ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 45(3): 1111-1126, (2007).

BIOLOGICAL EVALUATION OF OMEGA-3 AND 6 POLYUNSATURATED FATTY ACIDS OF FLAX AND SESAME SEEDS AND ITS UTILIZATION IN PREPARING HIGH-RATIO LAYER CAKE

BY

Keshk, Y.F.M.; Abdel-Razik, M.M. and Ashoush, I. S.
Food Sci. Dept., Fac. of Agric., Ain Shams Univ., Cairo, Egypt.

ABSTRACT

The major fatty acids in extracted lipids from flaxseed and sesame seeds were alfa linolenic acid (C18:3 n3) and linoleic acid (C18:2 n6), respectively. The fatty acid profile was completely enhanced by mixing flaxseed and sesame oils at the ratio of 2:1, respectively. Flaxseed, sesame oils and their mixture at the ratio of 2:1, respectively were used to replace the shortening at 25, 50, 75 and 100% levels in high ratio layer cakes. Sensory evaluation of prepared cakes revealed that, using of sesame, flaxseed oils or their mixture as shortening replacers at 50, 75 or 75 % respectively significantly ($p<0.05$) improved the sensory characteristics of cakes compared to control sample (100% shortening).

Also, hypercholestroemic rats were fed on diets containing 75, 50 and 75 % of flaxseed, sesame oils and their mixture (2:1), respectively, it was found that, the animal fed on diets prepared by supplementation of saturated palm oil with the aforementioned unsaturated fatty acids sources significantly ($p<0.05$) reduced the body weight gain compared to control and high saturated fat groups. As well as, the flaxseed, sesame oils and their mixture improved the lipid profile compared to control and high fat group. Furthermore, the flaxseed oil provided protection from hepatocellular damage.

Key words: Flaxseed oil, sesame oil, omega-3, omega-6, cake, organoleptic evaluation, hypolipidemic and rats.

INTRODUCTION

Abnormal lipid metabolism is a main cause of dyslipidemia, which is a major risk factor for cardiovascular disease, obesity, cholesthiasis and overall mortality (Rizvi *et al.*, 2003). The concentration of plasma cholesterol can be regulated by cholesterol biosynthesis, removal of cholesterol from the circulation, absorption of dietary cholesterol and excretion of cholesterol via bile and feces (Choi *et al.*, 2001). It is well known that diet plays an important role in the control of cholesterol homeostasis. Winston, (1999) reported that herbs have been used as food and for medicinal purpose for hyperlipidemia that may be useful adjuncts in reducing the risk of cardiovascular disease and alterations in liver metabolism.

Recent studies have demonstrated that ingestion of polyunsaturated fatty acids (ω-3 and ω-6), present in vegetable oils, is inversely related to the incidence of heart disease by decreasing cholesterol and triacylglycerol plasmatic levels (Simopoulos, 1999). Cintra, *et al.*, (2006) reported that total cholesterol levels in rats fed the polyunsaturated fatty acids (flaxseed diet) were lower than in rats fed the saturated fatty acid (chicken skin diet). Flaxseed contains 32–45% of its mass as oil of which 51–55% is alpha-linolenic acid (ALA) (18:3 n-3 Omega-3 fatty acid), a precursor to eicosapentanoic acids (EPA). Flaxseed oil (FO) is one of the vegetable sources of ALA and its content ranges from approximately 40% to 60% of the total fatty acids (Prasad, 2000). FO (1 g) contains alfa linolenic acid (ALA) 550 mg, linoleic fatty acid (170 mg), palmitic acid (60 mg), stearic acid (40 mg) and oleic acid (180 mg). ALA, found in FO desaturates and elongates in the human body to EPA and docosahexanoic acid (DHA) and by itself may have beneficial effects in health and in control of chronic diseases (Mantzioris *et al.*, 1994). Effect of flaxseed oil on growth parameters and lipid metabolism of rats fed on high fat diet was investigated by Devi *et al.*, (2006). The high fat diet resulted in significant alterations in hepatic lipids, increase in body weight gain and negative effect on lipoprotein metabolism. Flaxseed oil supplementation lowered the increase in body weight gain, liver weight, plasma cholesterol, triglycerides, phospholipids, free fatty acids, high-density lipoprotein (HDL), low-density lipoprotein-cholesterol (LDL-C), very low-density lipoprotein (VLDL), LDL/HDL and TC/HDL ratio in high fat diet fed rats. Clinical conditions such as cardiovascular disease, blood pressure, cancer, skin diseases and immune disorders such as renal failure, rheumatoid arthritis and multiple sclerosis may be prevented by ALA in flaxseed oil (Kelley *et al.*, 1991). The n-3 PUFAs in FO have anti-inflammatory properties that are mediated by the production of anti-inflammatory eicosanoids (Cohen *et al.*, 2005). Hasler *et al.*, (2000) demonstrates that the flaxseed is a functional food that has recently gained attention in the area of ASCVD prevention because it contains alpha linolenic acid (ALA). Flaxseed and flaxseed oil have been cited as potentially useful foods by the American Heart Association.

Recently research has been conducted on the effect of dietary ALA on hepatic cholesterol metabolism in the hamster model (Morise *et al.*, 2004). However, little is known about the effects of flaxseed oil on hepatic lipid metabolism in rat model, it is therefore of interest to conduct research in this line.

Chena *et al.*, (2005) Reported that the diet with sesame significantly decreased the levels of serum total cholesterol and LDL cholesterol and slightly reduced the levels of thiobarbituric acid–reactive substances in LDL in 21 hyperlipidemic patients. The time for erythrocyte hemolysis and the lag phase of LDL oxidation were significantly increased by sesame ingestion. The mechanism by which a diet containing 24% sesame oil reduces levels of serum and liver cholesterol, liver LDL cholesterol, and liver lipids is not known. However, the high degree of unsaturation (85%) of sesame oil and the presence of linoleic acid may be important factors (Satchithanandam *et al.*, 1996).

Satchithanandam *et al.*, (1996) determined the total cholesterol, LDL-cholesterol, HDL-cholesterol, triglyceride, and Liver cholesterol levels in Wistar rats (75-100 g) which fed on a control diet or a diet containing 12 or 24% sesame oil. All previous parameter levels were significantly lower in rats fed on the 24% sesame oil diet, compared with those of in the control group. When hypercholestrolemic rats were fed on diets containing alpha-linolenic acid of linseed oil or linolenic acid of sesame seeds it was found that linseed oil were effective for lowering the cholesterol as compared to sesame oil Cintra, *et al* (2006).

The objective of the current study was to prepare cake with different levels of flaxseed, sesame oils or their mixture as shortening replacers, and to determine the best replacement levels. Also, to examine the effects of selective levels from flaxseed, sesame oils or their mixture on hyperlipidemia by determining the changes of plasma lipid levels, lipoprotein cholesterol levels and hepatic lipids in high fat diet fed rats.

MATERIALS AND METHODS

Materials

Flaxseed and Sesame oils were procured from the Research Department, Field Oils. Research Institute, Agriculture Research Center, Ministry of Agriculture, Giza, Egypt.

Liver functions, total cholesterol, total triglyceride kits were purchased from Biodiagnostic, Co. Egypt. High density lipoprotein, Low Density Lipoprotein kits were purchased from Biosystem, Spain.

Flour (72% exteraction), whole fresh egg, sucrose, shortening, fresh milk, baking powder, vanilla and salt (sodium chloride) were purchased from local market.

Male albino rats (Wister strain), with an initial body weight of 150 g were obtained from Organization of Biological Products and Vaccines, Helwan farm, Egypt.

Methods

Fatty acid profile

Fatty acid profile of extracted lipids was estimated according to AOAC (2000).

Animals experiment and diets

Twenty five albino rats were housed in screen-bottomed aluminum cages in room maintained at 25 ± 1°C with alternating cycles of light and dark of 12h; duration. Rats were randomly allocated into two groups, the first group (normolipidemic) contained five animals and the second group (hyperlipidemic) contained twenty animals with a noticeable mark on their tails as a mean of differentiation. In the normolipidemic group, rats were fed on normal diet. In the hyperlipidemic group, rats were forward to be hypercholesterolemic by feeding a hypercholesterolemic diet.

After arising the cholesterol level to ≥ 240 mg/dl, the hypercholesterolemic rats were divided into four groups (with five rats each) to be fed on the experimental diets. One group received a high-fat (HF) diet of 10% palm oil, 6% cholic acid, and 30% lard. The other groups received diets similar to the HF diet, but with lipids provided by flaxseed (FP), sesame oil (SP) or their combination (MP) to replace the palm oil. Corn starch and protein contents of the diets were adjusted to maintain isocaloric diets (Table 1), and the changes in body weight were recorded ones every week. Blood samples were also obtained from the retro-orbital plexus of the eyes from all animals of each group on 10, 20 and 30 days, after which rats were slaughtered at the end of the experiment for organ weight.

Table (1): Composition of experimental diets (%) fed to the investigated male albino rats.

Composition %	Control	Types of Diets			
		HF	FP	SP	MP
Corn starch	65	50	50	50	50
Casein	15	15	15	15	15
Palm Oil	10	10	2.5	5	2.5
Mineral mixture	4	4	4	4	4
Vitamin mixture	1	1	1	1	1
Cellulose	5	5	5	5	5
Lard	--	14.8	--	--	--
Cholic acid	--	0.2	--	--	--
Flaxseed oil	--	--	7.5	--	5
Sesame oil	--	--	--	5	2.5

HF, High fat; FP, 75% Flaxseed oil with 25% Palm oil; SP, 50% Sesame oil with 50% Palm oil; MP, 75% Mixture of Flaxseed and Sesame oil (2:1) with 25% Palm oil

Cake preparation

High-ratio layer cake was prepared according to AACC (1983). The cake batter was formulated from 100 g flour, 60 g whole fresh egg, 140 g sucrose, 50 g shortening, 110 g fresh milk, 9 g baking powder, 2 g vanilla and 1.6 g salt (sodium chloride). Shortening and sucrose powder were creamed together until light for 5-10 min. Flour and baking powder were mixed together, then the mixture were added gradually to shortening, sucrose, egg, vanilla, salt, milk mixture and beaten for 3 min. using the mixing machine at low speed. The batter was scaled at 375 g into each of two 20 cm diameter pans and baked at 175 °C for 25 min. After baking cakes were left to cool for 1 hr at room temperature until analysis. For evaluating the effect of different oil types, shortening used in cake making was partially replaced by 25, 50, 75 and 100 % of sesame, flaxseed oils and their mixture.

Sensory evaluation

High-ratio layer cakes were evaluated for cells, grain, texture, crumb color and flavor according to AACC (1983).

Biochemical analysis

Liver functions

The activities of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were determined colorimetrically according to the method adopted by Reitman and Frankel (1957), using special Biodiagnostic kits, (Egypt).

Total cholesterol

Enzymatic determination of total cholesterol was carried out according to the method of Allain (1974).

Total triglyceride

Enzymatic determination of total triglycerides in plasma was measured colorimetrically at 546 nm. according to the method of Fossati and Principe (1982).

Low Density Lipoprotein

Low Density Lipoprotein (LDL) in the tested samples was precipitated with polyvinyl sulphate. Its concentration was calculated from the difference between the serum total cholesterol and the cholesterol in the supernatant after centrifugation. The cholesterol was measured according to the method of Assmann, *et al.* (1984).

High density lipoprotein

Very low density lipoprotein (VLDL) and low density lipoprotein in the tested samples were precipitated with phosphotungstate and magnesium ions. The HDL was measured according to the method of Burstein, *et al.* (1980).

Statistical analysis procedure

Internal organs weight, AST and ALT data were subjected to statistical analysis using t-test. Other obtained data was exposed to analysis of variance. The analysis was carried out using the PROC ANOVA procedure. Duncan multiple ranges at 5 % level of significance was used to compare between means. Results followed by different alphabetical letters were significantly differed. All procedures were subjected using Statistical Analysis System program (SAS, 1996),

RESULTS AND DISCUSSION

1. Fatty acid composition of flaxseed, sesame and its mixed oils

Figure (1) presented the fatty acid pattern of lipids extracted from flaxseed and sesame oils and their mixture. The major fatty acid in extracted lipids from flaxseed was alfa linolenic acid (C18:3 n3). On the other side, the linoleic acid (C18:2 n6) was the main fatty acid in extracted lipid from sesame seed. The percent of C18:3 n3 and C18:2 n6 in flaxseed and sesame oils were 55.04 and 43.20 %, respectively. The fatty acid profile was enhanced with mixing the flaxseed and sesame oils at the ratio of 2:1, respectively. The balance between C18:3 n3 and C18:2 n6 was observed in the mixture however, their percent was achieved to 36.8 and 26.3 %, respectively. The obtained results are agreed with Baba, *et al.* (2000) and Cintra, *et al.* (2006)

2. Effect of oil types on sensory characteristics of cake

Results in Table (2) presented the sensory properties mean score values of cake samples prepared by partially using replacement of shortening with sesame, flaxseed oils or their mixture. The results showed that, there were no significant differences ($p>0.05$) in cell characteristics (uniformity, size and thickness), grain, moistness, softness and flavor of prepared cake samples contained 25 and/or 50 % of sesame oil as fat replaces compared to control cake sample which prepared using 100 % shortening. The same trend could be also noticed in prepared cake samples using flaxseed oil as fat replacer with the same substituted levels for the same characteristics. While, the flavor in sample prepared using 75 % flaxseed oil appeared no significant difference ($p>0.05$) compared to the control. On the other hand, tenderness and crumb color of prepared cake samples were significantly ($p<0.05$) improved compared to the control cake sample. Using the mixture of both flaxseed and sesame oils (2:1) as shortening replacer appeared no significant differences in cell characters grain, softness and flavor of cake crumb samples at levels of 25, 50 and 75 % compared to the control sample. While, the moistness, tenderness and crumb color were significantly ($p<0.05$) improved compared to the control sample. From the same Table it could be noticed that, cake samples prepared by replacing 100% shortening by sesame, flaxseed oils and their mixture was significantly affected on the flavor of cake samples in comparison with control sample.

In conclusion it could be reported that, using of sesame, flaxseed or their mixture oils as a shortening replacers at 50, 75 or 75 % respectively improved the sensory characteristics of cakes. Therefore, there levels were used in the nutritional experiment.

3. Effect of FP, SP and MP oils on the body and internal organs weight of male albino rats:

Body weight gain of animals fed on HF diet significantly increased as compared to those fed on the normal diet. Animals fed on diets supplemented as replacer with unsaturated fatty acids oils (flaxseed, sesame and their mixture) significantly reduce the body weight gain compared to control and HF groups. No statistically changes were noted between groups fed on FP, SP and MP diets (Fig. 2). This trend has also been reported for humans (Almario *et al.*, 2001). The hypothesized that the content of polyunsaturated fatty acids compared to that of saturated fatty acids may decrease body weight and that the lipid intake type may stimulate satiety (Hill *et al.*, 1993).

Statistical analysis ($P<0.05$) of the data in Table (3) revealed no significant differences in the relative weights of the considered internal organs of different rats groups. The only exception was observed in liver weight that showed significant increase in animals fed on HF diet. This unexpected result may be due to cholesterol deposition in the liver of HF group compared with others group.

4. Biochemical analysis of the blood plasma of male albino rats:

4.1. Liver Function parameters:

Data in Tables (4 & 5) indicated that high fat diet induced significant elevation in aspartate aminotransferase (AST) and alanine aminotransferase (ALT) enzymes in plasma over the experimental period. Conversely, no detectable hepatocellular enzyme leakage as assessed by an increase in aspartate aminotransferase, alanine aminotransferase in the high-PUFA flaxseed, sesame oil and their combinations groups. Furthermore, the flaxseed oil provided protection from hepatocellular damage as evidenced by a decrease in the decline rate in liver function and a reduction in hepatocellular injury; these findings are in agreement with the results obtained by Vijaimohan *et al.* (2006).

4.2. Lipid profiles:

The fat enriched diet is regarded as an important factor in the development of cardiac diseases since it leads to the development of hyperlipidemia, atherosclerosis and abnormal lipid metabolism (Onody *et al.*, 2003).

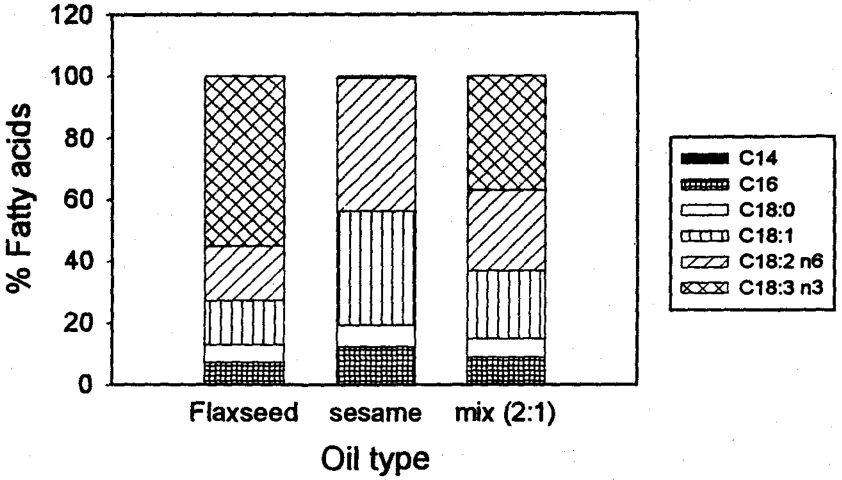

Fig. (1): Fatty acid composition of flaxseed, sesame oils and their mixture at 2:1

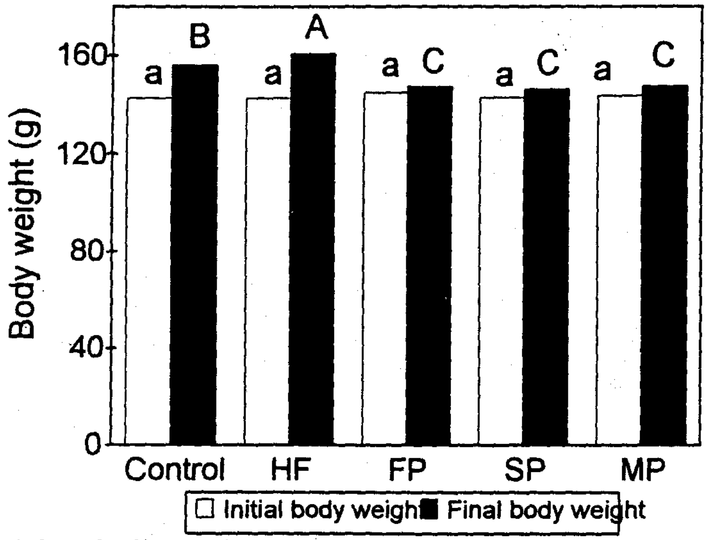

Fig. (2): Effect of different oil types on body weight (gm) of rats.

4.2.1 Triglycerides

Plasma triglyceride levels (mg/dl) are shown in Table (6). It could be noticed that, the total plasma triglycerides after 10 days was significantly ($p<0.05$) lowest in animals fed on the FP, MP and SP diets compared with animals fed on control diet. While, no other difference in triglycerides level was observed in animals fed on HF diet compared with the control group. The same trend was observed between animal groups over the experimental period; with increase the fed period the triglyceride level decreased in all groups except animals fed on HF diet. While, the animals fed on the FP, MP and SP diets showed the lowest triglyceride levels without any significant differences over the experimental period ($p<0.05$). Triglyceride in the blood tend to damage vascular endothelial cells, leading to heart disease (Suprijana *et al.*, 1997). High fat diet produces an increase in triglyceride levels due to lipoprotein lipase triglyceride hydrolysis, so that the accumulation in the liver becomes more evident (Feoli *et al.*, 2003). While; the effect of ALA in the flaxseed oil could be attributed to a reduction in the hepatic synthesis of fatty acid, which decreases the concentration of triglyceride in the liver. Prasad (2000) and Baba *et al.* (2000) reported that flaxseed oil lowers triglyceride levels in high fat diet fed rats, which might be due to the increased activity of adipose tissue lipoprotein lipase. Moreover, in the male hamster model the hypotriglyceridemic effect of flaxseed oil is well documented (Morise *et al.*, 2004). This view is paralleled in our study also by decreased triglyceride levels in animals fed on FP diet which could be due to lipid lowering effect of flaxseed (Chan *et al.*, 1991). Baba *et al.* (2000) reported that rats fed on high fat diets containing olive oil increased serum triglyceride concentrations compared with rats fed on sesame oil diet.

Table (2): Mean values of sensory characteristics of cake prepared using flaxseed, sesame oils or its mixture.

Treatment		Cells			Grain	Texture			Crumb color	Flavor	Overall Acceptability
		Uniformity	Size	Thickness of walls		Moistness	Tenderness	Softness			
Scores		10	10	10	20	10	20	10	10	10	110
Control		10.0^{a}	9.3^{a}	8.6^{a}	16.0^{a}	8.0^{ab}	11.3^{b}	8.6^{a}	8.0^{b}	10.0^{a}	89.8
Sesame oil	25 %	10.0^{a}	10.0^{a}	10.0^{a}	16.0^{a}	9.3^{ab}	13.3^{a}	9.3^{a}	10.0^{a}	10.0^{a}	97.9
	50 %	10.0^{a}	10.0^{a}	10.0^{a}	15.6^{a}	10.0^{a}	14.0^{a}	10.0^{a}	10.0^{a}	8.0^{a}	97.6
	75 %	8.6^{a}	9.3^{a}	8.6^{a}	14.0^{a}	10.0^{a}	14.0^{a}	10.0^{a}	10.0^{a}	2.0^{b}	86.5
	100 %	4.6^{b}	8.6^{a}	3.3^{b}	8.6^{b}	7.3b	14.0^{a}	10.0^{a}	10.0^{a}	1.0^{b}	67.4
Control		10.0^{a}	9.3^{a}	8.6^{a}	16.0^{a}	8.0^{b}	11.3^{b}	8.6^{a}	8.0^{b}	10.0^{a}	89.8
Flaxseed oil	25 %	10.0^{a}	10.0^{a}	10.0^{a}	16.0^{a}	9.3^{a}	13.3^{a}	9.3^{a}	10.0^{a}	10.0^{a}	97.9
	50 %	10.0^{a}	10.0^{a}	10.0^{a}	16.0^{a}	10.0^{a}	14.0^{a}	10.0^{a}	10.0^{a}	10.0^{a}	100
	75 %	10.0^{a}	10.0^{a}	10.0^{a}	16.0^{a}	10.0^{a}	14.0^{a}	10.0^{a}	10.0^{a}	9.3^{a}	99.3
	100 %	10.0^{a}	9.3^{a}	10.0^{a}	13.3^{a}	10.0^{a}	14.0^{a}	10.0^{a}	10.0^{a}	4.3^{b}	90.9
Control		10.0^{a}	9.3^{a}	8.6^{a}	16.0^{a}	8.0^{b}	11.3^{b}	8.6^{a}	8.0^{b}	10.0^{a}	89.8
Flaxseed: sesame (2:1)	25 %	10.0^{a}	9.3^{a}	8.6^{a}	16.0^{a}	9.3^{a}	12.6^{a}	9.3^{a}	10.0^{a}	10.0^{a}	95.1
	50 %	10.0^{a}	10.0^{a}	10.0^{a}	16.0^{a}	10.0^{a}	14.0^{a}	10.0^{a}	10.0^{a}	9.3^{a}	99.3
	75 %	10.0^{a}	10.0^{a}	10.0^{a}	16.0^{a}	10.0^{a}	14.0^{a}	10.0^{a}	10.0^{a}	8.6^{a}	98.6
	100 %	4.6^{b}	7.3^{b}	8.3^{b}	8.0^{b}	6.0^{c}	14.0^{a}	10.0^{a}	10.0^{a}	5.3^{b}	73.5

Different alphabets are significantly at $P<0.05$.

Table (3): Effect of different oils on some internal organs weight (g/100g b.wt.) in male albino rats.

Organs	Organs weight (g/100g b.wt.) after 45 days				
	Control	HF	FP	SP	MP
Liver	2.01 ±0.208	2.91*±0.139	2.42±0.029	2.46±0.064	2.37±0.133
Kidney	0.67 ±0.109	0.89 ±0.012	0.86±0.111	0.85±0.034	0.85±0.004
Lung	1.08 ±0.060	0.88 ±0.039	1.00±0.005	1.02±0.051	0.87±0.041
Spleen	0.38 ±0.056	0.33 ±0.018	0.27±0.006	0.32±0.007	0.32±0.021
Heart	0.40 ±0.016	0.50 ±0.029	0.37±0.030	0.38±0.012	0.41±0.025
Testes	2.92 ±0.112	2.27 ±0.350	2.30±0.026	2.39±0.459	2.66±0.255

* Statistical significant differences ($P<0.05$)

Table (4): Effect of treatment with different Oils on AST (U/L) in male albino rats.

Treatment	AST activity (U/L) at the indicated post-treatment (days)		
	10	20	30
Control	10.6 ± 2.5	13.0 ± 5.8	20.5 ± 1.4
HF	16.5 ± 4.0*	19.9 ± 3.2*	25.3 ± 5.3*
FP	9.5 ± 0.7	22.6 ± 7.3	16.2 ± 2.5
SP	10.8 ± 1.8	12.5 ± 1.5	19.5 ± 2.2
MP	6.4 ± 1.9	11.1 ± 5.8	14.8 ± 3.1

HF, High fat; FP, 75% Flaxseed oil with 25% Palm oil; SP, 50% Sesame oil with 50% Palm oil; MP, 75% Mixture of Flaxseed and Sesame oil (2:1) with 25% Palm oil
* Statistical significant differences ($P<0.05$)

Table (5): Effect of treatment with different Oils on ALT (U/L) in male albino rats.

Treatment	ALT activity (U/L) at the indicated post-treatment (days)		
	10	20	30
Control	10.6 ± 1.6	11.8 ± 1.2	12.3 ± 0.9*
HF	24.1 ± 1.5*	21.0 ± 0.6*	21.6 ± 1.8*
FP	5.7 ± 1.1	10.9 ± 1.8	8.0 ± 1.4
SP	9.2 ± 2.0	11.8 ± 1.2	10.1 ± 1.6
MP	15.0 ± 1.8	8.7 ± 1.2	11.8 ± 1.6

HF, High fat; FP, 75% Flaxseed oil with 25% Palm oil; SP, 50% Sesame oil with 50% Palm oil; MP, 75% Mixture of Flaxseed and Sesame oil (2:1) with 25% Palm oil
* Statistical significant differences ($P<0.05$)

4.2.2 Total cholesterol

Animals fed on the FP diet showed the significantly ($p<0.05$) lowest levels of plasma total cholesterol after ten days of treatment (Table 7). On the contrary; the animals fed on the HF diet showed the statistically highest levels of serum total cholesterol compared to animals fed on SP and MP diets over the experimental period. Serum total cholesterol levels were decreased after 20 and 30 days, its levels in animals fed FP, SP and MP diets were significantly ($p<0.05$) lower than those of the animals fed on control and HF diets. The decrease of plasma cholesterol by administration of flaxseed oil was ascribed to the decrease of both free and esterified cholesterol (Wiesenfeld *et al.*, 2003). ALA rich flaxseed oil results in a higher cholesterol secretion into bile, leading to a depletion of the intrahepatic pool of cholesterol, and thus to an increase in cholesterol synthesis and turnover (Morise *et al.*, 2004). Moreover, ALA rich diet reduces hepatic lipid accumulation both by stimulating β-oxidation and by suppressing fatty acid synthesis (Murase *et al.*, 2005). All these mechanisms may account for the better regulation of hepatic lipid metabolism by flaxseed oil. On the other hand, the mechanism of sesame oil is difference. The serum total cholesterol levels were reduced after 4 weeks of sesame supplementation (Chen *et al.*, 2005). The hypolipidemic effect from sesame oil might be related to the amounts of sesamin or unsaturated fatty acids (Tsai *et al.*, 2004). Hirata *et al.*, (1996) reported that daily oral intake of sesamin in hypercholesterolemic patients for 4 weeks significantly decreased total cholesterol concentrations. In hyperlipidemic rats, dietary supplementation with sesamin reduced plasma and liver total cholesterol concentration (Kamal-Eldin *et al.*, 2000). In the rat, the mechanism for the hypocholesterolemic effect of sesamin is believed to be related to inhibition of intestinal absorption of cholesterol, increased excretion of cholesterol into bile, and decreased activity of 3-hydroxy-3-methylglutaryl coenzyme A reductase (Hirose *et al.*, 1991). The content of fatty acid may be associated with this effect because unsaturation has been reported to be inversely related to serum cholesterol levels. The γ-linolenic fatty acid (C18:3) in flaxseed oil may also be associated to its cholesterol-lowering property, according to Cintra, *et al.*, (2006),

Table (6): Effect of different oils on plasma triglycerides level (mg/dl) in male albino rats at the indicated (days).

Treatment	Triglycerides (mg/dl) level at the indicated (days)		
	10	20	30
Control	104.3 ±17.4^{a}	96.8 ±2.7^{b}	97.4 ±12.5^{a}
HF	113.0 ±3.0^{a}	116.5 ±11.4^{a}	115.3 ±11.8^{a}
FP	77.1 ±10.2^{b}	74.2 ±7.2^{c}	73.6 ±8.8^{b}
SP	84.6 ±4.4^{b}	78.2 ±7.6^{c}	75.9 ±7.8^{b}
MP	81.1 ±9.0^{b}	76.5 ±4.6^{c}	74.2 ±8.2^{b}

HF, High fat; FP, 75% Flaxseed oil with 25% Palm oil; SP, 50% Sesame oil with 50% Palm oil; MP, 75% Mixture of Flaxseed and Sesame oil (2:1) with 25% Palm oil
Letters compared between the means in the same column.
Different alphabets are significantly at $P<0.05$.

Table (7): Effect of different oils on plasma total cholesterol level (mg/dl) in male albino rats at the indicated (days).

Treatment	T. Cholesterol (mg/dl) level at the indicated (days)		
	10	20	30
Control	103.0 ±16.6^{ab}	97.8 ±.31^{a}	95.6 ±.37^{b}
HFD	105.2 ±4.6^{a}	106.3 ±3.6^{a}	108.1 ±3.6^{a}
FP	70.9 ±1.8^{c}	63.4 ±.25^{b}	64.7 ±4.3^{c}
SP	80.8 ±21.3^{abc}	77.1 ±15.0^{b}	68.4 ±1.3^{c}
MP	72.6 ±.31^{bc}	64.4 ±4.9^{b}	63.5 ±.74^{c}

HF, High fat; FP, 75% Flaxseed oil with 25% Palm oil; SP, 50% Sesame oil with 50% Palm oil; MP, 75% Mixture of Flaxseed and Sesame oil (2:1) with 25% Palm oil
Letters compared between the means in the same column.
Different alphabets are significantly at $P<0.05$.

4.2.3 LDL and HDL cholesterol

Effect of oils type that used in preparation of animal diets on LDL-cholesterol levels is presented in (Table 8). No differences were observed in plasma LDL-cholesterol levels between treated animal groups after 10 days. At the end of experimental period, the LDL levels were significantly decreased reaching to lower levels in tested plasma for animals fed on diet prepared using FP, SP and MP with. Conversely, high fat diet showed the highest levels of low-density lipoprotein

Table (8): Effect of different oils on plasma LDL-cholesterol level (mg/dl) in male albino rats at the indicated (days).

Treatment	LDL (mg/dl) level at the indicated (days)		
	10	20	30
Control	127.1 ±55.0[a]	113.3±24.4[ab]	94.7 ±2.1[b]
HFD	142.1 ±6.2[a]	140.8 ±22.6[a]	144.2 ±6.5[a]
FP	86.3 ±17.2[a]	82.2 ±12.6[b]	78.8 ±9.2[b]
SP	87.9 ±20.0[a]	88.7 ±19.8[b]	80.6 ±29.1[b]
MP	87.3 ±2.0[a]	85.1 ±18.7[b]	78.7 ±4.9[b]

HF, High fat; FP, 75% Flaxseed oil with 25% Palm oil; SP, 50% Sesame oil with 50% Palm oil; MP, 75% Mixture of Flaxseed and Sesame oil (2:1) with 25% Palm oil
Letters compared between the means in the same column.
Different alphabets are significantly at $P<0.05$.

No significant differences ($p<0.05$) were observed in HDL-cholesterol levels between the control and HF groups. While, animals fed on the HF showed the lowest HDL-cholesterol levels than animals fed on FP, SP and MP diets (Table 9) with significant difference ($p<0.05$). Plasma levels of HDL are important predictors for the development of premature cardiovascular disease. HDL-cholesterol has been indicated as a positive factor in determining the development of atherosclerosis (Miller and Miller, 1997). The hypolipidemic effect of ω-3 polyunsaturated fatty acid decreases the LDL hepatic secretion (Kawahara *et al.*, 1997). Hyperlipidemic subjects fed with flaxseed and sesame oil had a significant reduction in LDL-cholesterol without a reduction in HDL-cholesterol (Bierenbaum *et al.*, 1993; Kaminskas et al., 1991; Jenkins *et al.*, 1999; Kamal-Eldin *et al.*, 2000). The obtained data are agreed with those of Mahfouz and Fred, 2000. They reported that, in high fat diet group, hyperlipidemia is accompanied by an increase in the secretion of LDL, which leads an increase in cholesterol.

Table (9): Effect of different oils on plasma HDL-cholesterol level (mg/dl) in male albino rats at the indicated (days).

Treatment	HDL (mg/dl) level at the indicated (days)		
	10	20	30
Control	41.1 ±1.1[a]	45.6 ±1.1[a]	42.2 ±7.8[ab]
HFD	40.1 ±0.1[a]	36.1 ±0.5[b]	37.1 ±7.3[b]
FP	43.6 ±8.4[a]	48.1 ±8.5[a]	52.8 ±3.9[a]
SP	46.5 ±4.9[a]	47.5 ±5.1[a]	53.7 ±2.6[a]
MP	45.2 ±1.0[a]	47.4 ±0.5[a]	52.7 ±2.3[a]

HF, High fat; FP, 75% Flaxseed oil with 25% Palm oil; SP, 50% Sesame oil with 50% Palm oil; MP, 75% Mixture of Flaxseed and Sesame oil (2:1) with 25% Palm oil
Letters compared between the means in the same column.
Different alphabets are significantly at $P<0.05$.

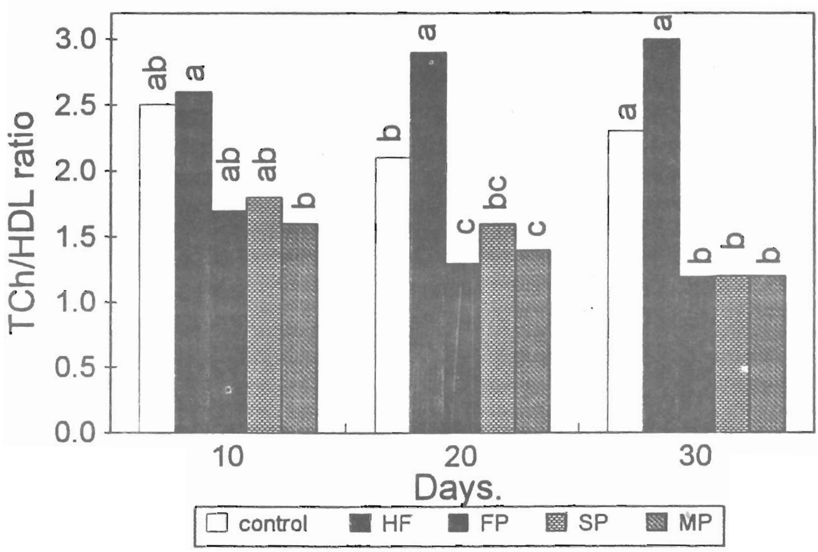

Fig. (3): Effect of different oil types on total cholesterol (TCh)/HDL-cholesterol ratio in male albino rats at the indicated (days).

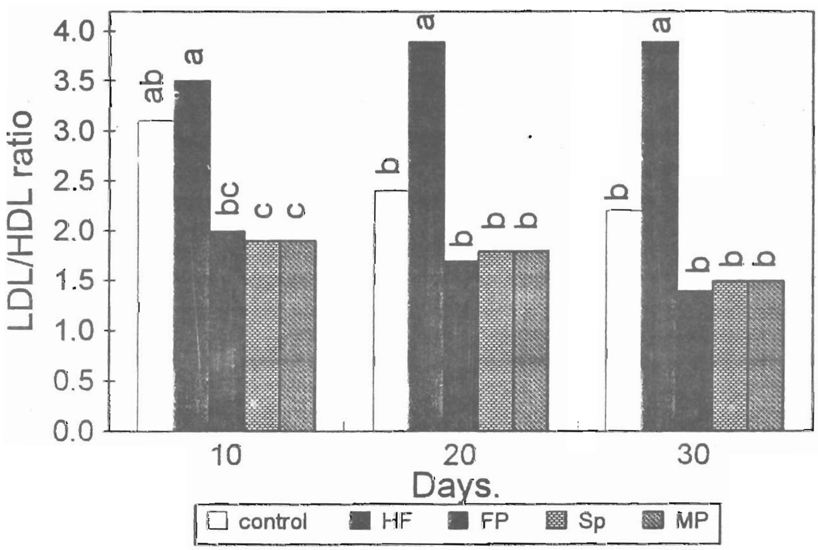

Fig. (4): Effect of different oil types on LDL/HDL-cholesterol ratio in male albino rats at the indicated (days).

4.2.4 Total cholesterol/HDL-cholesterol ratio

The plasma total cholesterol/HDL-cholesterol ratio in the control and experimental animals are shown in Figure (3). The ratio was significantly increased ($p<0.05$) after 10 day in animal fed on HF diet while decrease statistically in animal fed on FP, SP and MP diets. However, this ratio was decreased with progressing the experimental period to low values in animals fed on FP, SP and MP with significant difference ($p<0.05$) compared to control and HF diet groups. On the other hand, same trend was observed in the LDL/HDL- cholesterol ratios. However, this ratio was significantly ($p<0.005$) decreased in animals fed on FP, SP and MP compared to HF diet animals. These findings are presented in Figure (4) and agree with Ide *et al*., 2003; Vijaimohan *et al*., 2006.

Total cholesterol/HDL-cholesterol and LDL/HDL- cholesterol ratios are also predictors of coronary risk (NCEPEP, 1994). A significant increase in total cholesterol/HDL-cholesterol and LDL:HDL- cholesterol ratios were observed in high fat fed rats that has an effect on cardiovascular diseases. Flaxseed and sesame oils may inhibit the apolipoprotein B synthesis or increased its catabolism, which explained the reduction of these ratios in FP, SP and MP animals. ω-3 and ω-6 fatty acids rich diets resulted in significant decrease of a number of proatherogenic factors, such as LDL- cholesterol and LDL/HDL- cholesterol (Morise *et al*., 2004).

REFERENCES

AACC (1983): Approval Methods of the American Association of Cerial Chemsts. 8th Ed., st. Panl, MN.USA.

Allain, C.C. (1974): Enzymatic colourimetric method of the determination of plasma total cholesterol. Clin. Chem. 20: 470.

Almario, R.U.; Vonghavaravat, V.; Wong, R. and Kasim-Karakas, S.E. (2001): Effects of walnut consumption on plasma fatty acids and lipoproteins in combined hyperlipidemia. Am. J. Clin. Nutr., 74: 72-81.

AOAC (2000): Official Methods of Analysis. 17th Ed. Association Official Agriculture Chemists, Washington, D.C.

Assmann, G.; Jabs, H.U.; Kohnert, U.; Nolte, W.and Schriewer, H. (1984): LDL_Cholesterol determination in blood serum following precipitation of LDL with polyvinlysulfate. Clin. Chim. Acta 140:77-83.

Baba, N.H.; Ghossoub, Z. and Habbal, Z. (2000): Differential ffects of dietary oils on plasma lipids, lipid peroxidation and adipose tissue lipoprotein lipase activity in rats. Nutrition Research, Vol. 20, No. 8, 1 I I3- I 123

Bierenbaum, M.I.; Reichstein, R. and Watkins, T.R. (1993): Reducing atherogenic risk in hyperlipidemic humans with flaxseed supplementation: a preliminary report. Journal of American College of Nutrition 12 (5), 501–504.

Burstein, M.; Scholnick, H.R. and Morfin, R. (1980): Rapid method for the isolation of lipoprotein from human serum by precipitation with polyanions. Scand J. Clin Lab Invest; 40: 583-595.

Chan, J.K.; Bruce, V. M. and Mc Donald, B.E. (1991): Dietary alpha linolenic acid is as effective as oleic acid and linolenic acid in lowering blood cholesterol in normolipidemic men. Journal of American College of Nutrition 53 (5), 1230–1235.

Chen, P.R.; Chien, K.L.; Su, T.C.; Chang, C.J.; Liu, T.L.; Cheng, H. and Tsai, C. (2005): Dietary sesame reduces serum cholesterol and enhances antioxidant capacity in hypercholesterolemia. Nutrition Research 25, 559–567.

Chena, P.R.; Chienc, K.L.; Suc, T.C.; Change, C.J.; Liua, T.L.; H.C. and Tsai, C. (2005): Dietary sesame reduces serum cholesterol and enhances antioxidant capacity in hypercholesterolemia. Nutrition Research 25: 559–567.

Choi, M.S.; Do, K.M.; Park, Y.S.; Jeon, S.M.; Jeong, T.S.; Lee, Y.K.; Lee, M.K. and Bok, S.H. (2001): Effect of Naringin Supplementation on Cholesterol Metabolism and Antioxidant Status in Rats Fed High Cholesterol with Different Levels of Vitamin E, Ann Nutr Metab; 45:193-201

Cintra, D.E.C.; Costa, A.G.V.; Peluzio, M.C.G.; Matta, S.L.P.; Silva, M.T.C. and Costa, N.M.B. (2006): Lipid profile of rats fed high-fat diets based on flaxseed, peanut, trout, or chicken skin. Nutrition 22: 197–205.

Cohen, S.L.; Moore, A.M., and Warda, W.E., (2005): Flaxseed oil and inflammation-associated bone abnormalities in interleukin-10 knockout mice; Journal of Nutritional Biochemistry: 16(6) 368-374.

Devi, C.S.; Mallika, J., and Vijaimohan, K.S., (2006): "Role of flax seed oil on cardiac lipids in high fat diet fed rats". XIX Annual conference of the Indian Society of Artherosclerosis research conducted by Department of Biochemistry, University of Madras, Chennai – 600 025.

Feoli, A.M.; Roehrig, C.; Rotta, L.N.; Kruger, A.H.; Souza, K.B.; Kesseler, A.M.; Renz, S.V.; Brusque, A.M.; Souza, D.O.; and Perry, M.L.S. (2003): Serum and liver lipids in rats and chicks fed with diets containing different oils. Basic Nutritional Investigation 19 (9), 789–793.

Fossati, F. and Principe, L. (1982): Plasma Triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. Clin. Chem., 28 (10): 2077-2080.

Hasler, C.M.; Kundrat, S. and Wool, D. (2000): Functional foods and cardiovascular disease. Curr Atheroscler Rep.; 2:467–475.

Hill, J.O.; Peters, J.C.; Lin, D.; Yakubu, F.; Greene, H. and Swift, L. (1993): Lipid accumulation and body fat distribution is influenced by type of dietary fat fed to rats. Int. J. Obesity, 17: 23-29

Hirata, F.; Fujita, K.; Ishikura, Y.; Hosoda, K.; Ishikawa, T. and Nakamura, H. (1996): Hypocholesterolemic effect of sesame lignan in humans. Atherosclerosis 1996; 122:135-6.

Hirose, N.; Inoue, T.; Nishihara, K.; Sugano, M.; Akimoto, K. and Shimizu, S. (1991): Inhibition of cholesterol absorption and synthesis in rats by sesamin. J Lipid Res 1991; 32:629- 38.

Ide, T; Kushiro, M.; Takahashi, Y.; Shinohara, K.; Fukuda, N. and Sirato-Yasumoto, S. (2003): Sesamin, a sesame lignan, as a potent serum lipid-lowering food component. JARQ 37 (3), 151-158.

Jenkins, D.J.A.; Kendall, C.W.W.; Vidgen, E.; Agarwal, S.; Rao, A.V.; Rosenberg, R.S.; Diamandis, E.P.; Novoknet, R.; Mehling, C.C.; Perera, T.; Griffin, L.C. and Cunnane, S.C. (1999): Health aspects of partially defatted flaxseed, including effects on serum lipids, oxidative measures, and ex vivo androgen and progestin activity: a controlled crossover trial. American Journal of Clinical Nutrition 69 (3), 395–402.

Kamal-Eldin, A.; Frank, J.; Razdan, A.; Tengblad, S.; Basu, S. and Vessby, B. (2000): Effects of dietary phenolic compounds on tocopherol, cholesterol, and fatty acids in rats. Lipids;35:427- 35.

Kaminskas, A.; Mikalauskaite, D.A.; Levachev, M.M.; Lupinovich, V.L. (1991): Effect of linseed oil and fatty acid composition of low and very low density lipoproteins, cholesterol and its fractions in the blood serum of albino rats. Voprosy Pitaniâ Sep–Oct (5), 48–51.

Kawahara, S.; Inoue, K.; Hayashi, T.; Masuda, Y. and Ito, T. (1997): Lipids easy to accumulate in the liver and lipids hard to accumulate in it. Nutrition Research 17 (6), 1013–1023.

Kelley, DS; Branch, L.B.; Love, J.E.; Taylor, P.C.; Rivera, Y.M. and Iacono, J.M. (1991): Dietary a-linoleic acid and immunocompetence in humans; Am J Clin Nutr; 53:40-6.

Mahfouz, M.M. and Fred, A.K. (2000): Cholesterol-rich diets have different effects on LPO, cholesterol oxides and antioxidant enzymes in rats and rabbits. Journal of Nutritional Biochemistry 11 (5), 293–302.

Mantzioris E.; James, M.J.; Gibson, R.A. and Cleland, L.G. (1994): Dietary substitution with an alpha-linolenic acid-rich vegetable oil increases eicosapentaenoic acid concentrations in tissues; Am J Clin Nutr.; 59(6):1304-1309.

Miller, G.J. and Miller, N.E. (1997): Plasma HDL concentration and development of IHD. Heart and Stroke, Statistical Update. University Press, Dallas, Texas, pp. 16–21.

Morise, A.; Serougne, C.; Gripois, D.; Blouquit, M.F.; Lutton, C. and Hermier, D. (2004): Effects of dietary alpha-linolenic acid on cholesterol metabolism in male and female hamsters of the LPN strain. The Journal of Nutritional Biochemistry 15 (1), 51–61.

Murase, T.; Ioki, M. and Tokimitsu, I. (2005): Supplementation with alpha-linolenic acid rich diacylglycerol suppresses fatty liver formation accompanied by an upregulation of â-oxidation in Zucker fatty rats. Biochimica et Biophysica Acta 1733 (2–3), 224–231.

NCEPEP (1994): National Cholesterol Education program Expert Panel. Second report of the expert panel on detection, evaluation and treatment of high blood cholesterol in adults. Circulation 89 (3), 1333–1445.

Onody, A.M.; Csonka, C.; Giricz, Z. and Ferdinandy, P. (2003): Hyperlipidemia induced by a cholesterol-rich diet leads to enhanced peroxidative formation in rat hearts. Cardiovascular Research 58 (3), 663–670.

Prasad, K. (2000): Flaxseed: a source of hypercholesterolemic and antiatherogenic agents. Drug News Perspect 13 (2), 99–102.

Reitman, S. and Frankel, S. (1957): A colourimetric method of the determination of plasma glutamic oxaloacetic and glutamic pyruvic transaminases. Am. J. Clins. Pathol., 28: 56-63.

Rizvi, F.; Iftikhar, M. and George, J.P. (2003): Beneficial Effects of Fish Liver Preparations of Sea Bass *(Lates calcarifer)* Versus Gemfibrozil in High Fat Diet-Induced Lipid-Intolerant Rats, Journal of Medicinal Food 6(2): 123-128.

SAS, (1996): SAS/ Stat Users Guide: Statistics, System for Windows, version 4.10 (release 6.12 TS level 0020), SAS Inst., Inc. Cary, North Carolina, USA.

Satchithanandam, S.; Chanderbhan, R.; Kharroubi, A.T.; Calvert, R.J.; Klurfeld, D.; Tepper, S.A. and Kritchevsky, D. (1996): Effect of sesame oil on serum and liver lipid profiles in the rat. Int J Vitam Nutr Res; 66(4):386-92.

Simopoulos, AP; Leaf, A. and Salem, N.J. (1999): Essentiality of and recommended dietary intakes for omega-6 and omega-3 fatty acids; Ann Nutr Metab; 43:127–130

Suprijana, O.; Terpstra, A.H.M., Vanlith, H.A., Vantol, A., and Lemmens, A.G. (1997): Plasma lipids and apolipoproteins in rats fed diets with type of fat (fish oil, corn oil and fiber (pectin versus cellulose) as variables. Nutrition Research 17 (7), 1187–1197.

Tsai, C.M.; Yin, W.H.; Cheng, H.S.; Chen, P.R. and Lin, Y.L. (2004): Primary study of L-arginine on the concentrations of serum lipids in human. J Nutr Sci;29:176-83.

Vijaimohan, K.; Jainu, M.; Sabitha, K.E.; Subramaniyam, S.; Anandhan, C.; Shyamala Devi, C. S. (2006): Beneficial effects of alpha linolenic acid rich flaxseed oil on growth performance and hepatic cholesterol metabolism in high fat diet fed rats, Life Sciences, 79:448–454.

Wiesenfeld, P.W.; Babu, U.S.; Collins, T.F.X.; Sparndo, R.; O' Donell, M.W.; Flynn, T.J.; Black, T. and Olejnik, N. (2003): Flaxseed increased-linoleic acid and eicosapentaenoic acid and decreased arachidonic acid in serum and tissues of rat dams and offspring. Food and Chemical Toxicology 41 (6), 841–855.

Winston, J.C. (1999): Health-promoting properties of common herbs; Am J Clin Nutr; 70(3):491S–499S.

التقييم البيولوجي للأحماض الدهنية عديدة عدم التشبع من النوع أوميجا ٣ و ٦ في زيوت بذرة الكتان والسمسم واستخدامهم في تحضير الكيك الطبقي

ياسر فكرى محمد كشك ، محمد مصطفى عبد الرازق ، إيهاب صلاح عشوش
قسم علوم الأغذية – كلية الزراعة – جامعة عين شمس – شبرا الخيمة – القاهرة.

من الأحماض الدهنية الرئيسية فى الليبيدات المستخلصة من بذور الكتان والسمسم حمض اللينولينك وحمض اللينوليك وعند مزج كل من زيت السمسم والكتان بنسبة ٢:١ أدى ذلك إلى تحسين صورة الأحماض الدهنية، وباستخدام زيت السمسم والكتان والمزيج منهما بنسبة ٢:١ كبديل للدهن بنسب مزج ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠% عند إعداد الكيك وجد أن أفضل نسب أظهرت تحسين لصفات الكيك كانت ٥٠ ، ٧٥ ، ٧٥% لكل من زيت السمسم والكتان والمزيج منهما على التوالى مقارنة بالعينة الضابطة والتى احتوت على ١٠٠% دهن.

وبإجراء تغذية للفئران المصابة بارتفاع لبيدات الدم على وجبات تحتوى على زيت السمسم والكتان والمزيج منهما بنسب المزج السابقة وجد حدوث انخفاض فى وزن الجسم وتحسن فى صورة لبيدات الدم مقارنة بالمجموعة الضابطة والمجموعة المغذاه على وجبة مرتفعة فى نسبة الدهن، بالإضافة الى أن المعاملة بزيت الكتان أظهرت حماية للخلايا الكبدية من الضرر.