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Effect of bioactive compounds of defatted flaxseed meal on rheological and sensorial properties of toast and cake

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ABSTRACT

This study was conducted to investigate the chemical composition and the storage stability of flaxseeds defatted meal fractions as food ingredients, phenolic contents and antioxidant activity of flaxseed meal extracts. Effect of substitution of wheat flour with different concentrations of defatted flaxseeds meal on rheological and sensory properties of toast bread, and cake was also investigated.

The results indicated that flaxseed defatted meal is rich in protein, fiber and minerals and poor in its carbohydrate content comparing with whole wheat flour and wheat flour (72%). it contains 34.65 protein, 37.08 % crude fibers, 5.53% ash, 2.35 % fats and 5.972% moisture. While it had carbohydrate content of 14.408%.The results indicated that there were no significant ($P \leq 0.05$) changes in the peroxide values over the 105 day of storage. The results also showed that free fatty acid value was slightly increased during the storage time. Polyphenolic contents were varied from 360.14 to 595.76 mg/100g^{-1} DW according to the extraction solvent used. The results indicated that the flaxseed meal extracts showed a strong antioxidant activity against 1,1-dipheny-2-picrylhydrazyl (DPPH) .The effective concentration 50 % (EC_{50}) was 1.323 and 1.981mg/mg DPPH and anti-radical efficiency values ware 0.756 and 0.505 for methanol + water and ethanol +water respectively.

Rheological properties of the dough's were found to be affected with flaxseed meal addition. The results showed that replacement 5% of wheat flour by flaxseed meal flour increases the water absorption and development time of the dough. While the stability and the energy of the dough was decreased by addition of flaxseed meal. The results of sensory evaluation proved that toast and cake enriched with defatted flaxseed flour up to 10% was acceptable to the consumer.. The results of the sensory evaluation showed that the samples produced by replacement 5% of the wheat flour with defatted flaxseed meal had no significant differences for most of the sensory characteristics.

Keywords: *Flaxseed meal, toast bread, cake, Phenolic compounds, antioxidant activity, sensory evaluation.*

1. INTRODUCTION

Due to the increased awareness of consumers towards health; a demand for functional foods has risen dramatically. Flaxseed (*Linum usitatissimum,* L.) belonging to Linaceae family, is known to be an attractive material in production of functional foods (Oomah and Mazza,1998).The Latin name means "very useful". The use of flax has been documented as far back as 3000 BC. Flaxseed defatted meal is used as a potential source for functional food due to its unique nutrient profile. It is high in protein and fiber content and low in carbohydrate and fat content (Morris, 2001; Oomah and Mazza, 1993). Flaxseed meal is prosperous source of a variety of phytochemical compounds with antioxidant characteristics, including phenolic acids, lignans and flavonoids (Pouzo et al., 2016). It contain 8-10 g/kg total phenolic acids and It was reported to be a very good source of minerals especially Ca, K, P and Mg (Kasote *et al*., 2011; Abdel-Nabey, 2013). Flaxseed reported to be the richest source of lignan (secoisolariciresinol diglucoside), a phytoestrogen (Johnsson *et al.* 2000), and thus its supplementation to one's diet offers a possible alternative to hormone therapy. Flaxseed lignans are structurally similar to endogenous estrogens (Borriello *et al.* 1985) and have a high affinity to the sex steroid binding protein (Martin *et al.,* 1996). Flaxseed appears to protect the body against certain types of cancer such as breast, endometrium and prostate cancers. It reduces blood cholesterol levels and the risk of cardiovascular diseases (Oomah, 2001, Vaisey-Genser and Morris, 1997). Bread and cereals play an important role in human food all over the world. Since, they contain not only high amount of starch as an energy source, but also dietary fiber, nutritive protein and fatty acids (Dewettinck *et al*., 2008). An increasing demand for nutritionally enriched breads with whole grains and different seeds has emerged because of their positive effects on blood cholesterol and their dietary fiber content (Fukumitsu *et al.,* 2010).

Flaxseed was recently introduced to cereal industry as an ingredient which is added into products such as bread and pasta to improve their health promoting properties (Hall et al., 2006). It can be used in the production of breads, cakes, biscuits and morning cereals. Its fibers collaborate in the release of toxins and fats as well as in the constipation treatment. Flaxseed incorporation in various bakery products such as cookies (Ganorkar. and Jain, 2013)), Chinese steamed bread (Hao & Beta, 2012), toast bread (Marpalle , *et al.,* 2014; Pourabedin *et al.,* 2017), cake (Lee, *et al.,* 2004) and rice paper (Cameron & Hosseinian, 2013) has been studied. Evidences suggest that flaxseed dietary fiber reduces the risk of cardiovascular diseases, causes reduction in bodyweight and fat accumulation (Park & Velasquez, 2012), suppresses postprandial lipaemia and appetite (Kristensen *et al.,* 2013) and .protection of the blood vessels from inflammatory damage is also provided by the lignans in flaxseeds (Dodin *et al.,* 2008).

Considering the nutritional value of flaxseed, the objective of this study, therefore, was to determine the chemical composition and storage stability of flaxseeds defatted meal, Determination and identification of flaxseed meal phenolic compounds using HPLC technique and investigating the antioxidant activity of the flaxseed meal extracts. It also to determine the optimum amounts of ground flaxseed meal to be incorporated into bakery products such as toast bread and cake. Finally, to evaluate the effect of adding ground flaxseed meal on rheological properties of the dough and the sensory characteristics of those bakery products.

2. MATERIAL AND METHODS

2.1. Materials

2.1.1. Flaxseeds and flaxseeds cake:

About five kilograms of flaxseeds a brown variety (*linum usitatissimum*) and flaxseed cake obtained as waste from cold pressing of flax seed were obtained from Dakahlia Governorate, Egypt. The cake was dried and milled in laboratory blender to pass through sieve No 40 and the resultant is considered as Flaxseed Meal (FM). Soft wheat flour (72% extraction) was obtained from Middle Egypt Flour Mills Co., Fayoum Governorate, Egypt. Whole wheat flour was obtained from stone mills from Fayoum, governorate.

2.2. Methods

2.2.1. Chemical composition:

The Moisture content, Ash content, fat content, total nitrogen (TN) was determined by the method of micro-Kjeldahl. Crude protein was calculated by multiplying total nitrogen value by a factor of 6.25. Crude fiber content was determined according to the method described by **(A.O.A.C., 2010)**. Total carbohydrate were calculated by difference

2.2.2. Determination of peroxide and acid value:

Peroxide and acid values of flaxseed meal oil was determined according to A.O.C.S. Recommended Practice Cd 12-57 (A.O.C.S., 1998**).**

2.2.3. Determination of minerals:

Minerals including Fe, Cu, Mg, Ca, Mn, Zn, Cd and Pb were measured using Perkin Elmer Atomic Absorption Spectrophotometer (Model 2380, U.K.). On the other hand, Na and K was determined using flame photometer (Model PEP7, U.K.). Total phosphorus was assayed calorimetrically at 630 nm using a spectrophotometer (Spectronic 2000, USA) as described in the AOAC (2010).

2.2.4. Determination of total phenolic content.

The Folin–Ciocalteu method was used to determine total phenolic compounds (Singleton*, et al.,* 1999). Using Folin– Ciocalteu reagent. The total phenolic content was determined by comparing with a standard curve prepared using gallic acid (10–200 µg/ml; $Y = 0.025X + 0.2347$; $R^2 = 0.9986$). The mean of at least three readings was calculated and expressed as mg of gallic acid equivalents (mg GAE)/100 g of Flax seeds meal.

2.2.5. Identification of flaxseed meal phenolic compounds by HPLC.

The separation of phenolic acids and flavonoids were performed with an Agilent 1260 Infinity series HPLC system equipped with on-line degasser (G 1322A), quantum (G 1311C), auto sampler (G 1329B), column heater (G 1316A), and variable wave length detector (G 1314F). Instrument control and data analysis was carried out using Agilent HPLC Chem Station 10.1 edition through Windows 7. Column Zorbax C18 (5 µm, 4.6 mm × 150 mm, Agilent) was used. The flow rate of the mobile phase was kept at 0.5 mL/min. Mobile phase A was water containing 0.02% TFA, and phase B was methanol containing 0.02% TFA. The gradient conditions were as follows: 0-5 min, 25% B; 5-10 min, 25-30% B; 10-16 min, 30-45% B; 16-18 min, 45% B; 18-25 min, 45-80% B; 25 -30 min, 80% B; 30-40 min, 80-25% B. The temperature of column was controlled at 25 °C. Injection volume was 5 µL. The detection wavelengths were set at: 280. Prior to each run, the HPLC system was allowed to warm, and the baseline was monitored until it was stable before sample analysis.

2.2.6. Determination of radical scavenging activity

The free radical scavenging activity of thee flaxseed meal extract was analyzed by using the 1,1-dipheny-2 -picrylhydrazyl (DPPH) assay according to Abba Pacôme*et al.,* (2014). The scavenging or inhibition percentage was calculated according to the following equation:

Scavenging (%) = (abs. control – abs. sample) X 100 / abs. control

Where: abs. is absorbance at 515nm.. Inhibition of coloration was expressed as a percentage, and the effective concentration 50 % (EC_{50}) was obtained from the inhibition curve.

2.2.7. Rheological properties:

1. Farinograph test

. The farinograph parameters of the wheat four whit 5 % flaxseed meal replacement were determined as described in the (A.A.C.C., 2000) using a farinograph type (877563 Brabender Farinograph West Germany HZ 50). Water Absorption, Arrival Time, Dough Development and Dough Stability.

2. Extensograph Test:

Extensograph test was carried out according to the method described in the (A.A.C.C., 2000) using an Extensograph type (4821384 Brabender Extensograph West Germany, HZ50) to measure the following parameters: Dough Extensability, Dough Resistance to Extensoion, Proportional Number and Dough Energy.

2.2.8.1. Toast bread making

control toast bread sample was prepared as in the method described by (A.A.C.C, 2000) using the following formula.(wheat flour 100g., water 60ml, yeast 2g., sugar 2g. salt1g. and corn oil 2.5g.). Three toast bread samples were prepared with replacement of 5, 10 and 15% of wheat flour with flaxseed meal to investigate the effect of flaxseed meal in the physical and rheological properties of the produced bread.

2.2.8.2. Cake Making:

The cake was prepared according to the basic formula described by **Lee et al., (2004).** The formula included 100.0 g wheat flour (72% extraction), 120.0 g white sugar, 50.0 g whole egg, 3.0 g baking powder and 1.0 g vanilla. The effect of replacing 5, 10 and 15% FM based on the weight of wheat flour, on the quality of the cake was studied.. The cake after cooling was cut into slices, and kept at room temperature (25 °C), before assessed organoleptially.

2.2.8.3. Sensory Evaluation bakery products:

Prepared score card for evaluation of bread based on evaluation of toast bread by 10 experienced judges-from Food Science and Technology Department teaching members. The parameters are: Overall acceptability, texture, crust color, crust shape, Crumb color, Crumb grain, flavor, Mouth feel. Scoring based on a10-point scale for each dependent.

2.2.8.4. Physical properties of bakery products.

Loaf weight and Loaf volume: The loaves were weighted in grams after 2h. from baking. The volume in $cm^3$of each loaf was determined using the displacement method using clover seed.

2.2.8.5. Specific Loaf volume (S.L.V): It was calculated from the following equation:-

$$\textbf{(S.L.V)} = \frac{\text{volume (cm3)}}{\text{Weight (g)}}$$

2.3. Statistical analysis

Statistical Package for Social Science (SPSS) version (17) was used to analyze data obtained. One way analysis of variances (ANOVA) with tukey's comparision of means values. Differences between mean values with probability p < 0.05 were recognized as statistically signifcant differences. way analysis of variances (ANOVA) with tukey's comparision of means values. Differences between mean values with probability p < 0.05 were recognized as statistically significant differences.

3. RESULTS AND DISCUSSION

3.1. proximate chemical composition of flaxseed deffated meal

Flaxseed meal was found to have high contents of dietary fiber, and protein and low content of starch. The chemical composition of the flaxseed meal was analyzed and the results indicated that flaxseed meal found to contains 34.65 protein, 37.08 % crude fibers, 5.53% ash, 2.35 % fats and 5.972% moisture. While it is poor in its carbohydrate content 14.408% comparing with whole wheat flour and wheat flour **(72%).** These results are in agreement with those reported by (Fazary and Younis, 2015, Satija and Hu, 2012, and Wandersleben *et al*., 2018).

3.2. Effect of storage time on chemical composition of flaxseeds meal

The free fatty acid value and the peroxide value of flaxseeds meal oil were determined during the storage time at room temperature in dark glasses containers to determine the stability of the flaxseed meal oil. The results in table (1) indicated that there were no significant (P ≤ 0.05) changes in the peroxide values over the 105 day of storage. These low values indicate high stability of flaxseed meal to oxidation. These findings suggest the natural antioxidants found in the milled flaxseed may cause the stability observed by prevented unsaturated fatty acids from oxidation.

Table (1): Effect of storage time on peroxide and acid values of flaxseeds meal oil.

Storage time (Days)	Peroxide value (meq O_2 / Kg)	Acid value
0	0.20	0.13
21	0.20	0.19
42	0.21	0.26
63	0.22	0.32
84	0.22	0.59
105	0. 23	0.85

The results also showed that free fatty acid value was slightly increased during the storage time. It recorded 0.19, 0.26, 0.32, 0.59 and 0.85 after 21, 42, 63, 84, and 105 days of storage respectively. This increased could be attributed to enzymatic activity possibly owing to the presence of immature seed in the sample. Our results are agreed with those reported by Malcolmson *et al*., (2000) and Abdel-Nabey *et al*., (2013). Hall *et al.* (2006) investigate the storage stability of flaxseed under various conditions and found that flaxseed was stable to oxidation even on exposure to light and high temperature.

3.3. Polyphenolic content of flaxseeds meal

3.3.1. Efficiency of solvents on extract yield and total phenolic content of flaxseeds meal

The influence of different solvents {ethanol+ water (80:20), methanol +water (80:20) and methanol + Ethanol (50:50)} were evaluated to identify the most suitable solvent for yield extract and total phenolic content of the obtained extracts. The obtained results are presented in Table (2). It could be notes from the results that with increasing the polarity of the solvents the Polyphenolic yields were found to increase. The extract yields were varied from 3.574 to 8.13g /100g^{-1} DW. The results showed that the highest yield was noticed when methanol and water (80: 20) followed by ethanol and water (50:50) while, methanol + ethanol recorded the lowest yield of phenolic extract (3.574g/100g DW. many researchers had reported that hydro-alcoholic mixtures are usually used as solvent for extraction of phenolic compounds from flaxseed meal to their high selectivity for these compounds (Pourabedin *et al.,* 2017, Albahari *et al.,* 2018). Regarding to the polyphenolic content of the different extracts, the results in Table (2) indicated that polyphenolic content ranged from 360.14 to 595.76 9mg/100g^{-1} DW. Methanol and water extract had the highest total phenolic content followed by ethanol and water, while, ethanol + methanol extract recoded the lowest polyphenolic content. This finding could be due to the high polarity of methanol and ethanol. Obtained results are in consonance. The results reported by other researchers who used many solvents for extracting the phenolic compounds from flaxseed flour and flaxseed meal (Akl, *et al.*, 2017, Alu'datt *et*

Table (2): Effect of solvent type on extraction of phenolic compounds from flaxseed meal

Extraction solution	**Yield %**	**Total phenols (mg/100g)**	**EC_{50}** µg/µg DPPH	**Antiradical efficiency**
Ethanol +water (80:20)	6.4326	470.43	1.981	**0.505**
Methanol +water (80:20)	8.1027	595.766	1.323	**0.756**
Etha + Metha. (50:50)	3.578	360.134	4.326	**0.231**

Wang *et al.*, (2017) studied the phenolic contents on six flaxseed cultivars and found the total phenolic content was ranged between 324.38 and 474.72 mg/100g.

3.3.2. Identification and quantification of phenolic compounds of methanolic extract from flaxseed meal

Flaxseed is a rich source of different types of phenolics such as lignans, phenolic acids, flavonoids, phenylpropanoids and tannins. The HPLC analysis of the phenolic extract resulting from extraction of FM with methanol and water (80:20) was studied and the results are explained in Table (3).In the present study, a total of 11 phenolic compounds found in the flaxseed methanolic extracted were identified namely: ellagic acid, gallic acid, pyrogallol, resorcinol, caffeic acid, chlorogenic acid, gallic acid, Kaempferol, coumaric acid, Salicylic acid and rutin. Table (3)

Kaur *et al.,* (2017) used ultra-performance liquid chromatography for identification and quantification of phenolic compounds from flaxseed and reported that flaxseed contained ten phenolic compounds namely, kaempferol, catechin, gallic acid, umbelliferone, coumaric acid, epicatechin, caffeic acid, rutin. chlorogenic acid aand ellagic acid

Table (3): Phenolic compounds distribution as appeared from chart of analysis.

Peak	Ret. time (min)	Area %	Name
1	3.27	0.12	Gallic acid
2	3.56	0.86	Pyrogallol
3	4.93	2.91	Catechin
4	5.70	0.15	Chlorogenic acid
5	16.27	0.18	Caffeic acid
6	16.88	0.31	Ellagic acid
7	18.5	0.53	Kaempferol
8	20.47	1.24	Coumaric acid
9	21.26	0.38	Salicylic acid
10	25.00	37.52	Cinammic acid
11	33.65	26.04	Rutin

Ret.= retention time

The phenolic acids content of flaxseed are usually varied according to seasonal effects, both cultivar and environment (Oomah *et al.,* 1995). Dabrowski and Sosulski (1984) reported the presence of major phenolic acids in flaxseed i.e., *trans*-ferulic acid (46 %), *trans*-sinpaic (36%), p-coumaric (7.5%), and *trans*-caffeic (6.5%). The total levels of phenolic acids in de-hulled and defatted flaxseed meal varied between 74and 81 mg/100 g, respectively.

3.4 Antioxidant activity of flaxseed meal extracts

The Free radical scavenging activity of the flaxseed meal extracts was evaluated at different concentrations against the stable free radical DPPH$^{\bullet}$ and the results are persented in Figure (1) summarize the effect of flaxseed meal different extracts at different concentrations on the remaining percentage of DPPH. It could be noticed that remaining percentage of DPPH is decreases with increasing of extracts concentrations of the flaxseeds for all tested extracts. At low concentration 0.5mg/mg DPPH the remaining DPPH was 72.71% for ethanol + water extract while it was only 22.82% at concentration of 6.21mg /mg DPPH. Methanol + water extract showed inhibition ratio of 37.28% at concentration of 0.638mg/mg DPPH. While, when the concentration was increased to 5.95mg/mg DPPH the remaining of DPPH was decreased to 9.548% and the inhibition ratio was 90.45%. The $EC_{50\%}$ was 1.323 and 1.981mg/mg DPPH and antiradical efficiency values ware 0.756 and 0.505 for methanol + water and ethanol +water respectively. On the other hand ethanol + methanol extract recorded the lowest scavenging activity with EC_{50} value of 4.326mg/mg DPPH.

This finding could be attributed to the high phenolic compounds content in methanol and ethanol +water extracts as it shown in **Table (2).**

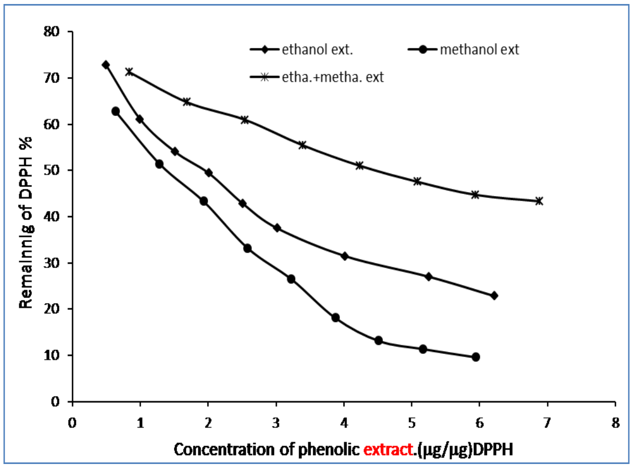


Figure (1): Scavenging activity of the flaxseed extracts at different concentrations.

It was reported that phenolic acids such as p-coumaric acid and ferulic acid glucosides which accumulated in the flaxseed found to possess antioxidant activity (Yuan *et al.,* 2008).

3.5. Rheological properties of whole wheat flour, wheat flour 72% extracts and wheat flour with 5% flaxseed meal replacement

3.5.1. Farinograph and Extensograph characteristics:

The Farinograph and Extensograph properties of dough's made from whole flour, wheat flour 72% , whole wheat flour with 5% flaxseed meal replacement and wheat flour 72% with 5% flaxseed meal replacement are presented in Table (4). The results showed that substitution of 5% wheat flour by flaxseed meal flour (whole or 72% extract) increases the water absorption and development time of the dough. The water absorption was increased from 65 to 74.5 for whole wheat flour (WWF) and whole wheat flour with 5% FM replacement and from 63.5 to 71.5% for wheat flour (72% extract) and wheat flour (72% extract) with 5% FM replacement, respectively.

Table: (4) Effect of adding flaxseed meal to whole wheat flour and wheat flour 72% on Farinograph and Extensograph characteristics

Samples	Farinograph characteristics					Extensograph characteristics			
	Water abs. (%)	Arrival time (min)	Dough develop. (min)	Stability time (min)	Degree of softening	Resistance to extension	Exten. (mm)	P.N	Energy (Cm^2)
W. W.F.	65.0	2.05	2.75	8.0	66	320	115	2.78	78
W.W.F.+ 5% FM	74.5	2.5	4.50	7.0	85	240	95	3.79	44
W.F.7 2%	63.5	0.5	1.75	8.5	75	360	130	1.84	92
W.F. 72% +5% FM	71.9	1.0	2.25	7.7	120	280	110	2.55	74

W. W.F= Whole wheat flour, W.W.F.+ 5% FM =Whole wheat flour + 5% Flaxseed meal, W.F. = Wheat flour (72%) , W.F.+ 5% FM Wheat flour (72%) +5% Flaxseed meal, abs.= absorption, Exten= Extensibility, P.N = Proportional No

The increased water absorption was attributed to the increased fiber content associated with flaxseed flour. The greater number of hydroxyl groups that exist in the fiber structure allows for more water interaction through hydrogen bonding. These results are agreed with Ghanbari and Farmani (2013)**.** The results showed that the stability values of 5% flaxseed dough's were lower than that of wheat flour without flaxseed meal in both whole or 72% wheat flour. Flaxseed flour-replacement dough's had significantly ($P < 0.05$) higher degree of softening indices than wheat flour dough. These changes in dough properties could result from the dilution of gluten and the difficulty of mixing fiber and wheat flour homogeneously (Koca and Anil, 2007 and Pourabedin *et al.,* 2017) .

The results showed that adding flaxseed meal to the flour at 5% replacement lead to decrease in the resistance to extension. These results are agreed with that reported by Pourabedin *et al.,* (2017) and Koca and Anil, (2007). Wang *et al.,* (2003) reported that addition of insoluble fiber to the wheat flour had negative effect on the formation of gluten network due to dilution of gluten. The results indicated that the extensibility and the energy of the dough were decreased by addition of flaxseed meal. This finding could be due to the increasing level of fiber in the dough which makes the dough become harder in the presence of flaxseed meal. The present results indicate that flaxseed meal flour decreases dough strength. These results are agreed with that reported by (Gilbert, 2002)..

3.6. Minerals content of flaxseed meal, toast bread and cake.

Micronutrient such as calcium, phosphorous, iron, magnesium, zinc and potassium were analyzed for flaxseed meal, toast and toast with 5% flaxseed meal substitution. The result in Table (5) exhibits the micronutrient composition of 100g of flaxseed meal, wheat flour toast and toast with 5% flaxseed meal substitution. Results showed that calcium, magnesium, potassium and phosphorous content of the flaxseed meal contain were 239, 679, 1835 and 874 mg/100g flaxseed meal, respectively. It is clear from the results that flaxseeds meal is a very good source of minerals especially potassium 1835mg/100 g), magnesium (679), phosphorus (874)mg/100g. several researchers reported different minerals content for different flaxseed varieties Bassette *et al.*, 2009, Hiremath, 2013).

Table (5). Effect of 5% flaxseed meal substitution on minerals content of toast bread and cake.

Samples	Flaxseeds meal	Toast (control)*	Toast with (5%) FM.	Cake (control)	Cake with (5%) FM
Potassium	1835	221.30	288.71	143.29	161.19
Magnesium	679.60	49.00	62.63	25.11	47.53
Phosphorus	784.50	132.43	151.17	81.83	104.43
Calcium	293.7	28.75	34.82	19.23	24.10

*toast control sample made from wheat flour (82%) and cake control made from wheat flour (72%).

When flaxseed meal was added to toast with (5%) substitution, the results indicated that potassium, magnesium, phosphorus and calcium were 288.71, 62.63, 151.17, and 34.82 mg/100g, respectively. The toast control recorded potassium, magnesium, phosphorus and calcium content of 221.30, 49.0, 132.43 and 28.75mg/100 g., respectively. These results agreed with those reported by Moura, (2015) and Abdel-Nabey,(2016). The results in the same table indicated that minerals content of cake with 5% flaxseed meal were potassium, magnesium, phosphorus and calcium. 161.19, 47.0, 104.43 and 24.10(mg/100g), respectively. While the cake control recorded potassium, magnesium, phosphorus and calcium of 143.29, 25.11, 81.83and 19.23, (mg/100g), respectively. These results agreed with Moura, (2015) and Abdel-Nabey, (2016).

3.7. Physical characteristics of the produced toast bread and cake.

Toast bread and cake from wheat flour with three different levels substitutions of defatted flaxseed meal (5, 10 and 15%) was prepared and physical characteristics of the products were determined and compared with the control treatments. From the results in table (6) it could be noted that bread and cake sample which prepared with 5% flaxseed flour was similar to the control sample in all the characteristics evaluated.

Table (6): Physical characteristics of toast bread with different flaxseed meal percentages.

Samples	Toast			Cake		
Treatments	weight (g)	volume (cm^3)	specific volume	weight (g)	volume (cm^3)	specific volume
Control	127.0	379	2.98	100.80	380	2.99
5% F.M.	127.5	370	2.94	100.00	378	2.89
10% F.M	128.2	365	2.86	91.00	375	2.87
15% F.M	129.5	365	2.87	80.50	365	2.87

F.M. =flaxseed meal

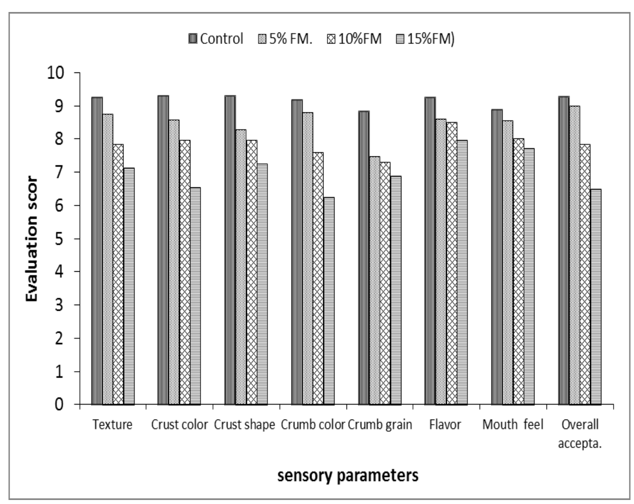
The results in the Table (6) showed that increasing the substitution level to 10 and 15% led to decrease of loaf volume and specific volumes of toast bread and cake compared to the control. The reduction in volume scores may be described to the decrease in gluten forming proteins and increase in dietary fiber contents contributed by flaxseed flour, which negatively affected the formation of gluten network and depressed the loaf volume due to lack of gas retention capacities of the composite flour.

The flaxseed flour supplemented acted as dilution factor on gluten content which may cause less volume and also is responsible for reduction in-SH groups. On the other hand the results indicated that cake weight, cake value and cake specific value clearly appeared to have been decreased as the amount of flaxseed flour increased The results of our study are in conformity with the work of Frank and Sarah 2006, Marpalle *et al*., 2014, Bashir *et al*., 2006 and Lee *et al*., 2004).

3.8. Sensory evaluation of toast bread

One of the most important steps in the new product development is "the voice of consumers" (Crofton *et al.,* 2013**).** Thus we were interested in the sensory attributes of the produced toast bread and cake. The results of the sensory properties of the toast bread are presented in fig. (2). The results showed that there were no significant differences between the toast sample made from wheat flour with 5% flaxseed flour and the control sample in the in all the sensory properties evaluated. In the other hand, there were significant differences between the samples with 10% and 15% flaxseed flour substitution and the control sample.

It could be notes that the crust color was affected by addition of flaxseed meal to the bread. The results indicated that flaxseed flour- substituted breads at level of 15% had the brownest crust. The results showed that the toast bread crust shape score was 9.28 for control sample and changed to 8.28, 7.95 and 7.24 for treatments with 5%, 10% and 15% flaxseed meal, respectively. The results proved that Crumb darkness increased with increasing flaxseed flour level. These results were agreed with those reported by (Hussain *et al.,* 2011, Alpaslan and Hayta 2006 ,Koca and Anil, 2007and Pourabedin *et al*., 2017)).



Fig(2): Sensory evaluation of toast bread.

In the present study, assignment of fewer score by the panelists to the crust and crumb color of breads may be attributed to the darker color of flaxseed flour imparted to resultant breads as the flaxseed meal (flour) is darker in color than wheat flours. This factor might have affected the psyche of panelists when rating the breads with higher levels of flaxseed and they assigned lower scores with respect to their color. The darker color has also been attributed to millard reaction between reducing sugars phenolic compounds and proteins during baking process as reported by the Garden (1993). It could prove that the toast bread crumb grain score was 8.83 for control sample and 7.45, 7.78 and 6.87 for the samples with 5%, 10% and 15% flaxseed meal. This result are also in conformity with the work of (Amalia, 2016 and Frank and Sarah (2006). Koca and Anil (2007) showed that the crumb darkness increased by increasing the level of flaxseed flours levels. A significant decrease in assigning scores to all the sensory attributes has also been supported by the study conducted by Naz, (2000) who observed that breads exceeding 15% flaxseed supplementation in wheat flour resulted in lower scores for texture, crumb color, crumb grain, and volume and crust color.

Regarding to the flavor and the mouth feel of the bread samples fortified with different levels of flaxseed meal flour, the results showed that flavor score for the control sample was 9.25 and changed to 8.58, 8.50 and 7.95 for samples substituted with 5%, 10% and 15% FM respectively. This result agreed with that reported by Costa *et al.,* (2012), Aliani *et al.,* (2012) and Conforti and Davis (2006).

From the previous results it could conclude that the toast bread produced by addition of flaxseed meal flour to wheat flour at level of 5% had no significant variation in all sensory parameters compared to the control sample. According to panelists' score in sensory evaluation and considering the results obtained in this experiment, toast enriched with flaxseed flour up to 10% was found to be acceptable and beneficial food. Increasing the substitution level to 15% was found to have a negative effect of all the sensory parameters studied.

3.9. Sensory evaluation for cake:

The sensory properties of the cake produced by three different substitution levels of flaxseed (5, 10 and 15% from the wheat flour) were evaluated. The results are presented in Table (7) The control cake sample recorded overall acceptability of 9.29 while it was 8.66, 8,16 and 7,39 for 5, 10, and 15% flaxseed substitution, respectively. The results in the same table indicated that the texture score values also showed decrease trend as flaxseed meal in cake increased. This might be due to decrease in crispiness. 5% FM sample texture was not significantly differed from control sample but, afterwards significant difference was found. The cake texture score was 9.09 for control sample and changed to 8.96, 8.33 and 7.49 for addition of 5%, 10% and 15% FM respectively.

Table (7): Effect of flaxseed meal on the sensory evaluation of cake:

	Control	5% FM	10% FM	15%FM
Overall acceptability	9.29^{a} ±0.79	8.66^{a} ±1.28	8.16^{ab} ±0.85^{ab}	7.39 ^{b} ±1.89
Texture	9.09^{a} ±0.81	8.96^{a} ±0.89	8.33^{ab} ±1.0	7.49^{b} ±1.13
Crust color	9.09^{a} ±0.79	8.53^{ab} ±1.11	7.93^{b} ±1.00	7.47^{b} ±1.62
Crust shape	9.13^{a} ±0.88	8.93 a ±1.14	8.16^{a} ±1.35	8.03^{a} ±1.56
Crumb color	9.19^{c} ±0.6	8.29^{ab} ±1.21	7.86^{bc} ±0.94	6.96^{c} ±1.47
Crumb grain	9.13^{a}+0.66	8.93^{a}±0.74	8.43^{ab}±1.04	8.09^{b}±1.21
Flavor 10	9.39^{a}±0.70	8.89^{a}±0.81	8.86^{ab}±0.9	8.56^{b}±0.9
Mouth feel	9.16^{a}±0.39	9.13^{a}±0.94	8.33^{b}±1.07	7.53^{c} ±1.55
Overall acceptability	9.29^{a} ±0.79	8.66^{a} ±1.28	8.16^{ab} ±0.85^{ab}	7.39 ^{b} ±1.89

Regarding to the crust and crumb color score, results for control and different treated samples indicate that the score decreased with increasing the level of FM. The probable reason for these results could be brown color of flaxseed which became dark brown at high baking temperature. Pigments such as leutin/ zeaxanthin in flaxseed makes it dark brown. Pigments such as leutin/zeaxanthin in flaxseed makes it dark brown (United States Department of Agriculture, 2007). The crust color score for the control was 9.09 while it decreased to 8.53, 7.93 and 7.49 for 5%, 10% and 15% FM substitution, respectively.

The results proved that the cake crumb color score was 9.19 for control sample and changed to 8.29, 7.86 and 6.69 in for substitution of 5%, 10% and 15% FM respectively. These results are conformity with that reported by Moraes *et al.,* (2010) and Alpaslan and Hayta (2006).

The cake crumb grain score was 9.29 for control sample and changed to 9.13, 8.43 and 8.09 in case of 5%, 10% and 15% FM substitution, respectively. No significant difference was noticed between the score at 5% FM level and the control sample. The results cited in Table (7) revealed that the cake flavor was considerably influenced due to flaxseed incorporation. Results revealed that there was no significant difference ($p < 0.05$) in flavor up to 10% of wheat flour replacement with flaxseed and control sample cake. At 5% and 10% replacement with flaxseed meal, flaxseed pleasant nutty flavor is liked by judges. Beyond 15% FM level, taste score significantly reduced. This might be due to unacceptable high nutty flavor imparted by FM. These results are in agreement with that reported by Lee *et al.,* (2004).

4. CONCLUSION

It could conclude that flaxseed meal showed high polyphenolic content with strong antioxidant activity. Addition of flaxseed to bread and cake formula as partial replacement for wheat flour enhanced the fiber and protein content of the products. based on the results of sensory evaluation of bread and cake it could concluded that small to moderate inclusion levels4 of flaxseed meal, especially in the range of 5 to 10 per cent as partial replacement for wheat flour showed favorable baked.

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