algae to reach as maximum value in biscuit 4 as 3.15. Biscuit blends presented a similar specific gravity. Those results were in agreement with the results obtained by Ahmed,(2012).

Table (2): Some physical properties of prepared biscuit blends fortified with different levels of dried *Spirulina* algae

Physical properties / Biscuit blends	Moisture (%)	Baking loss (%)	Width (w)(cm)	Thickness/ Height (cm)(T)	Spread Ratio (W/T)	Colour	Specific gravity
Control	4.90^{a}	14.22^{a}	4.13^{a}	0.89^{a}	4.64^{ab}	0.23^{de}	0.56^{a}
Biscuit 1	4.70^{a}	14.41^{a}	4.01^{a}	0.87^{a}	4.61^{b}	0.98^{d}	0.59^{a}
Biscuit 2	4.10^{ab}	14.32^{a}	3.99^{a}	0.82^{a}	4.86^{a}	1.53^{c}	0.61^{a}
Biscuit 3	3.91^{b}	14.55^{a}	3.95^{a}	0.79^{a}	5.00^{a}	2.52^{b}	0.57^{a}
Biscuit 4	3.90^{b}	14.43^{a}	3.80^{ab}	0.71^{b}	5.35^{a}	3.15^{a}	0.62^{a}

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

Chemical properties of biscuits blends lipid during storage

The acid value is a measure of the free fatty acid contents of lipids. It is an index of the measurement of freshness of fat. Humidity and high temperature result in an increase of the acid value due to hydrolysis of triglycerides into free fatty acids. Higher values indicate undesirable changes as it not only results in greater refining losses but also increases susceptibility of oils to rancidity. The presence of free fatty acids in oils and fats is not desirable because they impart a sharp and unpleasant flavor to edible fats and oils (Belitz *et al*. 2009). Data in Table (3) showed the acid values of biscuit blends fortified with different levels of dried *Spirulina* algae during storage period at (25 ±5°C) for 3 months. From the obtained data, it could be notied an increase in acid value during storage.

Table (3): Acid values (expressed as mg KOH/g oil) of biscuit blends fortified with different levels of dried *Spirulina* algae during storage period at (25±5 ºC) for 3 months.

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Biscuit blends	Storage period (25±5 ºC for 3 months)			
	0	1	2	3
Control	0.61[a]	0.81[a]	0.99[a]	1.23[a]
Biscuit 1	0.66[a]	0.78[a]	0.99[a]	1.10[a]
Biscuit 2	0.67[a]	0.71[ab]	0.89[ab]	0.98[ab]
Biscuit 3	0.63[a]	0.71[ab]	0.91[ab]	0.94[ab]
Biscuit 4	0.59[a]	0.63[b]	0.87[b]	0.92[b]

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

The highest increase during 1,2 and 3 months of storage was noticed in the control biscuit 0.81, 0.99 and 1.23 , respectively, while in biscuit blends fortified with dried *Spirulina* algae, acid values decreased as comparing with the control biscuit. The values ranged between 0.59 and 1.23. The highest value was occurred in control biscuit(after three months of storage) and the lowest in biscuit 4 (at zero time of storage). During three months of storage, acid value was decreasing upon the increasing of *Spirulina* percentage. The minimum acid value after three months was for biscuit 4 (0.92 with significant decrease than the control biscuit, which record 1.23. Those results were in harmony with others obtained by Sharma and Dunkwal (2012) who prepared biscuit with 10 % dried

Spirulina algae. They found also that faty acidity revealed satisfactory quality of the value added biscuit at the end of three months of storage period.

The difference between biscuit blends became so clear during the time especially after three months. The antioxidant compounds like, phycocyanin, carotenes especially beta carotene, phenolic compounds in *Spirulina* algae could be the crucial reason in prolonging the shelf life of food products by retarding oxidation and peroxidation processes. These results agreeded with Burcu (2016) found that bread with *Spirulina* stored at room conditions was observed to have a positive effect on the inhibition of mold growth. Thus, it could be concluded that functional biscuits had good sensory and nutritional profiles and can be developed as new niche food market. In general, the addition of antioxidants to bakery products had a good effect on decreasing the acidity of biscuit during storage, so preventing the undesirable changes the taste and odour (Hussein *et al.*, 2010).

Several studies showed that a positive relationship between and antioxidant activity (oxidative stability) in certain microalgae

products (Abd El Baky *et al.*, 2014b and Aardt 2004) . Besides, *S.* platensis had heterogeneous group of molecules and also several vitamins provide strong antioxidant activity. These antioxidant vitamins compounds which are responsible for antioxidant activity in seaweed include vitamin E (α-tocopherol), carotenoids (β-carotene) and vitamin C (ascorbic acid), are responsible for preventing or retarding free radical-induced diseases such as cardiovascular diseases and certain types of cancers Dominguez (2013) , Abd El Baky *et al.*, (2009) Abd El Baky *et al.*, (2014a) and El Baky *et al.*, (2014b) Thus, *S. platensis* may be used as the first line of therapeutic defense against cancer before cancer treatment.

Data in Table (4) presented peroxide values (expressed as meq. O_2/kg oil)of biscuit blends fortified with different levels of dried *Spirulina* algae during storage period at 25± ºC for 3 months.It could be seen from the obtained results that in zero time the values were ranged from to 5.93 to 7.63 meq. kg oil. The highest value was found in the control biscuit and the lowest in biscuit 4 but without significant difference at $P < 0.05$. After one month of storage, it could be seen that there were an increase in peroxide value in all biscuit blends but with different ratio.

Table (4): Peroxide values (expressed as meq. O2/kg oil)of biscuit blends fortified with different levels of dried *Spirulina* algae during storage period at (25±5 ºC) for 3 months.

Biscuit blends	Storage period (25±5 ºC for 3 months)			
	0	1	2	3
Control	7.63[a]	8.26[a]	11.53[a]	12.92[a]
Biscuit 1	7.36[a]	8.12[a]	11.36[a]	12.31[ab]
Biscuit 2	5.96[ab]	8.06[a]	12.01[a]	12.06[ab]
Biscuit 3	6.93[ab]	7.52[b]	11.01[b]	11.51[b]
Biscuit 4	5.93[b]	7.51[b]	9.10[c]	10.20[c]

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

The highest increase was recorded in biscuit control was 12.92meq. O_2/kg oil,while the lowest were in biscuit 4 with significant difference. Biscuit 4 (10.20) and biscuit 3 (11.51) recorded low increase of peroxide value during the storage time with significant difference after three months comparing with the control (12.92). There were no significant difference between biscuit 1 (12.31), biscuit 2 (12.06) and control (12.92). From the obtained results, it can be concluded that all biscuit blends except biscuit 4 become rancid after two months of storage(Pearson, (1971), who reported that peroxide value ranged between 10 to 20 meq. /kg oil, food product is considered rancid but still acceptable, but if more than 20 meq. O_2/kg oil, it considered food products already rancid and unacceptable to consumer. After three months of storage, all biscuit blends became rancid but acceptable.

Thiobarbituric acid (TBA) assay measured by release of MDA the secondary oxidative products of polyunsaturated fatty acids (Pearson *et al.*, 1983). TBA number is much more sensitive and responds to latter stages of fat and oils auto oxidation. MDA test is measuring the reaction of TBA and MDA (a product of fatty acids oxidation). This test which measure the secondary products, starting to occur in the reaction mixture after formation of hydroperoxides (Ali, 2005).

Data in Table (5) showed TBA (expressed as mg MDA/kg oil) of biscuit blends fortified with different levels of dried *Spirulina* algae during storage period at (25 °C) for 3 months.

The TBA values of biscuit blends during storage period for three months at room temperature ranged between 0.43 and 1.32 mg MDA/kg oil. The highest value was noticed in the control biscuit and the lowest value was detected in biscuit 1. No significant differences were detected between biscuit blends at 0 or after one month of storage. TBA slowly increase after 0 time till the first month of storage, then started to be with quick rate till the second month and reached the highest rate in the final stage of storage after third month. After three months, biscuit 2 and biscuit 4 recorded the lowest value of TBA as 0.91 and 0.80 mg malondialdehyde/kg oil while the highest value was the control biscuit as 1.32 mg MDA/kg oil.

Table (5): Thiobarbituric acid (TBA) (expressed as mg MDA/kg oil) of biscuit blends fortified with different levels of dried *Spirulina* algae during storage period at (25±5 °C) for three months.

Biscuit blends	Storage period (25±5 °C for 3 months)			
	0	1	2	3
Control	0.56[a]	0.62[a]	1.00[a]	1.32[a]
Biscuit 1	0.43[a]	0.60[a]	0.89[a]	1.11[ab]
Biscuit 2	0.46[a]	0.61[a]	0.92[a]	0.91[b]
Biscuit 3	0.56[a]	0.58[a]	0.79[b]	1.11[ab]
Biscuit 4	0.49[a]	0.51[a]	0.56[c]	0.80[c]

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

Ke et al., (1984) reported that TBA values less than 0.57 mg/kg samples are considered not rancid, whereas values of 0.65-1.44 mg/kg samples are regarded to rancid but still acceptable and values greater than 1.5 mg/kg samples are said to be rancid and unacceptable. So it could be concluded depending to this review that all biscuit blends except biscuit 4 became rancid (but acceptable) after two months of storage.

CONCLUSION

Biscuit blend fortified supported with dried ***Spirulina*** algae percentage 3% were the best one as nutritive aspect and relatively accepted as organoliptic aspects.

Biscuit blend fortified with dried ***Spirulina*** algae were better than without under room temperature.

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