SENSORY, CHEMICAL AND BIOLOGICAL EVALUATION OF SOME PRODUCTS FORTIFIED BY WHOLE FLAXSEED

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(Manuscript received 16 December 2010)

Abstract

The purpose of this study was to develop a mainstream food item using whole flaxseed and test the consumer acceptability, chemical and biological evaluation of the products. Chemical composition of flaxseed showed that contents of moisture was (7.06 %), protein (24.87 %), fat (39.64 %), crude fiber (8.74%), ash (3.51 %) and total carbohydrate (23.19 %). Flaxseed oil was have high content of unsaturated fatty acids. oleic acid (17.11%), linoleic acid (15.56%) and linolenic acid (58.68 %). Sensory evaluation of (pan bread-pizza-Tahina) showed that all were acceptable of eating qualities. Also, results showed that addition of flaxseed to wheat flour by 15% increased the protein content, fat, fiber, and ash. Meanwhile, the content of carbohydrates was decreased in the bread and pizza. Carbohydrates increased and fat decreased for Tahina 50% flaxseed. Data indicated that feed efficiency ratio of rats fed on diets containing flaxseed products were higher than rats fed on diets without flaxseed and results indicated also that, the diets containing flaxseed decreased concentration of serum total cholesterol compared to diet with no flaxseed. Flaxseed diet increased the level of serum HDL-C while serum LDL-C and VLDL-C significantly decreased.

Key word: Flaxseed, Chemical composition, Flaxseed oil, Pan Bread, Pizza, Tahina, Biological Evaluation.

INTRODUCTION

Flaxseed *(Linum unisatissimum)* has a history of food use in Europe and Asia. In the US, until the early 1990s flaxseed had been incorporated at low levels in some brands of cereal, bread, and other bakery products. However, during the past decade, potential health benefits associated with consumption of flaxseed and flaxseed meal have become more prominent. These potential health benefits include anticancer effects, antiviral and antibactericidal activity, anti-inflammatory effect, ion reduction, laxative uses, and reduction of atherogenic risks (Jenkins et al., 1999, Yamashita et al., (2003).

Flaxseed food products have been found with increasing frequency in supermarkets and health food stores all over the some country. Increased consumption of flaxseed products by everyone, including pregnant women, is anticipated due to these potential health benefits. The major constituents of flaxseed are oil (36%), protein (24%), and fiber (32%). Historically, flaxseed has been prized for its oil, called linseed oil, which is used in industrial applications. Most of the protein is concentrated in flaxseed meal, a by-product of the flaxseed- crushing industry (Arafat et al.,2008). Flaxseed is one of the richest plant sources of the n-3 fatty acid, α-linolenic acid (ALA), and the richest source of secoisolariciresinol diglycoside (SDG). SDG, a lignan precursor, is converted by the bacterial flora of the human colon to two major mammalian lignans, enterodiol and enterolactone, found in the biological fluids of humans and animals (Sylvie Dodin ET AL., 2008).

Thus, this study aimed to throw light on the chemical composition of flaxseed as well as to process some untraditional new foods from these seeds which may be prepared under home conditions or commercially such as (bakery and other oilseeds products), also this study includes investigation of biological effects of flaxseed on hypercholesterolemic rats.

MATERIALS AND METHODS

2.1. Materials

Flaxseeds (2007 year of production) were obtained from Agricultural Research Center, Oil Crops Department, Giza, Egypt. Wheat flour (82%), corn oil, eggs, salt, sugar, instant dry yeast, green pepper, tomato, mozzarella cheese, black olive, tomato sauce, ground black pepper and sesame seeds were obtained from the local market of Shibin El-Kom, Minufiya.

2.2. Methods

2.2.1. Chemical analysis:- The contents of moisture, crude oil, crude protein (N x 6.25), crude fiber and total ash of flaxseed and their products were determined as described in A.O.A.C. (2000). The carbohydrate content was calculated by difference.

2.2.2. Fatty acid composition:- The methyl esters of crude oil were prepared according to Chalvardjian (1964), using 1% of H_2SO_4 in absolute methyl alcohol. A Perkin-Elmer gas chromatography (Model F22) with a flame ionization detector was used in the presence of nitrogen as a carrier gas. A glass column (2 m x 2.5 mm) packed with Chrom Q 80/100 mesh at a temperature of 270°C was used. Standard fatty acids methyl esters were used for identification. The area under each peak was measured and the precentage expressed in regard to the total area.

2.2.2. Technological methods

2*.2.2.1. Preparation of flaxseeds:-* The seeds were dry cleaned to remove dust and undesirable materials. After cleaning, the seeds were roasted at 150°C for 15 min in an electric oven. Then the seeds were grounded and kept stored at 4°C until used.

2*.2.2.2. Preparation of sesame seeds:-* Sesame seeds were cleaned to remove dust and undesirable materials, washed with tap water, the seeds were toasted in an electric oven for 3 hours at 150°C. Finally, the toasted sesame were grind in an electric grinding mill until Tahina produced.

2*.2.2.3. Preparation of some bakery products:-* Flaxseeds powders were added to wheat flour (82 extraction) for making products, the different ingredients used in preparation pizza and toast bread are shown in table (1), provided that several formulae were tested and the best one presented.

2.2.2.3.1. Pan bread preparation:- Pan bread prepared according to the formula shown in the table (1). The flour 82% (fortified with 10, 15 and 20% flaxseed powder) added to sugar, salt and yeast then mixed together by hand to form homogeneous mass. The mixing was continued until the dough had as smooth texture (mixing time was 10 min). Dough was left to ferment for 30 min then put in oblongtray and left for arrest period of 15 min. Then dough baked in gas oven at 220°C for 30 min.

2.2.2.3.2. Pizza preparation:- Pizza is prepared as home made method, using the wheat flour (72%). Flaxseeds powder was added at the percentages of 10, 15 and 100% on the account of flour, oil and eggs are added with yeast and sugar, finally little salt and water were incorporated to holding dough. The dough is formed, left to ferment for 30 minute, and then cut into round pieces. Slices of tomato, cheese, green pepper, tomato sauce with little from milled black pepper and black olive formed the cover of surface. The covered dough disc was then baked at 225°C for 30 min in gas oven.

4.2.2.3.3. Tahina preparation:- Tahina is pressed from sesame seeds. There are two types of Tahina, red and white according to colour and kind of used sesame (Saba, 1991). Toasted sesame seeds and toasted flaxseeds were mixed at the percentages 25, 50, 75 and 100 %, then ground in an electric mill until Tahina formed.

4.2.3. Sensory evaluation

4.2.3.1. Pan bread

The sensory evaluation of the produced pan bread including:- Pan bread was organoleptically evaluated for appearance, crust colour, crumb colour, crumb texture, taste, and odour. A hedonic scale of 1 to 7 was used, 1 = poor and 7 = excellent according to the methods described by Gaafar (2005).

2.2.3.2. Pizza:- Sensory evaluation of control and experimental samples of pizza was carried out by aid of 10 panalists in the Faculty of Home Economics, Minufiya University for: 1) texture, 2) aroma, 3) taste, 4) colour and 5) overall acceptability using hedonic scale as follows:1 to 7 was used, 1 = poor and 7 = excellent

2.2.4. Biological experiments

2.2.4.1. Animals:- Forty-eight male albino rats of Sprague Dawley strain weighting (110 . 122 g) distributed on 8 groups (6 rats each). All rats were housed in well aerated cages under hygienic condition, and fed on basal diet for one week for adaptation in the Animal House of Food Technology Research, Institute, Agricultural Research Center, Giza, from which also the rats were obtained.

2.2.4.2. Basal diet:- The basal diet (Campbell, 1963) consisted of (12%) casein (protein source), (10%) corn oil, (0.25%) choline chloride, (1.0%) vitamin mixture, (4.0%) salt mixture, (5.0%) cellulose, (10%) sucrose, and the remainder is corn starch (57.75%).

2.2.4.3. Experimental design:- After feeding on the basal diet, rats were divided into 2 main groups. The first main group: (6 rats) fed on basal diet as control negative (control). The second main group: (42 rats) fed on hypercholesterolemic diet for 2 weeks (basal diet supplemented with 1% cholesterol + 10% sheep tail fat + 0.25% cholic acid). The later main group was then divided into 7 groups (6 rats each). The first group was feed on the hypercholesterolemic diet for 4 weeks and considered as positive control group. The second (group 2) and third (group 3) were fed on dried bread control and dried bread with 15% flaxseed meal. The fourth (group 4) and fifth (group 5) were fed on dried Margarita pizza and dried Margarita pizza with 15% flaxseed meal. The sixth (group 6) and seventh (group 7) were fed on Tahina (100% sesame) and Tahina with 50% flaxseed.

4.2.5. Biochemical analysis

4.2.5.1. Determination of lipid profile:- Total cholesterol, Serum tricylglyceride, Total lipids High density lipoprotein (HDL) in the plasma were determined according to the method of **(Allain and Poon, 1974), Fredrickson *et al.,* (1967), Toro and Ackerman (1975) and Burstein (1970)** by a quantitative enzymatic colorimetric method using standard kit.

Low density lipoprotein cholesterol (LDL-cholesterol) was calculated according to the method of Lee and Nieman (1996) using the following formulae:

$$VLDL = TG / 5$$

$$LDL = TC - (VLDL + HDL)$$

2.6. Statistically analyzed:- Data were statistically analyzed according to **Snedecor and Cocheran (1980).**

RESULTS AND DISCUSSION

3.1. Chemical composition of whole flaxseed

Data presented in table (1) show the chemical composition of flaxseed on dry weight basis. It could be noticed that the whole flaxseed is rich in fat, protein and fiber. The moisture content of whole flaxseed was 7.06%. Meanwhile, the protein content was 24.87%, the fat content 39.69%, crude fiber 8.74%, ash 3.51% and total carbohydrate 23.19%, respectively. In this respect, EL-kady, Eman (1995) determined the chemical composition of linseed, and found that, the moisture, fat, protein, crude fibers and ash were 5.12, 39.19, 21.17, 4.86 and 5.50%, respectively. This finding may focus the interest of utilizing flax as a high protein source in some food formulation. Generally, the value of fat content was higher than those reported by Mahgoob, Magda (2008) and slightly lower than that reported by Arafat *et al.,* (2008).

Table 1. Chemical composition of whole flaxseed (on dry weight basis).

Components	%
Moisture	7.06±1.01
Oils	39.69±2.14
Protein	24.87±1.54
Carbohydrates	23.19±2.35
Ash	3.51±0.26
Fiber	8.74±0.57

3.2. Fatty acids composition of flaxseed oils

The fatty acids composition of flaxseed oil was investigated by gas liquid chromatography technique. The results obtained are tabulated in table (2). It could be observed that flaxseed oil was found to have high content of unsaturated fatty acids. From the obtained results it could be observed that the major fatty acids in flaxseed oil were linolenic acid C18:3 (58.68%), linoleic acid C18:2 (15.56%) and oleic acid C18:1 (17.11%). The fatty acid composition of flaxseed oil indicated that flaxseed oil rich in essential fatty acids, in particular the omega-3 fatty acids, and may replace sesame oil in Tahina making. Harper *et al.,* (2006) found that, the fatty acids composition in flaxseed oil were C18:3 (58.9%), C18:2 (17.9%), C18:1 (16.9%), C16:0 (6.91%) and C18:0 (3.90%), respectively.

Table 2. Fatty acids composition of flaxseed oils (%).

Fatty acids	%
Palmitoliec acid $C_{14:0}$	0.16
Palmitic acid $C_{16:0}$	5.43
Stearic acid $C_{18:0}$	3.06
Oleic acid $C_{18:1}$	17.11
linoleic acid $C_{18:2}$	15.56
linolenic acid $C_{18:3}$	58.68
Total saturated	8.65
Monounsaturated	17.11
Polyunsaturated	74.24
Total unsaturated	91.35

3.3. Sensory evaluation of products made from different levels of flaxseed replacement

3.3.1. Sensory evaluation of pan bread

The results concerning sensory evaluation of pan bread produced from different levels of flaxseed used are shown in table (3). It could be noticed from table (6) that pan bread samples made from 100% wheat flour was characterized with high acceptability for all parameters (6.56, 6.62, 6.54, 6.42, 6.80, and 6.94) with total score 39.88. However, from the same table (6) flaxseed used instead of wheat flour up to 15% gave somewhat similar scores provided that crumb grain score was very slightly less compared to the control sample. Therefore, from the above result it can be concluded that pan bread substitute samples 10 and 15% instead of wheat are suitable for using. Generally, these data agree well with Afaik and Munir (2007) who indicated that the sensory properties showed that an acceptable bread could be produced using flaxseed flour up to a level of 200 g / kg (20%).

Table 3. Sensory evaluation of fortified pan bread with flaxseed.

Parameters	control	pan bread with Flaxseed (%)		
		10	15	20
Appearance	6.56 ± 0.52^{a}	6.31 ± 0.46^{a}	6.16 ± 0.35^{a}	5.34 ± 0.53^{b}
Crumb texture	6.62 ± 0.63^{a}	6.54 ± 0.39^{a}	6.26 ± 0.48^{a}	4.75 ± 0.36^{b}
Crumb grain	6.54 ± 0.43^{a}	6.02 ± 0.48^{a}	5.88 ± 0.45^{a}	4.75 ± 0.40^{b}
Crust colour	6.42 ± 0.51^{a}	6.40 ± 0.55^{a}	6.21 ± 0.42^{ab}	5.32 ± 0.28^{b}
Taste	6.8 ± 0.60^{a}	6.24 ± 0.37^{a}	6.00 ± 0.52^{ab}	5.45 ± 0.39^{b}
Odour	6.94 ± 0.54^{a}	6.52 ± 0.61^{a}	6.16 ± 0.48^{a}	4.63 ± 0.31^{b}
Total score	39.88 ± 1.23^{a}	38.03 ± 1.08^{a}	36.67 ± 1.45^{ab}	30.25 ± 1.05^{b}

Means in the same raw with different letters are significantly different ($P \leq 0.05$).

3.3.2. Sensory evaluation of pizza

Table (4) represent sensory properties mean scores of pizza containing flaxseed at different levels of replacement. From this table it could be noticed that pizza made by 20% flaxseed replacement was decreased in all parameters tested (texture, aroma, taste, colour and overall acceptability) with total score of 38.7, being less when compared with control group (45.4), but was still acceptable (sample rated very good to good for different parameters). From the results of same table it could be noticed that pizza made at 10 and 15% flaxseed replacement gave more or similar less scores when compared with control (with total score 44.6, 43.8% and 45.4%, respectively). Montesano *et al.,* (2002) reported that, when samples covered with the toppings of pizza (sauce and cheese), the consumers could not detect a difference in the crust made with high gluten flour and high gluten flour with flaxseed.

Table 4. Sensory evaluation of fortified pizza with flaxseed.

Parameters	control	pizza with Flaxseed (%)		
		10	15	20
Texture	8.9±0.68[a]	8.5±0.76[ab]	8.3±0.44[ab]	7.1±0.43[b]
Aroma	9.3±0.73[a]	9.0±0.84[a]	8.8±0.67[a]	7.2±0.58[b]
Taste	9.2±0.65[a]	9.1±0.57[a]	8.9±0.53[a]	7.9±0.60[b]
Colour	8.9±0.71[a]	9.0±0.64[a]	8.9±0.65[a]	8.3±0.54[b]
Overall acceptability	9.1±0.66[a]	9.0±0.74[a]	8.9±0.64[a]	8.2±0.66[b]
Total score	45.4±1.57[a]	44.6±2.33[a]	43.8±1.86[a]	38.7±2.54[b]

Means in the same raw with different letters are significantly different ($P \leq 0.05$).

3.3.3. Sensory evaluation of Tahina

Average scores concerning sensory evaluation of Tahina produced from different seeds (sesame and flaxseed) are shown in table (5). It could be noticed from table (8) that Tahina sample made from 100% flaxseed was characterized with low acceptability according to taste, colour, texture, odour and overall acceptability with total score 24.2%. However, from the same table (8) flaxseed used instead of sesame seed up to 50% gave somewhat similar scores compared to the control. It is of great importance to conclude from the obtained results that flaxseed can be used instead of sesame seeds up to 50% in the making of Tahina substitute samples. Therefore, it is evident that Tahina substitution at 25 and 50% of sesame seeds are suitable for use, while samples made with 75 and 100% could not be recommended because lowest average scores.

Table 5. Sensory evaluation of fortified Tahina with flaxseed.

Parameters	control	Tahina with Flaxseed (%)			
		25	50	75	100
Taste	9.0±0.45[a]	8.7±0.38[a]	8.1±0.35[b]	6.8±0.49[bc]	5.5±0.44[c]
Colour	9.8±0.43[a]	9.3±0.45[ab]	8.3±0.52[b]	5.8±0.39[bc]	3.3±0.25[c]
Texture	9.5±0.25[a]	9.1±0.39[a]	8.5±0.67[ab]	7.0±0.53[b]	5.5±0.36[c]
Odour	9.0±0.40[a]	9.2±0.47[a]	9.1±0.59[ab]	6.3±0.51[b]	5.8±0.44[c]
Overall acceptability	9.3±0.48[a]	9.3±0.36[a]	8.7±0.61[ab]	6.2±0.45[b]	4.2±0.42[c]
Total score	46.6±1.54[a]	45.6±1.36[a]	42.7±2.24[ab]	32.1±2.35[b]	24.2±3.20[c]

Means in the same raw with different letters are significantly different ($P \leq 0.05$).

3.4. Chemical composition of the best products fortified with flaxseed

3.4.1. Pan bread

The changes in chemical composition of bread fortified with flaxseed at the level of 15% shown in table (6). Addition of flaxseed to wheat flour by 15% increased the protein content, fat, fiber and ash. Meanwhile, the content of carbohydrates was decreased in the bread substituted with 15% flaxseed. These results in accordance with the results of Pohjanheimo *et al.,* (2006) who showed that, analysis of chemical composition indicated that the flaxseed bread samples contained higher protein, fat, crude fibre and ash. This study has shown also that acceptable bread of higher nutritional value can be produced from linseed. Moreover, indicated that, the flaxseed rolls retained moisture and softness more efficiently than the control rolls that do not contain flaxseed. The flaxseed rolls were also high in fiber. Therefore, from a nutritional viewpoint flaxseed shows beneficial properties in bread making.

3.4.2. Pizza

The changes in chemical composition of pizza fortified with flaxseed at the level of 15% are shown in table (6). Addition of flaxseed to pizza at 15% level increased the protein content, fiber, fat and ash. The content of carbohydrates, however, was decreased in pizza fortified by 15% flaxseed. Gaafar (2005) reported that, the addition of hulled flaxseed (HF) and defatted flaxseed flour (FF) to cakes significantly increased all-chemical composition except the total carbohydrates.

3.4.3. Tahina

The chemical analysis in table (6) indicated some variations concerning the chemical composition of Tahina sesame (control) and Tahina substituted with 50% flaxseed. Addition of flaxseed to sesame seed to make Tahina increased the content of protein, fiber and total carbohydrates but, decreased ash and fat contents in Tahina made with 50% flaxseed. However, from above mentioned data it could be observed that there variation was not high between the chemical analysis of flaxseed Tahina and sesame Tahina. Therefore, the flaxseed Tahina may replace the sesame Tahina as a source of fat, protein and carbohydrates in salad and Halawa Tahiniya making.

Table 6. Effect of substitution by flaxseed on chemical composition of the best sensory evaluation sample of bread, pizza and Tahina products.

Samples	chemical composition				
	Protein	Fat	Crude fiber	Ash	Total carbohydrates
Bread					
Control	13.65±1.03[b]	3.51±0.46[b]	3.14±0.18[a]	1.31±0.31[b]	78.39±3.86[a]
Substitute 15%	15.59±1.36[a]	4.37±0.39[a]	3.96±0.20[a]	1.62±0.25[a]	74.46±3.41[b]
Pizza					
Control	14.0±1.56[a]	10.1±1.00[a]	2.5±0.08[b]	2.8±0.17[b]	70.6±2.05[a]
Substitute 15%	15.3±0.98[a]	11.0±0.95[a]	2.9±0.10[a]	3.1±0.21[a]	67.7±2.42[b]
Tahina					
Control	24.2±1.87[b]	58.0±3.14[a]	3.7±0.23[b]	3.1±0.25[a]	11.0±1.53[b]
Substitute 50%	26.1±1.54[a]	54.1±2.86[a]	4.1±0.11[a]	2.5±0.19[b]	13.2±1.87[a]

3.5. Biological evaluation of products

3.5.1. Effect of different products on lipids profile

The effect of different experimental products containing dried bread, (DB), dried bread 15% flaxseed, (DBF), dried pizza, (DP), dried pizza 15% flaxseed, (DPF), Tahina, (T) and Tahina 50% flaxseed (TF), on serum total cholesterol (TC), total lipids (TL) and triglycerides of hypercholesterolemic rats are shown in table (7). Feeding rats on hypercholesteromic diet for 28 days induced a significant increase ($p < 0.05$) in cholesterol levels. Feeding on experimental diets significantly decreased serum total cholesterol as compared to the positive control group. The diet containing dried bread DBF and dried pizza DPF containing 15% flaxseed decreased the level of TC more than the diets containing control dried bread and dried pizza groups. While, the hypercholesterolemic rats fed on Tahina 50% flaxseed led to significant differences in total cholesterol as compared to the hypercholesterolemic experimental diet. Yamashita et al., (2003) reported that, the flaxseed oil lowered plasma total cholesterol than defatted flaxseed and sesame seed. Generally, the diets containing flaxseed were more affecting on the concentration of serum total cholesterol than the same diet with no flaxseed.

Whole flaxseed contains approximately 40% fat. It is particularly rich in alpha-linolenic acid (about 57% of the total fatty acid) which has lipid-lowering properties. Thus, the reduction of blood cholesterol by different products containing flaxseed in these studies may be due in part to alpha-linolenic acid present in the seeds.

Bierenbaum et al., (1993) found that flaxseed supplementation in the form of either a flaxseed containing bread or 15 g of ground flaxseed resulted in significant reductions in serum total cholesterol in human subjects with hyperlipidemia. Also, Bhathena et al., (2002) found that total plasma cholesterol was lower by 41% ($p < 0.05$) in rats fed flaxseed meal and by 15% in rats fed soy protein.

Regarding the total lipids and triglyceride of serum for different groups of rats, results in the same table showed that, the total lipids of rats fed hypercholesterolemic diet was in high score (419.35 ± 6.89 mg/dl) and was significantly higher than in case of other groups of rats. On the contrary, rats fed on diets (DBF, DPF and TF) containing flaxseed were less in TL and TG than other groups fed on diets without flaxseed and showed significant difference. This low level of serum total lipids for three groups indicates about the effect of flaxseed as lowering lipid in rats blood. Furthermore, Tahina (sesame) exhibited the same manner in lowering lipid of rat serum, but was less effective compared with Tahina 50% flaxseed.

In this connection, the triglyceride of rat serum was scoped in the same way as total lipids which was at high concentration for hypercholesterolemic group, at low concentration for groups fed diets containing flaxseed (DBF, DPF and TF) and was in moderate state for the other groups. However, values were at very low concentrations for the normal rat which fed on basel diet. These data agree well with that of Bhathena et al., (2002) who found that, the diet content 20% flaxseed significantly reduced triglyceride level in F 344 rats with normal lipid levels as well as in obese SHR/N-CP rats with marked hyperlipidemia. Gaafar (2005) reported that hypercholesterolemic rats fed diet containing cakes fortified with hulled flaxseed showed a significant reduction in triglyceride level.

Table 7. Effect of different diets on total cholesterol (TC), total lipids (TL) and triglycerids (TG) of hypercholesterolemic rats (n = 6 rats).

Groups	Parameters (mg / dl)		
	TC	TL	TG
Control (-ve)	$89.71^{f} \pm 2.56$	$265.46^{e} \pm 8.53$	$93.05^{f} \pm 3.15$
Hypercholesterolemic (+ve)	$160.44^{a} \pm 4.08$	$419.35^{a} \pm 6.89$	$184.80^{a} \pm 4.97$
Dried bread (DB)	$139.65^{b} \pm 3.64$	$397.56^{b} \pm 4.04$	$132.67^{b} \pm 4.35$
Dried bread+15% flaxseed (DBF)	$123.52^{c} \pm 3.82$	$387.40^{bc} \pm 5.52$	$124.52^{c} \pm 4.28$
Dried pizza (DP)	$142.24^{b} \pm 4.05$	$396.17^{b} \pm 4.15$	$136.54^{b} \pm 4.09$
Dried pizza+15% flaxseed (DPF)	$115.16^{d} \pm 2.96$	$367.19^{c} \pm 4.54$	$115.64^{d} \pm 3.98$
Tahina sesame (T)	$127.59^{c} \pm 3.17$	$298.54^{d} \pm 2.76$	$113.65^{d} \pm 4.12$
Tahina 50% flaxseed (TF)	$106.94^{e} \pm 2.78$	$271.82^{e} \pm 4.97$	$105.80^{e} \pm 3.85$

Means in the same column with different letters are significantly different ($P \leq 0.05$).

3.5.2. Effect of different products on Lipoprotein cholesterol fractions

The effect of different experimental diets containing dried bread, (DB), dried bread 15% flaxseed, (DBF), dried pizza, (DP), dried pizza 15% flaxseed, (DPF), Tahina, (T) and Tahina 50% flaxseed (TF), on serum lipoprotein fractions (HDL, LDL and VLDL) of hypercholesterolemic rats are shown in table (7). HDL concentrations were significantly increased ($p < 0.05$) in the serum of rats fed all experimental diet except diet containing dried pizza control as compared to the hypercholesterolemic control group (increase was insignificant). On the other hand, all tested diets resulted in significant decrease ($p < 0.05$) as compared to the negative control except the hypercholesterolemic rats fed diet containing Tahina 50% flaxseed as it was 53.84 ±3.13 mg/dl.

These data may be due to the level of flaxseed in Tahina content. Flaxseed is rich source of lignans, with potential weak estrogenic and antiestrogenic activity similar to that of the isoflavones found in soy. If lignans block androgen or progesterone receptors, they may alter the cardiovascular disease risk profile by changing HDL-cholesterol metabolism (Thompson, 1998). On the other hand, Bierenbaum et al., (1993) showed no change in HDL cholesterol in human subject with hyperlipidemia when fed on bread containing flaxseed.

Table 8. Effect of different diets on lipoprotein fractions of hypercholesterolemic rats (n = 6 rats).

Groups	Parameters (mg / dl)		
	HDL-C	LDL-C	VLDL-C
Control (-ve)	54.73a ± 3.25	16.37^{f} ±1.08	18.61^{d} ±1.37
Hypercholesterolemic (+ve)	42.27^{c} ± 2.98	86.45^{a} ± 2.56	36.96^{a} ± 1.96
Dried bread (DB)	46.38^{b} ± 3.04	70.85^{b} ± 3.14	26.53^{b} ± 1.70
Dried bread+15% flaxseed (DBF)	39.12^{d} ± 2.71	52.24^{d} ± 3.06	24.90^{bc} ± 1.90
Dried pizza (DP)	45.19^{b} ± 2.97	75.81^{b} ± 2.97	27.31^{b} ± 2.03
Dried pizza+15% flaxseed (DPF)	53.84^{b} ± 3.13	46.84^{e} ± 2.05	23.13^{bc} ± 1.85
Tahina sesame (T)	56.84^{a} ± 3.13	51.02^{c} ± 2.96	22.73^{c} ± 1.76
Tahina 50% flaxseed (TF)	37.03^{d} ± 2.64	28.94^{f} ± 2.15	21.16^{c} ± 1.54

Means in the same column with different letters are significantly different ($P \leq 0.05$).

Concerning LDL, the concentration was 16.37 ± 1.08 mg/dl for the normal rats and 86.45 ± 2.56 mg/dl for the positive control group. Feeding experimental diets significantly decreased the concentration of LDL as compared to the hypercholesterolemic rat group. It is clear that, LDL concentration of hypercholesterolemic rat fed on dried pizza containing 15% flaxseed was lower than group rat fed on dried bread containing 15% flaxseed, its may be due to the higher feed intake. It could be noticed that serum LDLcholesterol for rats fed on Tahina 50% flaxseed diet (28.94 ± 2.15 mg/dl) was significantly decreased as compared to hypercholesterolemic rat fed on control Tahina (51.02 ± 2.96 mg/dl) and significantly increased when compared to the negative control group. The components of flaxseed to which health benefits have been ascribed as LDL lowering, include its high contents of lignans and vegetable protein, (Jenkins et al., 1999). These authors showed that, the defatted flaxseed reduced serum concentration of LDL cholesterol due to α-linolenic acid and soluble fiber, which may possess the mentioned effect. Generally, these data agree with those obtained by Gaafar (2005) who found that, LDL cholesterol decreased when hypercholesterolemic rats fed on cake content flaxseed.

Feeding hypercholesterolemic groups on experimental diets caused significant decreases ($p < 0.05$) in VLDL concentration, compared to control positive. The highest decrease VLDL was reported for the group of rats fed on diet containing Tahina control and Tahina 50% flaxseed. Serum very low-density lipoprotein was calculated as TG/5, so the decrease of triglyceride led to reduced concentration of VLDL. Bhathena et al., (2002) reported that plasma triglyceride was reduced by 37% in rats fed flaxseed meal and by 19% in rats fed soy protein.

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الخواص الحسية و الكيميائية والبيولوجية لبعض المنتجات المدعمة ببذور الكتان الكاملة

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الغرض من هذه الدراسة هو تنمية وتدعيم بعض المنتجات الغذائية ببذور الكتان واختبار القبول لدى المستهلكين كذلك تقييم تلك المنتجات كيميائيا وبيولوجيا. اظهر التركيب الكيميائي للبذور الكتان ان محتوى الرطـــوبة كانت (7.06 ٪) ، البروتين (24.87 ٪) ، والدهون (39.64 ٪) ، والألياف الخام (8.74 ٪) ، رماد (3.51 ٪) والكربوهيدرات مجمــــ وع (23.19 ٪). بينما يحتوى زيت بذور الكتان على نسبة عالية من الاحماض الدهنية غير المشبعة حمض الأوليك (17.11 ٪) ، وحمض اللينوليك (15.56 ٪) وحمض اللينولينيك (58.68 ٪). اظهر التقييم الحسي لل(الخبز- بيتزا – الطحينة) المدعمة ببذور الكتان قبولا حسيا. كذلك ، أظهرت النتائج أن إضافة بذور الكتان إلى دقيق القمح بنسبة 15 ٪ ادى الى زيادة محتوى البروتين والدهون والألياف والرماد. وفي الوقت نفسه ، فقد انخفض محتوى النشويات في الخبز والبيتزا. بينما اظهرت النتائج زيادة محتوى الكربوهيدرات وانخفاض محتوى الدهون للطحينة المصنوعة من 50 ٪ بذور الكتان. تشير النتائج إلى أن نسبة كفاءة تغذية الفئران التي تغذت على المنتجات الغذائية التي تحتوي على بذور الكتان كانت أعلى من الفئران التي تغذت على وجبات بدون بذور الكتان وأشارت النتائج إلى أن الوجبات الغذائية التي تحتوي على بذور الكتان ادت الى انخفاض مستوى تركيز مصل الكوليسترول مقارنة بالمنتجات الخالية من الكتان. كذلك وجد ان المنتجات التى تحتوى على بذور الكتان ادت الى زيادة فى مستوى الليبوبروتين عالية الكثافة (HDL) ، بينما وجد انخفاض كلٍ من الليبوبروتين منخفضة الكثافة (LDL) و الليبوبروتين منخفضة الكثافة جدا (VLDL).