Faculty of Home Economics

Journal of Home Economics
Menoufia University, Shibin El Kom, Egypt
https://mkas.journals.ekb.eg

Menoufia University

Nutrition and Food Sciences

Effect of Adding Lipoic Acid to Ameliorate the Flaxseed Oil for the Treatment of Rats with Hyperlipidemia

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Abstract

Hyperlipidemia is a major manifestation of the pathophysiology underlying cardiovascular disease. Flaxseed oil (FO) and α-lipoic acid (LA) have been reported to exert potential benefits to the cardiovascular system. This study tried to assess The effect of adding lipoic acid to ameliorate Flaxseed oil for the treatment of rats injured by hyperlipidemia on the hyperlipidemia risk factors in rats fed a high-fat diet. The effect of adding lipoic acid to a meliorate Flaxseed oil for treatment the rats injured by hyperlipidemia. LA was dissolved in flaxseed oil with different concentrate lipoic acid (6%, 9%, 12%) and flaxseed oil 25% to rats in addition to the main food for 28 days, Thirty male albino rats weighing 150-160 grams were used in this study and were divided into 6 equal groups, each group contained 5 mice, the first group was kept as a positive control and the second group was kept as a the negative control while the other groups were fed on Diet for 4 weeks flaxseed oil and (tested) lipoic acid ($P \leq 0.05$) decreased serum lipids, serum VLDL, HDL and AI. also improve liver and kidney functions. The hypothesis of the obtained results in which flaxseed oil and lipoic acid were tested contain several compounds capable of ameliorating the adverse effects and inhibition of hyperlipidemia rats. FO and LA supplementation may contribute to the reduction of hyperlipidemia by improving the plasma lipid .

Key words: HDL-c, liver and kidney function, hyperlipidemic rats, LA.

Introduction

Hyperlipidemia is a group of metabolic disorders characterized by elevated levels of lipids that include cholesterol, cholesterol esters, phospholipids and triglycerides (Karam et al., 2018). Lipid disorders are not dependent on total serum cholesterol, but also on its distribution among different lipoproteins. The low-density lipoproteins (LDL) are the

major carriers of cholesterol towards tissues having atherogenic potential, while the high-density lipoproteins (HDL) carry cholesterol from peripheral tissues to the liver. HDL thus gives protection against many cardiac problems and obesity. Although genetic factors recline behind these lipid disorders (Thirumalai et al., 2014)

A high-fat diet induces the development of metabolic syndrome, which consists of oxidative stress, initiated atherogenic dyslipidemia, a pro-inflammatory and pro-thrombotic state, high blood pressure, central obesity and cardiovascular disease (Lasker et al., 2019). Also, it has been established that consuming high amounts of refined carbohydrates (fructose) increases the risk of hyperlipidemia and may affect the liver (Lozano et al., 2016). Atorvastatin is a synthetic type of HMG-CoA analogue that exhibits a substantial efficacy for decreasing total and low–density lipoprotein cholesterol (LDL)levels, triglycerides and modification of lipoprotein composition (Abdelhalim and Somaia et al., 2019). Plant oils such as flaxseed oil are a major source of health care for about 80% of the world's population in the form of plant extracts and their active ingredients as a result of their properties (Shorinwa and Monsi, 2020) . Several studies in animal models and in human subjects have actually confirmed that phenols in fruits and vegetables are bioavailable and protect against oxidative stress and free radical (Luna-Vázquez et al., 2013).

Flaxseed (Linum usitatissimum) is the richest dietary source of omega-3 fatty acids among plant sources. Flaxseed is widely used for its edible oil in many parts of the world. A number of investigations have demonstrated that a diet supplemented with flaxseed oil has profound beneficial health effects in various pathologies. Flaxseed is also the richest source of lignans, which have been reported to have antioxidant and hypolipidemic effects (Newairy, and Abdou, 2009). Moreover, Vijaimohan et al., (2006) demonstrate that, flaxseed oil present in flaxseeds may be developed as a useful therapy for hyperlipidemia through reducing hepatic lipids, thereby proving its hypolipidemic activity. Addition, of flaxseed in the diet in animal studies has shown inhibit atherogenesis (Prasad, 2005) and protect during hypercholesterolemic conditions (Dupasquier et al., 2006).

Flaxseed oil (FO) is the main component of flaxseed and one of the world's most important vegetable sources of α-linolenic acid (LNA, 18:3n-3). As a nutritionally essential polyunsaturated fatty acid (PUFA), LNA can act as the precursor of longer chain n-3 PUFA (EPA and DHA) or compete with linoleic acid or direct interaction with ion

channels and nuclear receptors, and thus may exert various biological functions in the human body, such as accelerating brain growth in preterm and neonatesand, antiarrhythmic functions and neuroprotective functions (Barcelo-Coblijn and Murphy,2009). In addition, LNA is also reported to have beneficial effects on blood lipid profiles (Tzang et al .,2009) and inflammation (Caughey et al., 1996) which may responsible for the protection against CVD bestowed by FO. However, on the other hand, since LNA is highly susceptible to oxidation, FO addition leads to a significanty higher tendency toward plasma lipid peroxidation (Trebušak et al., 2011) which may have an adverse effect on the protection of the cardiovascular system.

Alpha-lipoic acid (ALA), also known as 1,2-dithiolane- 3-pentanoic acid, 1,2- dithiolane-3-valeric acid or 6,8-thioctic acid has generated considerable clinical interest as a cellular thiol-replenishing and redox modulating agent(Marsh et al., 2015). Lipoic acid is a unique antioxidant because it has beneficial effects on fuel metabolism and also an essential cofactor of mitochondrial respiratory enzymes, including the pyruvate dehydrogenase complex (Siti et al., 2018). It is said that Lipoic acid offer advantages over other antioxidants as it increases the level of reduced glutathione (Osfor et al., 2010) and can also regenerate other antioxidants such as vitamin C and E (Cakatay et al., 2015). Accordingly, the present study was performed to investigate the improving effect of alpha lipoic acid administration on hyperlipidemic rats after 8 weeks of treatment by determination of the following biochemical parameters such as lipid profile, glucose and insulin. Moreover, liver antioxidant enzymes such as catalase enzyme (CAT), superoxide dismutase activity (SOD) and reduced glutathione (GSH) in addition to L-malondialdehyde (L-MDA) as oxidant substrate were also determined.

α-lipoic acid (LA), also referred to as thioctic acid, is a disulfide compound that is found naturally in mitochondria as the coenzyme for pyruvate dehydrogenase and α-ketoglutarate thus serves a critical role in mitochondrial energy metabolism. Although orally supplied LA may not be used as a metabolic cofactor, there are a unique set of biochemical activities with potential pharmacotherapeutic value against a host of pathophysiologic insults (Shay et al., 2009). For example, LA has gained considerable attention as an excellent antioxidant to reduce oxidative stress (Evans and Goldfine, 2000). Further, LA is fat- and water-soluble, which makes it effective against a broader range of free radicals. Early studies have shown the capacity of LA to decrease plasma lipids in rats (Yang et al., 2018). Besides, LA also exhibits anti-inflammatory activity in

the clinical trials (Sola et al., 2015). These mechanisms make LA possess the potential abilities for antiatherogenesis. To our knowledge, the effects of a simultaneous intake of FO and LA on the cardiovascula system have not been investigated.

Materials and methods

Materials: lipoic acid 300 mg: was purchased from future pharmaceutical industries, Badr City, Egypt. Flaxseed oil: was purchased local market, Shibin EL-kom, Menoufia ,Egypt.

Rats and diets: Thirty Male albino rats weighing 150-160 g per each were purchased from Menoufia ,Egypt.

Fat : The fat of a lamb was brought from the butcher Shibin EL-kom, Menoufia ,Egypt. which was used to induce hyperlipidemia in rats.

Diet: The basal diet in the experiment consisted of casein (10%), corn oil (10%) vitamin mixture (1%), salt mixture (4%), choline chloride (0.2%), methionine (0.3%), cellulose (5%) and the remained is corn starch (69.5%) according to (Campbell, 1963) presented in the table (1), salt mixture and vitamins mixture were prepared according to (Hegested et al., 1941) and (Campbell, 1961).

Experimental Design:

Thirty Adult male albino rats, Sprague Dawley Strain, which fed on basal diet for one week. Then, rats were divided into six groups each group consists of four rats and were housed individually in the wire cage.

All groups of rats were fed on the experimental diet for 28 days according to the following groups:

Group (1):- Rats will feed on basal diet as control the the negative.

Group (2):- Rats were Fed on basel diet and feed on high-fat food.

Group (3):- A group infected hyperlipidemic fed on the 6% lipoic acid and 25% flaxseed oil of the weight of the diet.

Group (4):- A group infected hyperlipidemic fed on the 9% lipoic acid and 25% flaxseed oil of the weight of the diet.

Group (5):- A group infected hyperlipidemic fed on the 12% lipoic acid and 25% flaxseed oil of the weight of the diet.

Group (6):- A group infected hyperlipidemic is fed on the flaxseed oil by 25% of the weight of the diet.

At the end of the experiment (4 weeks), rats were fasted for 12-h then scarified. Blood samples were collected from the portal vein into dry clean centrifuge tubes for serum

separation, blood samples centrifuged for 10 minutes at 3000 rpm to separate the serum according to Drury and Wallington, (1980). The pencreases of sacrificed rats were kept in 10% formalin solution till processed for histopathological examination.

Biochemical analysis:

Lipids profile:

Determination of serum lipids:

Total lipid was determined by colorimetric method according to (Schmidt-Sommerfeld, 1981). triglycerides, total cholesterol and high-density lipoprotein(HDL) were determined according to Schmidt-Sommerfeld, (1981);Fassati and prencipe, (1982) and Allain, (1974) respectively. Low-density lipoprotein (LDL)and very Low – density (VLDL) were calculated according to the method of Lee and Nieman, (1996) using the following equations:

LDL (mg/dl) = Total cholesterol - (HDL + VLDL).

VLDL (mg/dl) = Triglycerides ÷ 5

AI (Atherogenic Index):

The concentration of (AI) was estimated according to (Kikachi et al., 1998).by calculation the follows:

$$\mathrm{AI} = \frac{\mathbf{VLDL - c + \ LDL - c}}{\mathbf{HDL - c}}$$

Liver functions:

Determination of serum alanine aminotransferase (ALT):

Determination of serum ALT was carried out according to the method of (Tietz, 1976).

Determination of serum aspartate aminotransferase (AST):

Determination of serum AST was carried out according to the method of (Henary, 1974).

Determination of serum alkaline phosphatase

(ALP):

Determination of serum ALP was carried out according to the method of (Moss, 1982).

Determination of serum albumin:

Determination of albumin in serum was carried out according to the method by (Henary, 1974).

Determination of serum total protein:

Serum total protein (STP) was determined according to the method described by (Henary, 1974).

Kidney functions:

Determination of serum urea:

Urea was determined by the enzymatic method according to (Petton and Crouch, 1977).

Determination of serum creatinine:

Serum creatinine was determined according to the method described by (Henary, 1974).

Determination of serum uric acid:

Serum uric acid was determined calorimetrically according to the method of (Petton and Crouch, 1977).

Statistical analysis:

The results were recorded as the mean ± SD. The experimental data were subjected to an analysis of variance (ANOVA) for a completely randomized design using a statistical analysis system (SAS,2000). Duncan's multiple range tests were used to determine the deference's among means at the level of 5%.

Results and Discussion

Data in table (1) showed the effect of adding lipoic acid to a meliorate flaxseed oil on Atherogenic Index (A.I.) in hyperlipidemia rats. It could be observed that the negative control group was significantly lower than the positive control group ($P \leq 0.05$), which were 41.84±7.405 & 73.98±1.427 respectively, whereas the mean values of G3, G4 & G5 were 51.53±14.002, 49.92±2.273 & 44.47±6.779 respectively, which were significantly lower than the positive control group ($P \leq 0.05$), but G6 was lower than the positive control with any significantly differences ($P > 0.05$). This is in agreement with Morrison et al., 2015 who showed that the combination of FO and LA is effective in amelioration of oxidative stress, lipid profile and inflammation of plasma in rats fed a high-fat diet.

Table (1) Effect of adding lipoic acid to a meliorate Flaxseed oil on Atherogenic Index (A.I.) (mg/dl) in hyperlipidemia rats

Groups	A.I.	% of Positive control group
The the negative control (G1)	41.84^{b}±7.405	56.56
Positive control (G2)	73.98^{a}±1.427	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	51.53^{b}±14.002	69.65
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	49.92^{b}±2.273	67.48
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	44.47^{b}±6.779	60.11
Flaxseed oil (25gm) only (G6)	58.95^{ab}±11.797	79.68
LSD	16.66	

Means under the same column bearing different superscript letters are different significantly (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (1) showed the effect of adding lipoic acid to a meliorate flaxseed oil on serum triglyceride the the the negative control group was lower than the positive control group with any significanty differences (P>0.05), which were 113.67±1.528 & 139.33±22.030 respectively, whereas the mean value of G5 was 99.67±20.306, which was significanty lower than the positive control group (P≤0.05), but G3, G4 & G6 were lower than the positive control with any signicantlly differences (P>0.05).

Table (2) Effect of adding lipoic acid to a meliorate Flaxseed oil on serum triglyceride (TG) (mg/dl) in hyperlipidemia rats

Groups	TG	% of Positive control group
The the negative control (G1)	113.67^{ab}±1.528	81.58
Positive control (G2)	139.33^{a}±22.030	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	115.33^{ab}±3.055	82.77
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	115.00^{ab}±2.000	82.54
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	99.67^{b}±20.306	71.54
Flaxseed oil (25gm) only (G6)	132.66^{ab}±5.033	95.21
LSD	24.85	

Means under the same column bearing different superscript letters are different significanty (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (2) showed that the effect of adding Lipoic acid to a meliorate flaxseed oil on Serum Low – density lipoprotein cholesterol (LDL) in hyperlipidemia rats. It could be observed that the the negative control group was significanty lower than the positive control group (P≤0.05), which were 41.00±7.277 & 75.80±4.678 respectively, whereas the mean values of G3, G4, G5 & G6 were 50.60±14.030, 49.00±2.358, 43.73±6.992 & 57.80±11.605, which were significanty lower than the positive control group (P≤0.05).this is in agreement with (Amin et al., 2013 and Li et al., 2015) who saied that Our results showed a marked increase in the lipid profile (total cholesterol, triglycerides and LDL) in the high fat diet group, while serum HDL showed significanty decrease. Administration of flaxseed oil prior to and after induction of hyperlipidemia markedly improved these parameters. These results were consistent with the studies by others .

Table (3) Effect of adding lipoic acid to a meliorate Flaxseed oil on Serum low-density lipoprotein cholesterol (LDL) (mg/dl) in hyperlipidemia rats

Groups	LDL	% of Positive control group
The the negative control (G1)	41.00^{b}±7.277	54.09

Positive control (G2)	75.80[a]±4.678	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	50.60[b]±14.030	66.75
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	49.00[b]±2.358	64.64
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	43.73[b]±6.992	57.69
Flaxseed oil (25gm) only (G6)	57.80[b]±11.605	76.25
LSD	17.20	

Means under the same column bearing different superscript letters are different significanty ($p \leq 0.05$)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (4) showed that the effect of adding lipoic acid to a meliorate flaxseed oil on Serum low-density lipoprotein cholesterol (VLDL) in hyperlipidemia rats. It could be observed that the the negative control group was lower than the positive control group with any signicantlly differences ($P>0.05$), which were 22.73±0.306 & 27.87±4.406 respectively, whereas the mean value of G5 was 20.03±3.963, which was signicantlly lower than the positive control group ($P \leq 0.05$), but G3, G4 & G6 were lower than the positive control with any signicantlly differences ($P>0.05$).this is in agreement with Hussein et al. (2014) who reported that flaxseed oil supplementation to rats fed high cholesterol diet decreases the serum lipid profile.

Table (4) Effect of adding lipoic acid to a meliorate Flaxseed oil on Serum Low – density lipoprotein cholesterol (VLDL) (mg/dl) in hyperlipidemia rats

Groups	VLDL	% of Positive control group
The the negative control (G1)	22.73[ab]±0.306	81.56
Positive control (G2)	27.87[a]±4.406	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	23.07[ab]±0.611	82.78
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	23.00[ab]±0.400	82.53
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	20.03[b]±3.963	71.87
Flaxseed oil (25gm) only (G6)	26.53[ab]±1.007	95.19
LSD	4.91	

Means under the same column bearing different superscript letters are different significanty ($p \leq 0.05$)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (5) showed the effect of adding lipoic acid to a meliorate flaxseed oil on Serum Low – density lipoprotein cholesterol (HDL) in hyperlipidemia rats. It could be observed that the the negative control group was signicantlly higher than the positive control group ($P \leq 0.05$), which were 27.00±5.000 & 18.33±1.528 respectively, whereas

the mean value of G5 was 26.67±3.512, which was signicantlly higher than the positive control group (P≤0.05), but G3, G4 & G6 were higher than the positive control with any signicantlly differences (P>0.05). this is in agreement with Tzang etal., 2009 who showed that FO has been shown to have hypocholesterolaemic effect, which might result from increases of hepatic HDL-receptor expression and cholesterol catabolism/output

Table (5) Effect of adding lipoic acid to a meliorate Flaxseed oil on Serum Low – density lipoprotein cholesterol (HDL) (mg/dl) in hyperlipidemia rats

Groups	HDL	% of Positive control group
The the negative control (G1)	27.00^{a}±5.000	147.30
Positive control (G2)	18.33^{b}±1.528	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	24.00^{ab}±2.000	130.93
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	25.00^{ab}±3.000	136.39
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	26.67^{a}±3.512	145.50
Flaxseed oil (25gm) only (G6)	23.33^{ab}±3.055	127.28
LSD	5.55	

Means under the same column bearing different superscript letters are different significanty (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (6) showed the effect of adding lipoic acid to a meliorate flaxseed oil on Serum Glutamic Pyruvate Transaminase (GPT) or (ALT) enzyme in hyperlipidemia rats. It could be observed that the the negative control group was signicantlly lower than the positive control group (P≤0.05), which were 30.00±4.359 & 53.33±1.528 respectively, whereas the mean value of G3, G4, G5 & G6 were 41.33±1.528, 31.67±0.577, 32.33±2.082 & 39.33±5.859, which were signicantlly lower than the positive control group (P≤0.05).

Table (6) Effect of adding lipoic acid to a meliorate Flaxseed oil on Serum Glutamic Pyruvate Transaminase (GPT) or (ALT) enzyme in hyperlipidemia rats

Groups	ALT	% of Positive control group
The the negative control (G1)	30.00^{c}±4.359	56.25
Positive control (G2)	53.33^{a}±1.528	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	41.33^{b}±1.528	77.50
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	31.67^{c}±0.577	59.38
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	32.33^{c}±2.082	60.62
Flaxseed oil (25gm) only (G6)	39.33^{b}±5.859	73.75
LSD	5.59	

Means under the same column bearing different superscript letters are different significanty (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (7) showed the effect of adding lipoic acid to a meliorate flaxseed oil on Serum Glutamic Oxaloacetate Transaminase (GOT) or (AST) enzyme (U/L) in hyperlipidemia rats. It could be observed that the the negative control group was signicantlly lower than the positive control group (P≤0.05), which were 121.00±3.000 & 183.33±3.786 respectively, whereas the mean values of G3, G4, G5 & G6 were 174.00±4.583, 156.67±3.055, 127.33±2.517 & 172.67±9.292, which were signicantlly lower than the positive control group (P≤0.05).

Table (7) Effect of adding lipoic acid to a meliorate Flaxseed oil on Serum Glutamic Oxaloacetate Transaminase (GOT) or (AST) enzyme (U/L) in hyperlipidemia rats

Groups	AST	% of Positive control group
The the negative control (G1)	121.00^{d}±3.000	66.00
Positive control (G2)	183.33^{a}±3.786	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	174.00^{b}±4.583	94.91
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	156.67^{c}±3.055	85.46
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	127.33^{d}±2.517	69.45
Flaxseed oil (25gm) only (G6)	172.67^{b}±9.292	94.19
LSD	7.90	

Means under the same column bearing different superscript letters are different significanty (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (8) showed the effect of adding lipoic acid to a meliorate flaxseed oil on Serum Alkaline phosphatase (ALP) enzyme in hyperlipidemia rats. It could be observed that the the negative control group was signicantlly lower than the positive control group (P≤0.05), which were 108.50±3.500 & 219.50±54.500 respectively, whereas the mean values of G3, G4, G5 & G6 were 159.00±7.000, 152.50±6.500, 125.00±11.000 & 156.50±9.500, which were signicantlly lower than the positive control group (P≤0.05).

Table (8) Effect of adding lipoic acid to a meliorate Flaxseed oil on Serum Alkaline phosphatase (ALP) enzyme (U/L) in hyperlipidemia rats

Groups	ALP	% of Positive control group
The the negative control (G1)	108.50^{b}±3.500	49.43
Positive control (G2)	219.50^{a}±54.500	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	159.00^{b}±7.000	72.44
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	152.50^{b}±6.500	69.48

Flaxseed oil (25gm) + Lipoic acid 12%(G5)	125.00^{b}±11.000	58.00
Flaxseed oil (25gm) only (G6)	156.50^{b}±9.500	71.30
LSD	44.90	

Means under the same column bearing different superscript letters are different significanty (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (9) showed the effect of adding lipoic acid to a meliorate flaxseed oil on IgA in hyperlipidemia rats. It could be observed that the the negative control group was signicantlly lower than the positive control group (P≤0.05), which were 63.00±1.000 & 136.00±0.500 respectively, whereas the mean values of G3, G4, G5 & G6 were 111.67±1.528, 105.00±1.000, 99.00±1.000 & 112.00±1.000, which were signicantlly lower than the positive control group (P≤0.05).

Table (9) Effect of adding lipoic acid to a meliorate Flaxseed oil on IgA in hyperlipidemia rats

Groups	IgA	% of Positive control group
The the negative control (G1)	63.00^{e}±1.000	46.32
Positive control (G2)	136.00^{a}±0.500	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	111.67^{b}±1.528	82.11
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	105.00^{c}±1.000	77.21
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	99.00^{d}±1.000	72.79
Flaxseed oil (25gm) only (G6)	112.00^{b}±1.000	82.35
LSD	1.77	

Means under the same column bearing different superscript letters are different significanty (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (10) showed the effect of adding lipoic acid to a meliorate flaxseed oil on IgE in hyperlipidemia rats. It could be observed that the the negative control group was signicantlly lower than the positive control group (P≤0.05), which were 46.00±1.000 & 119.00±1.000 respectively, whereas the mean values of G3, G4, G5 & G6 were 89.67±2.517, 82.00±2.000, 74.00±1.000 & 93.00±2.000 respectively, which were signicantlly lower than the positive control group (P≤0.05).

Table (10) Effect of adding lipoic acid to a meliorate Flaxseed oil on IgE in hyperlipidemia rats

Groups	IgE	% of Positive control group
The the negative control (G1)	46.00^{e}±1.000	38.66
Positive control (G2)	119.00^{a}±1.000	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	89.67^{b}±2.517	75.35

Flaxseed oil (25gm) + Lipoic acid 9% (G4)	82.00^{c}±2.000	68.91
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	74.00^{d}±1.000	62.18
Flaxseed oil (25gm) only (G6)	93.00^{b}±2.000	78.15
LSD	3.35	

Means under the same column bearing different superscript letters are different significanty (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Data in table (11) showed the effect of adding lipoic acid to a meliorate flaxseed oil on Uric Acid (UA) in hyperlipidemia rats. It could be observed that the the negative control group was signicantlly lower than the positive control group (P≤0.05), which were 2.03±0.153 & 3.13±0.126 respectively, whereas the mean values of G3, G4, G5 & G6 were 1.90±0.045, 1.74±0.010, 1.62±0.015 & 2.45±0.050 respectively, which were signicantlly lower than the positive control group (P≤0.05).

Table (11) Effect of adding lipoic acid to a meliorate Flaxseed oil on Uric Acid (UA) in hyperlipidemia rats

Groups	UA	% of Positive control group
The the negative control (G1)	2.03^{c}±0.153	64.86
Positive control (G2)	3.13^{a}±0.126	-
Flaxseed oil (25gm) + Lipoic acid 6% (G3)	1.90^{c}±0.045	60.70
Flaxseed oil (25gm) + Lipoic acid 9% (G4)	1.74^{d}±0.010	55.59
Flaxseed oil (25gm) + Lipoic acid 12%(G5)	1.62^{d}±0.015	51,76
Flaxseed oil (25gm) only (G6)	2.45^{b}±0.050	78.27
LSD	0.13	

Means under the same column bearing different superscript letters are different significanty (p≤0.05)
Each value is presented as Mean ± standard deviation (n=3)

Conclusion

The flaxseed oil and lipoic acid selected in this study were effective in protecting the mice from hyperlipidemia. These results supported our hypothesis that the tested flaxseed oil and lipoic acid contained several important compounds such as (omega 3 , Alpha Linoleic Acid, Eicosapentaenoic acid and docosahexaenoic acid) capable of inhibiting hyperlipidemia, so the data recommended the use of flaxseed oil and lipoic acid in a moderate amount to include in our dailydiets.

Conflict of interest

The authors declare that they have no conflict of interest concerning the publication of

this article. This article is extracted from a Master's thesis submitted to the Department of Nutrition and Food Science, Faculty of Home Economics, Menoufia University, Shebin El-Kom, Egypt.

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تأثير اضافة حمض ليبويك لتحسين زيت بذرة الكتان لعلاج الفئران المصابة بإرتفاع دهون الدم

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الملخص العربي

دهون الدم هو مظهر رئيسي من مظاهر الفسيولوجيا المرضية الكامنة التي تؤدي الي الاصابة بأمراض القلب والأوعية الدموية. ترجع أهمية بذور الكتان في أن زيت بذور الكتان (FO) وحمض ألفا ليبويك (LA) لما لهما من فائدة محتملة لحماية القلب والأوعية الدموية. حاولت هذه الدراسة تقييم تأثير إضافة حمض ليبويك إلى زيت بذور الكتان لعلاج الفئران المصابة بارتفاع دهون الدم في الفئران التي تغذت على نظام غذائي غني بالدهون. الهدف: تأثير إضافة حمض ليبويك إلى زيت بذور الكتان لعلاج الفئران المصابة بارتفاع دهون الدم. يذاب الفا ليبويك (LA) في زيت بذور الكتان مع تركيزات مختلف من حمض ليبويك بنسب (6٪ ، 9٪ ، 12٪) وزيت بذور الكتان بنسبة 25٪ للفئران بالإضافة إلى الغذاء القياسي لمدة 28 يومًا ، استخدمت فى الدراسة 30 فأر تتراوح أوزانها بين 150: 160 جرامًا. المستخدمة في هذه الدراسة وتم تقسيمها إلى 6 مجموعات متساوية ، كل مجموعة تحتوي على 5 فئران ، المجموعة الأولى بقيت كمجموعة تحكم إيجابية والمجموعة الثانية بقيت على أنها تحكم سلبي بينما تم تغذية المجموعات الأخرى بنظام غذائي لمدة 4 أسابيع. أدى زيت بذور الكتان وحمض الليبويك (المختبَر) (P≤0.05) إلى انخفاض نسب الدهون في الدم و VLDL و HDL و AI. مع تحسين في وظائف الكبد والكلى. تحتوي فرضية النتائج التي تم الحصول عليها والتي تم فيها اختبار زيت بذور الكتان وحمض الليبويك على عدة مركبات قادرة على تخفيف الآثار الضارة وتثبيط فرط الدهون في الدم. الخلاصة: مكملات FO و LA قد تسهم في الحد من فرط دهون الدم عن طريق تحسين ملف الدهون في البلازما

الكلمات المفتاحية: دهون الدم، وظائف الكبد والكلى، الفئران المصابة بارتفاع دهون الدم