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Effect of flaxseed addition on the omega-3 fatty acid composition of pan bread and Arabic bread

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Abstract

Flaxseed being a useful source of ω-3 fatty acid (alpha linolenic acid, ALA)has been used as whole flaxseed and crushed flaxseed to develop acceptable quality functional food products, namely pan bread and Arabic bread. The addition of whole and crushed flaxseed 0%, 2%, 4%, 6%, 8% in all of these products with white wheat flour and wholegrain wheat flour had significant effect on their nutritional quality when compared with the control sample. In the flaxseed based products, the alpha linolenic acid was the predominant fatty acid followed by oleic acid and linoleic acid. The average of ω-3 alpha linolenic acid content in wholegrain wheat flour pan bread with crushed flaxseed ranged from 11.75 to 17.95% and with whole flaxseed ranged from 13.75 to 23.05%, when compared with wholegrain wheat flour control (3.55%). Average of ω-3 alpha linolenic acid content on wholegrain wheat flour Arabic bread with crushed flaxseed ranged from 20.0 to 26.75% and with the whole flaxseed it ranged from 27.1 to 38.65%, when compared with the wholegrain wheat flour control (4.0%). The research data presented in this report lends staunch support to the view that good-quality bread nutritionally rich in ω-3 and ω-6 fatty acids (e.g., linolenic, oleic, linoleic acid), can be produced successfully to provide health-promoting functional food products to the consumers.

Keywords: ω-3 fatty acids, flat bread, pan bread, crushed flaxseed, whole flaxseed

1. Introduction

Flaxseed is a small seed, the same size as a sesame seed, and is packed with many health-giving nutrients, which makes it in great demand among the health-conscious consumers, and more so for the oil [1,2]. Because of this, it has attracted the attention of many nutritionists and dietitians for it's contributions to a healthy diet for the maintenance of a healthy body, for the prevention of heart diseases and for the reduction of cancer risk[3]. As reported by Kaur et al., [4], flaxseed has been utilized in the production of functional foods, such as, bread, cakes and cookies. Gao et al [5] have investigated the use of flaxseed flour in producing Chinese steamed bread with desirable nutritional and sensory qualities. Although flaxseed is rich in proteins, minerals, phytochemicals, but is an excellent vegetarian source of ω-3 fatty acids, mainly the α-linolenic acid (ALA) which constitutes about 57% of the total fatty acids [6,7]. However, flaxseed proximate composition can vary appreciably with genetics, growing environment, seed processing and analytical method [8,9]. The chemical composition, extraction of bioactives present in flaxseed and their bioavailability has recently been reviewed by Yang et al., [10].

The ω–3 fatty acids have been shown to regulate gene transcription and expression, thus altering enzyme synthesis [11], and to modify several risks factors for coronary heart disease, including reducing serum triglycerides and blood pressure [12]. They also protect against thrombosis and certain types of cancer and modify immune and inflammatory reactions [13]. Essential fatty acids are required for maintaining the structure of cell membranes and the permeability of the skin, as precursors for eicosanoids, such as prostaglandins and thromboxanes, and in cholesterol transport and metabolism [14]. The ω-3 fatty acids are essential class of polyunsaturated fatty acid (PUFAs) derived primarily from fish oil.

Flaxseed is naturally low in saturated fat and provides a moderate amount of monounsaturated fat [1,6]. Roughly, 73% of the fatty acids in flaxseed are polyunsaturated. Flaxseed is particularly rich in alpha-linolenic acid (ALA), an ω-3 fatty acid [8,15]. In a recent review, Yu et al., [16] have examined the effect of microwave treatment on the chemical composition of flaxseed gums. According to them, microwave treatment resulted first in the cross linking of polysaccharide chains but then got degraded, affecting the molecular weight and phenolics. Removal of the phenolics improved the rheological and emulsifying properties of these flaxseed gums. Suri et al., [17] have investigated the influence of microwave roasting of flaxseed on the chemical composition, oxidative stability and fatty acid profile. The importance of ω-3 fatty acids in human health has prompted researchers to examine the role of these fatty acids in a number of diseases particularly in cardiovascular diseases [18]. The lignans specifically, have been reported recently for their anticancer benefits [19].

Obviously, the imbalance in n-6:n-3 ratio needs to be corrected, and the flaxseed used in commonly consumed foods will be of immense help in restoring this balance for the vegan food consumers. Considering the importance of flaxseed as a source of ω-3 fatty acids, the fatty acid composition of locally available flaxseed has been investigated and the results are presented here.

2. Materials and Methods

2.1. Raw materials

Wholegrain wheat flour (WGF) and white wheat flour (WWF) samples were collected from the Kuwait flour Mills & Bakeries Co. Shuwaikh. Fine granulated sugar, common salt, bakery shortening (Wesson, USA), whole flaxseed & crushed flaxseed, instant dry yeast, non–fat dry milk (NFDM) were produced from the local market. The diacetyl tartaric acid esters of mono- and diglycerides (DATEM) was provided free of cost by the American Ingredient Co. Kansas City, Missouri, USA.

2.2. Pan bread making procedure

For pan bread baking, optimized straight-dough bread making method (AACC method 10-10-B) was used for conducting all these baking trials [20]. Every bake was repeated 3-4 times and the average data of two best bakes was tabulated. For bread making, wholegrain wheat flour (WGF) and white wheat flour (WWF) were used as controls while varying levels of flaxseed (whole or crushed were added). The pan bread samples were prepared using the optimized breadmaking method of AACC (Method 10-10B, AACC, 2000), but with slight modifications [21]. The wholegrain wheat flour and white wheat flour was replaced with flaxseed at 2, 4, 6, 8% levels for pan toast breads, respectively. The amount of flour, with flaxseed used in these trials was calculated on 14% moisture content basis. After preliminary trials, the use of 0-8% flaxseed levels of vital 0.5% DATEM were optimized for producing bread samples of acceptable sensory quality. Water absorption was optimized by adding as much water as possible while still keeping the dough manageable to handle. The bread, immediately taking out of the oven, was weighed, and loaf volume was measured by the rapeseed displacement method [20].

2.3. Arabic bread making procedure

For Arabic bread making, wholegrain wheat flour (WGF) and white wheat flour (WWF) were used as controls with varying levels of flaxseed (whole or crushed). These breads were made as per the method reported earlier [21]. The WGF and WWF was replaced with flaxseed at 2, 4, 6, 8% levels for Arabic bread. The amount of flour and flaxseed used in these trials were calculated on 14% moisture basis. As explained above in the preliminary trials for pan bread, the use of 0-8% flaxseed levels and 0.5% DATEM were also optimized for the Arabic bread formulations.

2.4. Chemical analysis

The bread samples were freeze-dried and powdered in a Falling Number Mill (Model 3100, Sweden) to pass through a 100-mesh sieve, and stored in airtight containers in a refrigerator until required for further chemical analysis.

All the bread samples were analyzed for moisture (Method 44-19), crude protein (Method 46-12), total ash (Method 08-01), and crude fat (Method 30-25) using the standard methods (AACC, 2000), and the results are expressed on a moisture-free basis. The nitrogen content determined by the Kjedalhl method was converted into protein content using a conversion factor of N X 5.70. All analyses were done in triplicate, and the average values are presented. In addition, all the samples were analyzed, in duplicate, for fatty acid profiles using HP Gas Chromatograph, Flame Ionization Detector and column CP-Sil-88 Tailor Made FAME, 50M X 0.25mm (Chrompack7488) by using Fatty A-MTH method [22].

2.5. Statistical analysis

All of the chemical analyses were reported on % dry basis. The research data obtained were analyzed statistically for analysis of variance, and the mean values were evaluated for statistical significance (P = 0.05) using Duncan's New Multiple Range Test (SAS Program, Windows Version 6.08, ANOVA Procedure), and inferences were reported at the appropriate places[21]. For the results on the proximate analyses, the mean values are reported.

3. Results and Discussion

3.1. Chemical analyses

Bread from whole wheat flour and white flour having different percentage of whole and crushed flaxseed and emulsifiers were prepared in both (pan and flat breads). In this section, the result of fatty acid composition of pan bread and the Arabic bread made in a laboratory are presented. The data shown in Table 1 indicates that flaxseed when compared with both the wheat flours, was found to be very high in fat (29.06 ± 0.29), ash (3.52 ± 0.14) but low in protein contents (2.70 ± 0.11). As expected, the addition of flaxseed to the Arabic bread made either from the WWF or WGF, significantly increased the protein, ash and fat contents, but the showed insignificant increase in protein content in the WWF Arabic bread (Tables 2 and 3).

Table 1. Proximate analysis of raw materials (%, dry basis).

Type of raw material	Total ash	Crude fat	Crude protein
WWF	0.52^{d}±0.08	0.97^{c}±0.04	13.48^{a}±0.19
WGF	1.13^{c}±0.08	1.83^{b}±0.04	12.64^{a}±0.18
Crushed flaxseed	3.52^{b}±0.14	29.06^{a}±0.29	2.70^{b}±0.11
Whole flaxseed	4.31^{a}±0.02	--	2.95^{b}±0.90

Table 2. Proximate analysis of WWF Arabic bread with flaxseed added.

Type of Arabic bread	Total ash	Crude fat	Crude protein (N x 5.7)
WWF control	1.67^{b}±0.05	0.84^{c}±0.01	13.52^{a}±0.15
WWF +4% Crushed flaxseed+ 0.5% DATEM	2.14^{a}±0.15	1.59^{b}±0.03	13.20^{a}±0.07
WWF +8% Crushed flaxseed+ 0.5% DATEM	2.26^{a}±0.20	2.77^{a}±0.04	13.14^{a}±0.42
WWF +4% Whole flaxseed+ 0.5% DATEM	2.19^{a}±0.19	1.82^{b}±0.03	13.17^{a}±0.09
WWF +8% Whole flaxseed+ 0.5% DATEM	2.29^{a}±0.09	2.92^{a}±0.04	13.07^{a}±0.09

Table 3. Proximate analysis of WGF Arabic bread with flaxseed added.

Type of Arabic bread	Total ash	Crude fat	Crude protein (N x 5.7)
WGF control	2.39^{b}±0.28	0.93^{c}±0.02	12.92^{c}±0.04
WGF +4% Crushed flaxseed+ 0.5% DATEM	$2.92^{a\text{-}b}$±0.27	2.05^{b}±0.05	12.15^{b}±0.13
WGF +8% Crushed flaxseed+ 0.5% DATEM	3.09^{a}±0.17	3.96^{a}±0.03	12.01^{b}±0.03

WGF +4% Whole flaxseed+ 0.5% DATEM	3.05^{a}±0.10	2.37^{b}±0.03	12.19^{b}±0.20
WGF +8% Whole flaxseed+ 0.5% DATEM	3.12^{a}±0.27	4.03^{a}±0.08	12.27^{b}±0.17

3.2. Fatty acid profiles

The detailed fatty acid profiles of the fat extracted from the pan bread and Arabic bread are presented in Tables 4 and 5, respectively. Crushed flaxseed used in the study had the highest content of linolenic acid (C18:3) amounting to about 49%, followed by oleic acid (C18:1) about 24.6%, and linoleic acid (C18:2) of about 13.25%. In case of both the pan and Arabic breads, the palmitic, oleic, and linoleic acids showed significant decreases, but linolenic and stearic acids increased significantly with the addition of both the crushed and whole flaxseeds. As the flaxseed is rich in linolenic acid, the increased linoleic acid contents in both the pan and Arabic breads can be attributed to the addition of crushed and whole flaxseed to the white wheat flour and the wholegrain wheat flour Arabic breads.

Table 4. Effect of flaxseed addition on the total fatty acid profile of pan bread.

Sample description	C14%	C16%	C18%	C18:1%	C18:2%	C18:3%	C20%
WWF control	0.35	21.05	2.4	37.7	35.35	2.4	0.3
WWF + 4% crushed flaxseed+ 0.5% DATEM	0.3	18.75	6	31.95	28.5	13.9	0.55
WWF + 8% crushed flaxseed +0.5% DATEM	0.25	17.1	5.9	27.35	28.6	20.0	0.5
WGF control	0.3	20.75	2.35	35.5	36.7	3.55	0.55
WGF+4% crushed flaxseed+ 0.5% DATEM	0.3	18.9	3.7	33.4	31.4	11.75	0.25
WGF+8% crushed flaxseed + 0.5% DATEM	0.25	17.75	3.85	31.45	28.2	17.95	0.3
WWF + 4%Whole flaxseed + 0.5% DATEM	0.3	18.55	6.6	33.75	26.55	13.65	0.25
WWF + 8% Whole flaxseed+0.5% DATEM	0.2	15.8	4.45	32.55	24.7	21.65	0.45
WGF+ 4%Whole flaxseed + 0.5% DATEM	0.15	18.3	3.9	32.9	30.3	13.75	0.45
WGF+ 8%Whole flaxseed + 0.5% DATEM	0.2	17.7	5.2	33.6	15.55	23.05	0.4

Table 5. Effect of flaxseed addition on the total fatty acid profile of Arabic bread.

Sample description	C14%	C16%	C18%	C18:1%	C18:2%	C18:3%	C20%
WWF control	1.5	22.55	3.6	31.35	35.3	4.4	2.55
WF4% crushed flaxseed+ 0.5% DATEM	0.3	15.6	12.05	22.85	19.3	29.9	0.25
WWF 8% crushed flaxseed+0.5% DATEM	1.55	12.65	9.55	24.45	17.55	33.9	0.2
WGF Control	ND	19.75	2.15	36.2	35.4	4	2.6
WGF + 4%crushed flaxseed + 0.5% DATEM	0.45	17.3	9.7	26.3	26.05	20	0.05
WGF + 8%crushed flaxseed + 0.5% DATEM	0.1	12.85	10.8	24.95	23.15	26.75	1
WWF + 4%Whole flaxseed + 0.5% DATEM	0.5	15.35	13.05	18	19.3	33.7	0.2
WWF + 8%Whole flaxseed + 0.5% DATEM	0.15	6.1	16.05	24.85	18.9	33.1	0.4

WGF + 4%Whole flaxseed + 0.5% DATEM	0.15	15	(9.6	25.2	22.4	27.1	0.15
WGF + 8%Whole flaxseed + 0.5% DATEM	ND	10.2	8.95	25.1	15.95	38.65	0.1

The pan breads (Table 4) had no significant difference in the oleic acid contents. Linoleic acid decreased slightly in the whole flaxseed and crushed flaxseed from the WWF bread (control) and the wholegrain wheat bread (control). The flaxseed being extremely rich in alfa-linolenic acid (ALA), significantly increased the ALA contents in the WWF pan bread both with the addition of crushed as well as whole flaxseed. In case of Arabic bread, quite similar results were obtained, ALA being creased significantly with the addition of both the crushed and whole flaxseed (Table 5). Obviously, the addition of flaxseed to both the pan bread as well as Arabic bread is an excellent way of increasing the ω-3 fatty acid contents for improving their nutritional quality. Over the last few decades, the nutritional significance of essential fatty acids, including the ω-3 fatty acids is getting immense importance among the health professionals [8]. Fatty fish, such as, salmon, mackerel and tuna are considered as the best sources of ω-3 fatty acids [23], for achieving the most important strategy for improving and maintaining human health. The ratio of saturated fatty acids (SFA) to polyunsaturated fatty acids (PUFA) is considered one of the most important influencers of cardiovascular diseases and the oxidative stress indicators [24, 25]. According to them, the quality of lipids present in foods is a good indicator of nutritional quality and their influence on the development of coronary diseases. Considering such nutritional and health effects, vegan food consumers are now looking for vegetarian sources of ω-3 fatty acids, and interestingly, flaxseed fits in very well for the development of health-promoting functional foods. Flaxseed flour when added to Chinese steamed bread at 10% level, it increased the resistant starch (a type of dietary fiber) to range from 34.89±0.80 to 54.64±0.23%, with a three-folds increase in total antioxidant capacity in the bread[5]. The results in this study bring out a possibility of increasing the amounts of nutritionally important ω-3 fatty acids in pan bread and Arabic bread for promoting the production of health-promoting functional foods.

Conclusions

Flaxseed is known to be rich in several bioactive compounds, such as, proteins, minerals, dietary fiber, lignans and ω-3 fatty acids. The results of this study have shown that adding flaxseed either as crushed or whole grains, significantly increased the α-linolenic acid, which can be utilized by the human to produce certain amounts of docosahexaenoic acid and eicosapentaenoic acid. Crushed flaxseed showed the highest content of alpha linolenic acid (C18:3) amounting to about 49%. With the addition of crushed flaxseed at 8% level to WWF, the ALA content was 20% and 33.9% in pan bread and Arabic bread, respectively. However, with the addition of crushed flaxseed at 8% level to WGF, the ALA content was 17.95% and 26.75% in pan bread and Arabic bread, respectively. Thus, the objective of producing pan bread and Arabic bread rich in ω-3 fatty acids was achieved to offer health-promoting functional baked products to the consumers.

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Author contributions

All authors contributed to the research. Jameela Al-Sager conceived the research idea and carried out the fatty acid analysis, Dr. Fatimah wrote the last version of the manuscript, Mohammad Al-Foudari conducted the proximate analyses, Prof. Sidhu initially guided the research team, Ms. Amani carried out the statistical analyses of research data. All the authors have read and approved the final manuscript for submission to this journal.

Conflict of interest

The authors do not have any conflict of interest.

Ethical approval

No ethical approval is required for this work.

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