Original Article

Effect of Fortification of Biscuits with Flaxseed on Omega 3 and Calcium Content of the Products

Heba Elshehy[1 ¥], **Neveen Agamy**[2], **Hanaa Ismail**[2]

[1] Department of Nutrition, Faculty of Allied Medical Sciences, Pharos University, Alexandria, Egypt

[2] Department of Nutrition (Food Analysis Specialty), High Institute of Public Health, Alexandria University, Egypt

Abstract

Background: Consumer's interest in healthy eating shifted towards the potential health benefits of specific foods and food ingredients. Flaxseed has a unique fatty acid profile. It is high in omega-3 fatty acid and calcium.

Objective(s): The purpose of this study was to highlight the nutritional quality of flaxseed and effect of fortification of biscuits on omega 3 and calcium content of products.

Methods: Different flaxseed concentrations (0%, 10%, 20% and 30%) were used in the preparation of fortified biscuits. Proximate analysis of flaxseed and produced biscuits was performed to determine moisture, fat, total ash, crude protein, crude fiber and carbohydrate content. Sensory evaluation of produced biscuits was done to assess color, taste, odor, texture, over-all acceptability and residual after taste. Omega-3 and calcium content of flaxseed and produced biscuits was determined.

Results: In our study, the changes in chemical composition of biscuits fortified with flaxseed showed that the addition of flaxseed to wheat flour significantly increased protein, fat and ash content, meanwhile, decreased the content of carbohydrates. Biscuit samples made from substitution of wheat flour with flaxseed up to 20% were acceptable and gave nearly similar scores to the control. Our results indicated that flaxseed was rich in polyunsaturated fatty acids (60.43 %) with omega-3 representing 47.22%. Biscuits fortified with flaxseed revealed that omega-3 content of flaxseed fortified biscuits was significantly higher than the control biscuits. In our study, the calcium content of the grinded flaxseed was 188.9 mg/100g. Control biscuits which were formulated from wheat flour contained 25.6 mg/100g calcium. Whereas, biscuits fortified with 10 %, 20% and 30% flaxseed exhibited significantly higher contents of calcium (168.3, 175.0 and 179.1 respectively).

Conclusion: The use of flaxseed in dietary products can be recommended as functional food. Substitution of wheat flour in biscuits with 20% flaxseed was acceptable by panelists. Enrichment of diets with flaxseed for better utilization of ω-3 fatty acids and calcium for better bone health is recommended.

Keywords: Flaxseed**,** omega-3, calcium, biscuits

Available on line at:
www.jhiph.alexu.edu.eg

¥***Correspondence***

Email: heba_elshehy@yahoo.com

Suggested Citations: Elshehy H, Agamy N, Ismail H. Effect of fortification of biscuits with flaxseed on Omega 3 and calcium content of the products**.** JHIPH. 2018;48(2):58-66.

INTRODUCTION

Consumer's interest in healthy eating, in the last decades, shifted towards the potential health benefits of specific foods and food ingredients.[(1)] In the last two decades, flaxseed has been the focus of increased interest in the field of diet and disease research due to the potential health benefits associated with some of its biologically active components. Flaxseed contains functional components such as dietary fibers, oil, protein and phenolic compounds including lignans, flavonoids and phenolic acids, which are responsible for several health benefits. The seed contains approximately 40% lipids, 30% dietary fiber and 20 % protein.[(2)] Flaxseed has a unique fatty acid profile. It is high in polyunsaturated fatty acids; alpha-linolenic acid (ALA) the essential omega-3 fatty acid and Linoleic acid an omega-6 fatty acid and low in saturated fatty acids.[(1, 3)] Flaxseed flour contains high concentration of calcium, which is a key component to mineralize the bone matrix.[(4)] Nowadays, bakers and commercial food companies in a number of countries are using whole flaxseed and its derivatives as ingredients for designer foods.[(5)]

The aim of the present study was therefore to assess the effect of fortification of biscuits with flaxseed on omega 3 and calcium content of the products.

METHODS

Study settings and design: An experimental study was conducted in a public bakery shop. The samples

were prepared and analyzed in the laboratory of Nutrition Department at the High Institute of Public Health, Alexandria University, as well as the Central Laboratory of the High Institute of Public Health, Alexandria University.

Sampling: Wheat flour was replaced by grinded flaxseed at different levels (10%, 20% and 30%) for preparation of biscuits.

Preparation of biscuits: Flaxseed was cleaned manually to remove dust particles, damaged seeds, seeds of other crops and other impurities such as weeds and metals then grinded to fine powder. All basic ingredients (wheat flour, grinded flaxseed, powdered sugar, shortening, egg, baking powder, salt, vanilla and water) were weighted accurately (Table I), mixed, cut to desired shapes and backed. After baking, the biscuits were cooled at room temperature and packed in glass boxes for further analysis.

Laboratory analysis

Biscuits were analyzed to determine the following:

1. Proximate analysis: Moisture, fat, ash, protein, fiber and carbohydrate content were determined according to the standard methods.[6, 7]

2. Sensory evaluation: The biscuits prepared by different concentrations of flaxseed were evaluated by the panelists for their characteristics: color, texture, odor, taste, over all acceptability and residual after taste. They were asked to score as rating 1-9 (9 = liked extremely and 1= disliked extremely).[8]

3. Fatty acid profile: Fatty acid profile was determined in grinded flaxseed and biscuits samples using gas chromatography.[9]

4. Calcium content: Calcium was determined in grinded flaxseed and biscuit samples according to standard methods using Atomic Absorption Spectroscopy.[6, 9]

Table I: Ingredients of control biscuits and biscuit fortified with different concentrations of flaxseed

Ingredients*	Flaxseed concentration in biscuits			
	Control (0%)	10%	20%	30%
Flour	250	225	200	175
Grinded flaxseed	---	25	50	75
Sugar (powdered)	80	80	80	80
Shortening	80	80	80	80
Eggs	1	1	1	1
Baking powder	10	10	10	10
Salt	0.3	0.3	0.3	0.3
Vanilla	0.5	0.5	0.5	0.5
Water	15	15	15	15

*Solid ingredients represented in grams while liquid ingredients in milliliter (ml)

Statistical analysis: Data were analyzed using IBM SPSS software package version 20.0. Quantitative data were described using mean and standard deviation for normally distributed data. For normally distributed data, comparison between two independent population were done using independent t-test while more than two population were analyzed F-test (ANOVA) to be used. Significance of the obtained results was judged at the 5% level. Duncan's method was used to find the significance between each two groups.

Ethical considerations

The study was approved by the Institutional Review Board and the Ethics Committee of High Institute of Public Health. The study conformed to the principles of Helsinki declaration (2013) and the international ethics guidelines.

RESULTS

A total of 50 consumers participated in the study including 20 men 30 women, between 16 and 52 years of age. Figure 1 shows the proximate composition of grinded flaxseed, the grinded flaxseed had 5.30% moisture, 21.90% fat, 3.13% ash, 25.8% protein, 1.30% crude fiber and 43.82% carbohydrate.

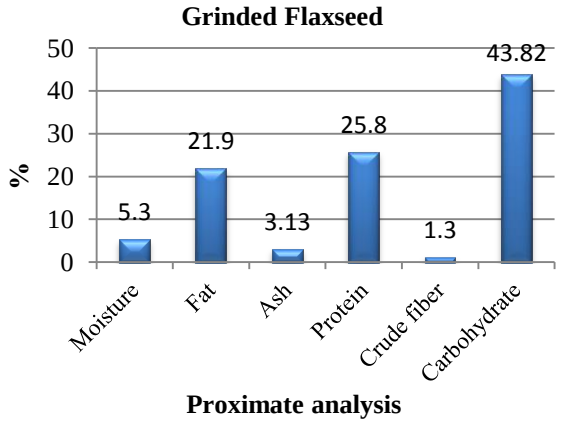

Figure 1: Proximate composition of grinded flaxseed

Table 2 shows the proximate composition of biscuit produced from different levels of flaxseed. The wheat

flour used in biscuits preparation had 4.01% moisture, 13.52% fat, 1.04% ash, 10.40% protein, 1.40% crude fiber and 71.08% carbohydrate. Proximate analysis of different concentrations of flaxseed incorporated biscuits indicated that fortification of biscuit with flaxseed significantly increased protein, fat and total minerals, while decreased total carbohydrates. There was no significant change in crude fiber content between control group and different concentration of flaxseed. Table 3 shows sensory evaluation of biscuit produced from different concentrations of flaxseed. Sensory evaluation of biscuits indicated that fortification of biscuit with different concentrations of flaxseed significantly decreased the sensory attributes of biscuit; although flaxseed substitution at moderate levels (20%) showed no significant difference from the control biscuits regarding odor, taste, overall acceptability and residual after taste.

The total quality score of sensory evaluation of biscuit produced from different concentrations of flaxseed decreased in relation to the control with addition of flaxseed flour. However, the 20% flaxseed substitution was the highest acceptable product and received best scores (39.61) comparable to the control (44.76).

Table 2: Proximate Composition of biscuits produced from different concentrations of flaxseed

Proximate Composition (%)	Flaxseed concentration in biscuits			
	Control (0%)	10%	20%	30%
Moisture	4.01±1.64[a]	4.90±0.50[b]	5.11±1.78[b]	5.20±0.52[b]
Fat	13.52±2.11[a]	17.24±1.76[b]	19.31±1.82[bc]	20.82±2.10[c]
Ash	1.04±0.08[a]	1.29±0.11[ab]	1.39±0.12[b]	1.54±0.11[b]
Protein	10.40±0.82[a]	10.90±0.86[ab]	11.80±0.93[bc]	12.30±1.03[c]
Crude fiber	1.40±0.11	1.20±0.11	1.30±0.11	1.31±0.12
Carbohydrate	71.08±5.69[a]	65.67±5.25[b]	62.38±5.11[b]	60.13±5.80[b]

Values represent the mean of three replicates ± standard deviation

Mean values in the same row which is followed by different superscript alphabet are significantly different ($p<0.05$)

Table 3: Sensory evaluation of biscuit produced from different concentrations of flaxseed

Sensory evaluation attributes	Flaxseed concentration in biscuits			
	Control (0%)	10%	20%	30%
Color	8.12±1.78[a]	5.33±2.30[b]	5.63±1.86[b]	5.38±2.06[b]
Texture	7.55±1.59[a]	6.17±2.10[b]	6.54±1.92[b]	6.46±2.04[b]
Odor	7.14±2.03[a]	6.27±2.19[b]	6.67±2.04[ab]	6.21±2.40[b]
Taste	7.31±1.59[a]	6.02±2.32[b]	6.92±2.02[a]	6.38±2.14[b]
Overall acceptability	7.33±1.47[a]	6.63±2.11[b]	7.02±1.75[ab]	6.54±2.09[b]
Residual after taste	7.31±1.74[a]	6.63±2.15[b]	6.83±2.02[ab]	6.54±2.20[b]
Total score	44.76±3.21	37.05±3.25	39.61±3.74	37.51±3.11

Values represent the mean ± standard deviation

Mean values in the same row followed by different superscript alphabet are significantly different ($p<0.05$)

The fatty acid profile of grinded flaxseed. The data reported that the major fatty acids in flaxseed oil were α-linolenic acid C18:3 (omega-3) representing 47.22%, followed by oleic acid C18:1 as 26.78% and linoleic acid C18:2 (Omega-6) representing 13.21%. The total polyunsaturated fatty acid content (ΣPUFA) was 60.43 and total saturated fatty acid content (ΣSFA) was 20.05. The polyunsaturated/saturated (P/S) ratio was 3.01 and ω-6/ω-3 ratio of 0.28:1 (Figure 2 & 3).

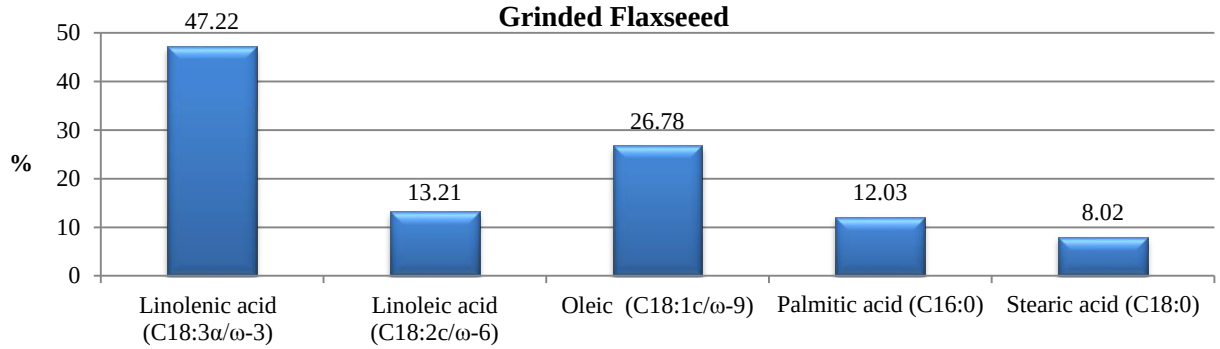

Figure 2: Fatty acid profile of grinded flaxseed

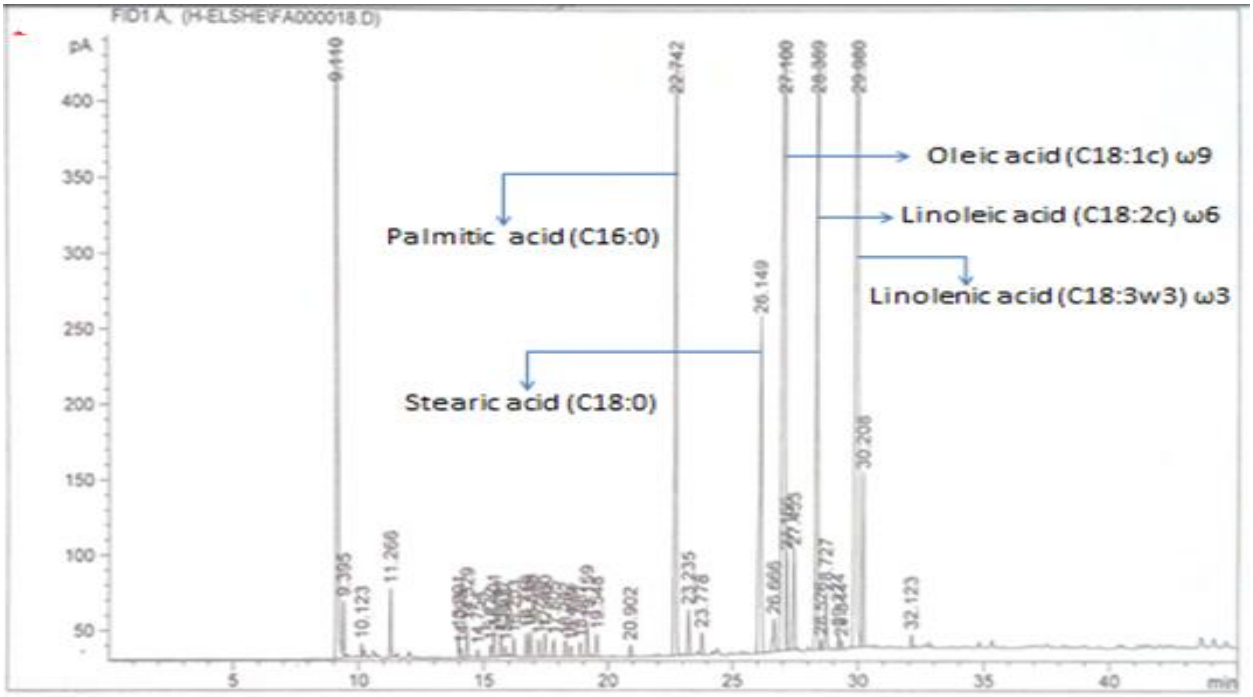

Figure 3: Gas chromatography chromatogram of fatty acid profile of grinded flaxseed

The fatty acid profile of biscuit fortified with different concentrations of flaxseed. It was found that concentration of linolenic acid (ω-3) significantly increased by increasing flaxseed concentrations in dose dependent manner. On the other hand, the concentration of oleic acid, Palmitic acid and stearic acid decreased with increasing concentration of flaxseed incorporated in the biscuits. Comparison of control and biscuit fortified with flaxseed profile revealed that the total polyunsaturated fatty acid content (ΣPUFA) significantly increased with increasing concentration of flaxseed incorporation, while the total saturated fatty acid content (ΣSFA) significantly decreased (Table 4, figure 4).

Table 4: Fatty acid profile of biscuit fortified with different concentrations of flaxseed

Fatty acid profile	Flaxseed concentration in biscuits			
	Control (0%)	10%	20%	30%
Poly unsaturated				
Linolenic acid (C18:3α/ω-3)	1.10±0.10^{a}	7.34±0.81^{b}	10.10±1.02^{c}	13.41±1.20^{d}
Linoleic acid (C18:2c/ω-6)	9.40±0.89	10.10±1.00	10.40±0.98	10.38±1.20
Mono unsaturated				
Oleic acid (C18:1c/ω-9)	43.69±5.01^{a}	34.50±3.10^{b}	33.40±3.20^{b}	33.10±2.90^{b}
Saturated				
Palmitic acid (C16:0)	42.35±5.60^{a}	38.60±3.70^{ab}	34.50±3.60^{b}	32.74±3.10^{b}
Stearic acid (C18:0)	5.87±4.90	6.00±0.56	5.70±4.80	5.92±0.62
Total polyunsaturated fatty acid content (ΣPUFA)	10.50±1.00^{a}	17.45±1.20^{b}	20.50±2.10^{c}	23.78±2.10^{c}
Total saturated fatty acid (ΣSFA)	48.22±3.90^{a}	44.60±3.90^{b}	40.20±3.90^{c}	38.66±3.90^{c}
P/S ratio	0.20±0.01^{a}	0.39±0.01^{b}	0.50±0.04^{c}	0.62±0.02^{c}
ω-6/ω-3 ratio	8.50±0.773^{a}	1.38±0.01^{b}	1.00±0.09^{b}	0.77±0.02^{b}

P/S ratio: polyunsaturated/saturated ratio, ω-3: omega 3, ω-6: omega 6

Values represent the mean of three replicates ± standard deviation

Mean values in the same row which is followed by different superscript alphabet are significantly different ($p<0.05$)

1 Monte-Carlo Exact Test. 2 Independent student t-test 3 Chi-square test

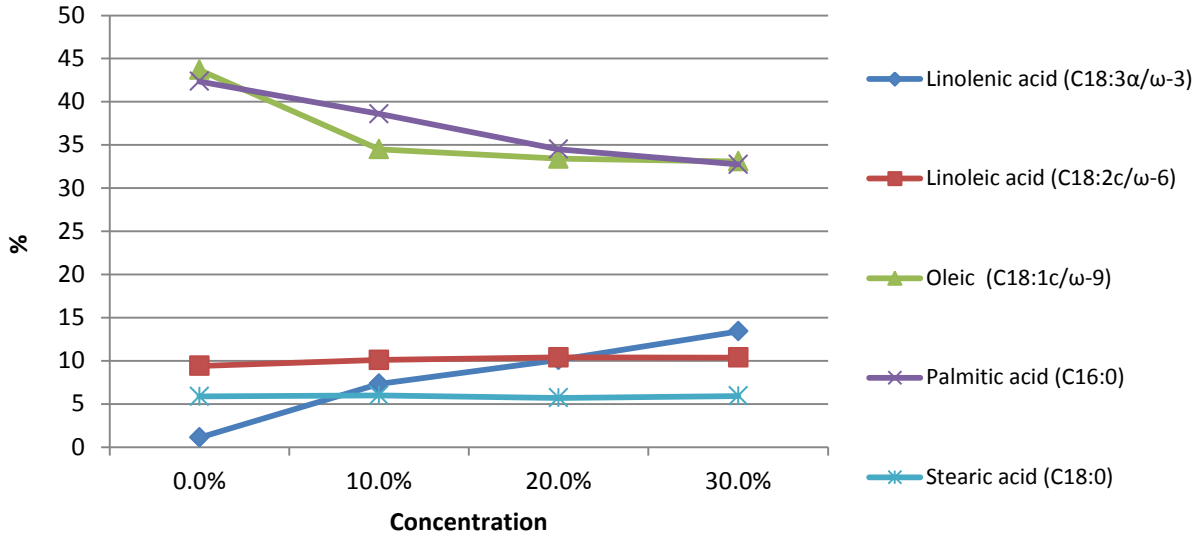

Figure 4: Fatty acid profile of biscuit fortified with different concentrations of flaxseed

By comparing the control and biscuit fortified with flaxseed the P/S ratio significantly increased while the ω-6/ ω-3 ratio significantly decreased with increasing concentration of flaxseed incorporation.

By comparing the control biscuit with biscuits fortified with 20% flaxseed flour which were found acceptable by the panelists with respect to their sensory attributes there was a significant increase in omega-3 from 1.10% to 10.10%, and that of linoleic acid shows an increase from 9.40% to 10.40%, while oleic acid significantly decreased from 43.69% to 33.40%. Regarding saturated fatty acids, biscuit fortified with flaxseed showed a significant decrease in palmitic acid from 42.35% to 34.50%, and that of stearic acid from 5.87% to 5.70%. Comparison of control and biscuit fortified with 20% flaxseed profile revealed that total polyunsaturated fatty acid content (ΣPUFA) significantly increased from 10.50% to 20.50%. While total saturated fatty acid content (ΣSFA) significantly decreased from 48.22% to 40.20%. Comparison of control and biscuit fortified with 20% flaxseed profile revealed that the P/S ratio significantly increased from 0.2% to 0.5% while the ω-6/ω-3 ratio significantly decreased from 8.50 to 1.00.

The calcium content of grinded flaxseed was 188.90 mg/100gm. The calcium content of biscuit fortified with different concentrations of flaxseed (Table 5, Figure 5).

The calcium content of the control biscuit was 25.60 mg/100gm. The calcium content of 10%, 20%, 30% flaxseed fortified biscuits increased by increasing the flaxseed concentration in dose dependent manner to 168.30, 175.00 and 179.10 respectively. The calcium content of biscuit fortified with 20% of flaxseed which was found acceptable by the panelists with respect to their sensory attributes, increased from 25.6 to 175.0.

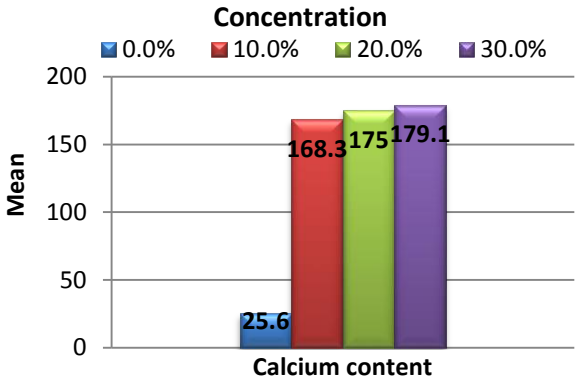

Figure 5: Calcium content of biscuit fortified with different concentrations of flaxseed

Table 5: Calcium content of grinded flaxseed

Calcium content (mg/100gm)	Grinded Flaxseed
	188.90±10.80

Values represent the mean of three replicates ± standard deviation

DISCUSSION

Flaxseed is one of the cheapest grains gaining popularity. It contains relatively high amounts of proteins that can help to enhance the quality of the foods of a large segment of population.[10] Proximate composition of flaxseed makes it more promising for its utilization in different food products. In our study,

the moisture content of whole flaxseed was 5.30%, that agreed well with those reported by Abdel-Nabey et al (2013)[11], and Herchi et al (2015).[12] The moisture content was slightly lower than that reported by Kajla (2015)[13] and higher than that reported by Fazary and Younis (2015).[14] The importance of flaxseed lies in its relatively high contents of protein, fat, ash and dietary fiber. The fat content of the flaxseeds determined in our study was found to be 21.90%, this data agreed with Herchi et al (2015)[12] who reported that the fat content was 22.65%. and Fazary (2015)[14] who reported that the fat content was 24.90%. On the other hand, this result was extremely lower than value reported in previous studies where they reported that the fat content of different varieties of flaxseed varied between 37.1% and 43.9%.[11, 13, 15]

The data in our study showed that the protein content was 25.80%, the obtained result agreed well with those reported by Herchi et al (2015), [12] and was higher than results obtained from previous studies, that reported that protein content of flaxseed ranged between 19.46 and 24.87%. Differences in protein can be attributed to both genetics and environmental factors.[11, 14, 15] Scientists reported that the protein content of the seed increased as the oil content decreased, this observation was confirmed in our study. This finding may focus the interest of utilizing flax as a high protein source in some food formulation.[16]

The total ash content of flaxseed, which was the mineral-rich residue left after samples were burned, was 3.13%. This result agreed with Herchi et al (2015)[12] who reported that the ash content was 2.9%, and with the results obtained by Gaafar (2010).[17] This value was higher than that reported by Kajla (2015) [13] and lower than that reported by Abdel-Nabey (2013).[11]

In our study, the crude fiber content was 1.30%, this value was lower than that reported in other studies that found that flaxseed varieties contained from 4.8 to 8.74% crude fiber.[11, 13, 15, 17] The total carbohydrate content in our study was 43.87%, this data was near to that of Herchi et al (2015) [12] who reported that the carbohydrate content was 34.12%. On the other hand, this result was higher than reported in previous studies.[11, 13, 17]

Baking industry is one of the largest organized processed food industries. The popularity of the bakery products is mainly due to their ready-to-eat nature, convenience, low cost and availability in large number of varieties of different tastes and textural profiles. The main advantage of bakery products is their amenability for fortification with cereals including flaxseed or other functional ingredients.[18] Proximate analyses of flaxseed fortified biscuit indicated that its moisture content increased as compared to the control biscuit. This can be attributed to fiber (gum mucilage) present in flaxseed which has higher moisture retention property.[18] The data recorded for fat percentage of biscuit showed that the fat percentage increased with the increase of flaxseed content in the composite flour. One of the prominent features of flaxseed is its high fat contents resulted in its categorization under oilseed crops. This result was in accordance with the findings of Bashir et al (2006)[19] and Gaafar et al (2010).[17] Ash content of fortified biscuit increased as compared with control. This result was in agreement with other previous results.[18, 19] Higher ash content of fortified biscuit might be due to higher mineral content of flaxseed flour.[18] The protein percentage of different concentrations of biscuits showed that the percent protein increased with the increasing level of flaxseed in composite flour. The results could easily be accounted for the fact that flaxseed is far higher in protein contents than wheat flour. These findings correlated with the findings of Bashir et al (2006)[19] and Gaafar et al (2010).[17]

The changes in chemical composition of biscuit fortified with flaxseed showed that the addition of flaxseed to wheat flour at different concentrations (10%, 20%, 30%) significantly increased the protein content, fat and ash. Meanwhile, the content of carbohydrates was decreased in the biscuit substituted with flaxseed. This increment in protein and total minerals as well as decrement in total carbohydrates is beneficial from nutritional point of view, since it increases the quantity and quality of amino acids and minerals, while decreases the total calories that acquired from this product.[20] Ganorkar (2014) [18] reported that, the addition of flaxseed to cookies significantly increased all-chemical composition except the total carbohydrates. Even though it is widely accepted that the consumption of flaxseed can provide significant health benefits, products enriched with flaxseed can only become commercially viable if its sensory properties are appreciated by consumers. [21]

In our study it was observed that the mean value for average quality score for sensory evaluation including color, texture, odor, taste, overall acceptability and residual after taste of biscuits fortified with different concentrations of flaxseed showed that biscuits with 20% flaxseed was found very appreciable and received higher scores comparable to the control. This difference was also obvious from different researchers.[19, 22] Conforti and Davis (2006)[23] reported no significant effect for the aftertaste of white bread with 15% flaxseed flour enrichment. In contrast, Alpaslan and Hayta (2006) [24] evaluated the consumer acceptance of bagels enriched with 0%, 5%, 10%, and 15% ground flaxseed. At 5% flaxseed enrichment, the scores for enriched breads were similar to the control bread, but at 10% enrichment, a negative effect for the mouth-feel, was reported. The results concerning sensory evaluation of biscuit produced from different concentrations of

flaxseed showed that biscuit samples made from 100% wheat flour were characterized with high acceptability for all parameters with total score 44.76. The mean quality score of the biscuit decreased with the increase in the level of the flaxseed flour supplementation. However, flaxseed used instead of wheat flour up to 20% was acceptable and gave somewhat similar scores (39.61). Generally, these data agreed well with Koca and Anil (2007) [25] who indicated that an acceptable bread could be produced using flaxseed flour up to a level of 200 g / kg (20%). Navickis and Nelsen (1992) [26] found that a 20% replacement of wheat flour by weight with milled flaxseed appeared to be a reasonable limit in preparing yeast bread and muffins. Similarly Gaafar et al (2010) [17] showed that pan bread substitute samples 10 and 15% instead of wheat were suitable for use.

Flaxseed contains a mixture of fatty acids. In our study, flaxseed was low in saturated fatty acids (20.05 %), moderate in monounsaturated fatty acids (26.78 %), and rich in polyunsaturated fatty acids (60.43 %). These findings were concordant with other studies.[2, 12] From the obtained results it could be observed that the major fatty acids in flaxseed oil were α-linolenic acid C18:3 (omega-3) representing 47.22%, followed by oleic acid C18:1 as 26.78% and linoleic acid C18:2 (omega-6) representing 13.21%. The composition of oils confirms that found by other researchers. [12, 16] The two main parameters currently used to assess nutritional quality of the lipid fraction of foods are the ratios between polyunsaturated and saturated (P/S) and between omega- 6 and omega-3 fatty acids.[18] It could be observed that the polyunsaturated / saturated (P/S) ratio was 3.01, that was higher than ratio reported by Fazary and Younis (2015) [14] where they reported P/S ratio of 1.3. On the other hand, Abdel-Nabey (2013) [11] reported a higher ratio.

In our study, alpha-linolenic acid (omega-3) comprised about 47.2% of the total fatty acids in flaxseed, whereas the omega-6 fatty acids comprised about 13.21%. Thus, flaxseed contained more than three times as much omega-3 as omega-6 fatty acids, giving an ω-6/ω-3 ratio of 0.28:1. This result was nearly similar to result obtained by Abdel-Nabey et al (2013) [11] who reported the ratio of 0.29:1. And others who reported a ratio of 0.3:1.[1, 2] Therefore, the seed may be an alternative for supplying this fatty acid to populations concentrated in regions of the world where there is not large access to marine foods.[1] The fatty acid profile of biscuit fortified with flaxseed revealed that polyunsaturated fatty acids, omega-3 content of flaxseed fortified biscuit was significantly higher than the control biscuits. omega-3 was nearly not detected in control (1.1%), because wheat flour does not contain omega-3, whereas it was significantly increased in flaxseed fortified biscuit. In case of monounsaturated fatty acid profile, oleic acid content of control biscuit was 43.69 % of total fatty acids which was significantly higher as compared to flaxseed fortified biscuit. In case of saturated fatty acid profile that is palmitic and stearic acid of control biscuits were significantly higher than flaxseed supplemented biscuits. These results were in agreement with previous results. [27, 28] Comparison of control biscuit and biscuit fortified with 20% flaxseed, which was found acceptable by the panelists with respect to their sensory attributes, there was an increase in omega-3 content from 1.1% to 10.1%. This result was in accordance with previous results.[27, 28] Comparison of control biscuit and flaxseed fortified biscuit fatty acid profile revealed that total saturated fatty acid content (ΣSFA) decreased while total polyunsaturated fatty acid content (ΣPUFA) increased. As implied by the data in our study, the fortified biscuit products had an improved proportion of PUFA compared with other fatty acids. Comparing the amounts of saturated and unsaturated fatty acids in dry substances, the products fortified with flaxseed revealed an increase of polyunsaturated fatty acids by about 50% of its initial content in control recipe. This result was in accordance with results reported by Gambuś et al (2009). [28]

In our study, the P/S ratio increased from 0.2 in the control biscuit to 0.39, 0.55 and 0.62 in the flaxseed fortified biscuit with flaxseed concentration of 10%, 20% and 30% respectively. On the other hand, the ω-6/ω-3 ratio decreased from 8.5 in control biscuit to 1.38, 1.00 and 0.77 in flaxseed fortified biscuit with flaxseed concentration of 10%, 20 % and 30% respectively because of the omega-3 increment. These results agreed well with study of Ganorkar and Jain (2014).[18] Accordingly, to improve the health status of the population, the nutritional authorities have recommended regulating the consumption of foods rich in ω-3 PUFAs, in such a way that ω-6/ω-3 PUFA ratio of less than 4 can be achieved and that the P/S ratio is higher than 0.4. In our study, biscuit fortified with 20% flaxseed, which was found acceptable by the panelists with respect to their sensory attributes, showed P/S ratio of 0.5 which was nearer to the recommended ratio (>0.4), and ω-6/ω-3 ratio of 1.0 which was well below the recommended ratio of 4. Similar results were reported by Ganorkar and Jain (2014).[18]

The National Institutes of Health Expert Panel recommends dairy foods as the preferred source of calcium, followed by calcium-fortified foods and calcium supplements. Individuals who choose not to consume dairy foods because of cultural preference, milk allergy, animal rights concerns or other reasons, will need to rely more heavily on calcium-fortified foods and calcium supplements to meet calcium recommendations. Vegans are anyway at an elevated risk of not meeting their calcium needs, especially during the phase of rapid growth.[29] Compared with other micronutrients, calcium is required in relatively

large amounts. Calcium consumption is generally very low in most populations considering the recommended values. A heightened awareness of the need to increase intakes of calcium for osteoporosis prevention has meant that calcium fortification has attracted a good deal of interest in recent years.[30]

The level of calcium in flaxseed in our study (188.90 mg/100 gm) was higher than that reported by Verma et al (2017), [31] and Mekebo et al (2014)[32] as 170 and 54-74 mg/100 gm respectively. On the other hand, the calcium content was lower than that reported in other studies.[2, 10] Because of the low calcium content of products made with wheat flour, it does not match that of dairy products. In contrast, products containing significant amounts of calcium, when regularly consumed, they can contribute significantly to the total calcium intake. [29]

Traditionally, biscuits are not considered to be a good source of minerals. However, recently, the biscuit industry has been enriching them with these micronutrients and including the information "mineral-enriched" on their nutritional labels. Biscuits fortified with flaxseed show high content of minerals as calcium.[33] In our study, control biscuits which were formulated from wheat flour contained 25.6 mg/100g calcium. Whereas, biscuits fortified with 10 %, 20% and 30% flaxseed exhibited significantly higher contents of calcium as 168.3, 175.0 and 179.1 respectively.

CONCLUSION & RECOMMENDATIONS

Flaxseed contains a mixture of fatty acids; it is rich in polyunsaturated fatty acids, moderate in monounsaturated fatty acids. Flaxseed contains more than three times omega-3 as much as omega-6 fatty acid; therefore, the seed may be an alternative for supplying this fatty acid. Flaxseed contains high concentration of calcium which is a key component to mineralize the bone matrix. The addition of flaxseed to wheat flour significantly increased: the protein, fat, ash, omega-3 and calcium content. Meanwhile, the content of carbohydrates was decreased in the biscuit substituted with flaxseed. The formulations made with 20% flaxseed flour as partial replacement of wheat flour had good acceptance, and the product presented high nutritional value. Biscuits with 20% flaxseed had higher content of omega-3 compared to that not containing flaxseed. The incorporation of flaxseed progressively increased the P/S ratio while the ω-6/ω-3 ratio decreased below the maximum recommended ratio. The fortification of biscuits with flaxseed progressively increased the calcium content.

Conflict of interest: The authors had no conflicts of interest to declare in relation to this article.

REFERENCES

1. Bernacchia R, Preti R, Vinci G. Chemical Composition and Health Benefits of Flaxseed. Austin J Nutri Food Sci. 2014;2(8):1-9.
2. Goyal A, Sharma V, Upadhyay N, Gill S, Sihag M. Flax and Flaxseed Oil: An Ancient Medicine & Modern Functional Food. J Food Sci Technol. 2014;51(9):1633-53.
3. Mridula D, Singh KK, Barnwal P. Development of Omega-3 Rich Energy Bar with Flaxseed. J Food Sci Technol. 2013;50(5):950-7.
4. Theobald HE. Dietary Calcium and Health. British Nutrition Foundation Nutrition Bulletin. 2005;30:237-77.
5. Giada Mde L. Food Applications for Flaxseed and Its Components: Products and Processing. Recent Pat Food Nutr Agric. 2010;2(3):181-6.
6. Horwitz W. Official Methods of Analysis of AOAC International. 17th ed. Gaithersburg, Md: AOAC International; 2000.
7. Pearson D. The Chemical Analysis of Food. 8th ed. London: Churchill JA; 1981.
8. Egan H, Kirk RS, Sawyer R. Pearson's Chemical Analysis of Foods. Edinburg, London, Melbourne and New York: Churchilli Livingstone; 1981.
9. Association of Official Analysis Chemists. Official Methods of Analysis. AOAC. 13th ed. Washington DC; 1984.
10. Hussain S, Anjum FM, Butt MS, Sheikh MA. Chemical Compositions and Functional Properties of Flaxseed Flour. Sarhad J Agric. 2008;24(4):649-54.
11. Abdel-Nabey AA, Abu–Tor ESM, Abou-Gharbia HA. Chemical and Technological Studies on Flaxseed (Linum usitatissimum) and Its Application in Some Functional Foods. J Food and Dairy Sci. 2013;4(5):193-216.
12. Herchi W, Bahashwan S, Sebei K, Saleh HB, Kallel H, Boukhchina S. Effects of Germination on Chemical Composition and Antioxidant Activity of Flaxseed (Linum usitatissimum L) Oil. Grasas y Aceites. 2015;66(1):1-8.
13. Kajla P, Sharma A, Sood DR. Flaxseed—A Potential Functional Food Source. J Food Sci Technol. 2015;52(4):1857-71.
14. Fazary NTAA, Younis YM. Seed Properties and Fatty Acid Composition of Flaxseed Oil (Linum usitatissimum). WJPPS. 2015;4(11):69-99.
15. Khattab RYI. Chemical and Technological Studies on Flaxseed to Improve its Sensorial and Nutritional Properties in Foods. Ph.D. Thesis, Fac. of Agric., Alexandria Univ., Egypt.; 2004.
16. Ganorkar PM, Jain RK. Flaxseed – a Nutritional Punch. IFRJ. 2013;20(2):519-25.
17. Gaafar AM, Header EA, El-Sherif FA, El-Dashlouty MS, El-Brollose SA. Sensory, Chemical and Biological Evaluation of Some Products Fortified by Whole Flaxseed. Egypt J Agric Res. 2010;88(1):257-71.
18. Ganorkar PM, Jain RK. Effect of Flaxseed Incorporation on Physical, Sensorial, Textural and Chemical Attributes of Cookies. IFRJ. 2014;21(4):1515-21.
19. Bashir S, Masud T, Latif A. Effect of Flaxseed (Linum usitatissimum) on the Baking Properties of Cakes and Cookies. IJAR. 2006;1(5):496-502.
20. Al-Marazeeq K. Chemical Characteristic and Sensory Evaluation of Biscuit Enriched with Wheat Germ and the Effect of Storage Time on the Sensory Properties for this Product. FNS. 2017;8:189-95.
21. Samuel M, S´ebastien V, Christine M, Martin M, Bernard M, Krista P. Flaxseed-Enriched Cereal-Based Products: A Review of the Impact of Processing Conditions. CRFSFS. 2014;13:400-12.
22. Rathi P, Mogra R. Sensory Evaluation of Biscuits Prepared with Flaxseed Flour. IJFANS. 2013;2(1):1-4.
23. Conforti F, Davis S. The Effect of Soya Flour and Flaxseed as a Partial Replacement for Bread Flour in Yeast Bread. Intl J Food Sci Technol. 2006;41(2):95-101.

24. Alpaslan M, Hayta M. The Effects of Flaxseed, Soy and Corn Flours on the Textural and Sensory Properties of a Bakery Product. J Food Qual. 2006;29:617-27.
25. Koca AF, Anil M. Effect of Flaxseed and Wheat Flour Blends on Dough Rheology and Bread Quality. J Sci Food Agric. 2007;87:1172-5.
26. Navickis LL, Nelsen TG. Mixing and Extensional Properties of Wheat Flour Doughs with Added Corn Flour. Cereal Foods World. 1992;37:30-5.
27. Chandel J. Development, Acceptability and Nutritional Evaluation of Linseed Flour Supplemented Value- Added Products. MD Thesis in Foods and Nutrition. College of Home Science of Haryana Agricultural University, Hisar. 2014.
28. Gambuś H, Gambuś F, Pastuszka D, Wrona P, Ziobro R, Sabat R, et al. Quality of Gluten-Free Supplemented Cakes and Biscuits. Int J Food Sci Nutr. 2009;60(4):31-50.
29. Burckhardt P. Calcium Revisited, Part III: Effect of Dietary Calcium on BMD and Fracture Risk. Bonekey Rep. 2015;4:708.
30. Allen L, Benoist B, Dary O, Hurrell R, eds. Guidelines on Food Fortification with Micronutrients. Geneva, World Health Organization and Food and Agricultural Organization of the United Nations. 2006.
31. Verma R, Prasad R, Gupta A. Functional Properties and Health Benefits in Flaxseed Fiber and Oil (Linum usitatissimum L.). International Journal of Home Science. 2017;3(1):368-9.
32. Mekebo D, Chandravanshi B. Levels of Essential and Non-Essential Metals in Linseed (Linum usitatissimum) Cultivated in Ethiopia. Bull Chem Soc Ethiop. 2014;28(3):349-62.
33. Passos M, Moreira C, Pacheco M, Takase I, Lopes M, Valente-Mesquita V. Proximate and Mineral Composition of Industrialized Biscuits. Food Sci Technol. 2013;33(2):323-31.