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Protective role of flaxseed oil on hypercholesterolemic rats

Mohamed M. Aly-Aldin[1], Esam H. Mansour[2], Elsayed H. Rahma[3], Alaa E. El-Beltagy Abo El-Fath A. ElBedawey[4] and Magida M. El-Habashy[5]

[1-5] *Department of Food Science and Technology, Faculty of Agriculture, Minufiya University, Shibin El-Kom, Egypt*

*Email: esam_mansour@yahoo.com

ABSTRACT

The present study aims to investigate the effects of replacing corn oil content (10%) in the standard diet of hypercholesterolemic rats (fed standard diet + 2% cholesterol for 4 weeks) with 50, 75 and 100% levels of flaxseed oil on the body weight gain, organ weight, blood glucose, liver and kidney functions and lipid profile. Data showed that 2% cholesterol administration caused significant increase in glucose, ALT, AST, ALP, urea, uric acid, triglyceride, total lipids, total cholesterol, LDL and VLDL levels in serum of hypercholesterolemic rats. Body weight gain and organ weight also significantly increased as compared to control rats. Consumption flaxseed oil at different replacement level diets by hypercholesterolemic rats resulted in significant decrease in body weight gain, organ weight and lipid parameters except HDL which decrease as compared to hypercholesterolemic rats fed standard diet. Blood glucose level, liver functions and kidney functions were also improved.

Key words: Flaxseed oil, hypercholesterolemic rats, lipid profile, liver functions, kidney functions

INTRODUCTION

The replacement of saturated fatty acids with polyunsaturated fatty acids has been recommended over the last few years that would lower serum cholesterol, and assist in preventing the development of atherosclerosis (Fernandez et al., 2007).

Flaxseed oil is one of the most important specialty oils, which contains high levels (51–55%) of α-linolenic acid (n-3 and ω-3 fatty acid). Higher intake of α-linolenic acid has been long recognized as a good nutritional intervention with increasing many health benefits. As an essential polyunsaturated fatty acid that cannot be synthesized by human being, α-linolenic acid serves as a precursor for long chain n-3 polyunsaturated fatty acids such as eicosapentaenoic acid and docosahexaenoic acid (Barcelo-Coblijn and Murphy, 2009). Alph-linolenic acid has been widely reported to have many beneficial effects on blood lipid profile, blood pressure, cancer, skin diseases and immune disorders such as renal failure, rheumatoid arthritis and multiple sclerosis (Prasad, 2000 and Tzang et al., 2009).

A number of investigations have demonstrated that diet supplemented with flaxseed oil has profound beneficial health effects in various pathologies. Likhodii et al., (2000) reported that flaxseed oil has been shown to slow the rise in blood glucose levels. Linseed oil prevents the increase in body weight gain and liver weight (Rasmy, 2007). Flaxseed oil in rats fed high cholesterol diet resulted in significant decrease in serum total cholesterol, LDL, VLDL and triglyceride levels as compared to control rats (EL-Sahar and Abed EL- Rahman, 2014, Hussein et al., 2014, Rahman et al., 2014). Rangrej et al., (2015) reported that replacement of shortening with flaxseed oil from 0 to 50 % level demonstrated an increase in weight, diameter, thickness, spread ratio and

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breaking strength of cookies. Beyond 30% shortening replacement with flaxseed oil in cookies adversely affected the quality. To the best of our knowledge there are no reports on the replacement of corn oil with flaxseed oil. Therefore, in the present study corn oil content (10%) in the standard diet of hypercholesterolemic rats was replaced with 50, 75 and 100% levels of flaxseed oil. The effects of this replacement in lipid profile, liver and kidney functions and glucose level were evaluated.

MATERIAL AND METHODS

Preparation of flaxseed oil:

Flaxseed (*Linum usitatissimum L.)* yellow variety was obtained from Research Station of Gemiza, Gharbia, Egtpt. Flaxseeds were cleaned and crushed in an electric mill (Braun, model 1021), then soaked in *n*-hexane (40-60°C) at room temperature (~25°C), and shaken for 36 h with several changes of solvent (eight times). Evaporation of *n*-hexane was performed using a rotary evaporator (ROT. VAC. EVA. RVA. 64, Prague Czech Republic) under vacuum. The oil was dried over anhydrous sodium sulfate, filtered, stored in closed dark brown bottles without any further purification in a deep freezer at -18°C until used.

Animals:

Thirty adult male Sprague Dawely rats, (initially weighing 120 – 125g) were obtained from the Agriculture Researcher Center, Animal House Department, Giza, Egypt. Rats were housed in wire cages under normal laboratory conditions and fed standard diet for a week as adaptation period before starting experiment. Diet was introduced to rats in special food cups to avoid scattering of food. Also, water was provided to rats by glass tubes projecting through the wire cages from an inverted bottle supported to one side of the cage. Food and water were provided ad-labium and checked daily.

Experimental groups:

Rats were randomly divided into two main groups, the first, negative control group (n=6), fed standard diet according to Reeves et al., (1993) and the second group (n=24) fed hypercholesterolemic diet (standard diet + 2% cholesterol) for 4 weeks to achieve hypercholesterolemia. Second group (n=24) was divided into 4 subgroups, 6 rats per subgroup. First subgroup is positive control fed standard diet, second subgroup fed standard diet containing 50% flaxseed oil, third subgroup fed standard diet containing 75% flaxseed oil and fourth subgroup fed standard diet containing 100% flaxseed oil. Flaxseed oil was replaced with corn oil content (10%) in the standard diet at 50, 75 and 100% replacement levels.

Body weight gain feed intake and feed efficiency ratio:

All rats were weighted at the beginning and at the end of experimental period (4 weeks) to determined body weight gain (BWG), feed intake and feed efficiency ratio (FER) according to Chapman et al., (1959) using the following formulas:

BWG (g) = final weight – initial weight.

FER= Body weight gain ÷ Feed intake.

Blood collection and preparation:

Blood samples were taken at the beginning and at the end of experimental period (4 weeks). The blood samples were collected from orbital plexus venus by means of fine capillary glass tubes according to the method described by Schermer, (1967). The blood samples were placed in dry clean centrifuge tubes and allowed to clot for 1-2 h at room temperature. Serum was then removed by centrifuging at 1500g for 10 min. The clear supernatant serum was kept at - 20°C until analysis.

Organ weights:

Liver and kidneys were removed from each rat carefully dissection, cleaned from the adhesive matter by a saline solution, dried by filter paper and weighed according to the methods described by Drury and Wallington (1980).

Analytical methods:

Serum glucose was estimated according to Trinder, (1969). Serum aspartate and alanine amino transferees (AST and ALT) and alkaline phosphatase (ALP) were determined by using enzymatic colorimetric method according to Reitman and Frankel, (1957) and Hayssement (1977), respectively. Urea, uric acid and creatinine levels were determined according to the method described by Patton and Crouch, (1977), Barham and Trinde (1972) and Faulkner and King (1976), respectively.

Serum total lipid (TL), total cholesterol (TC), triglyceride (TG) and high density lipoprotein cholesterol (HDL) were determined by using enzymatic colorimetric method as described by Zollner and Kirsch (1962), Allain et al., (1974), Wahlefeld (1974) and Burstein et al., (1977), respectively. Low density lipoprotein cholesterol (LDL) and very low density lipoprotein cholesterol (VLDL) were carried out according to the method of Lee and Nieman (1996) as follows:

VLDL = TG ÷ 5

LDL = Total cholesterol - (HDL + VLDL)

Statistical analysis:

Data are presented as mean ± SD (standard deviations). Data were analyzed by one-way ANOVA for a completely randomized design using Costat version 6.311 (Copyright 1998-2005, CoHort software). Duncan's multiple range tests were used

to determine the differences among means at the level of 95%.

RESULTS AND DISCUSSION

Effect of flaxseed oil on body weight gain, feed intake and feed efficiency ratio:

Body weight gain, feed intake and feed efficiency ratio of normal rats, hypercholesterolemic rats and hypercholesterolemic rats fed different replacement levels of flaxseed oil are shown in Table (1). Data showed that hypercholesterolemic rats fed standard diet (positive control rats) had higher (P≤0.05) body weight gain than normal rats fed standard diet (negative control rats) and hypercholesterolemic rats fed different replacement levels of flaxseed oil diets. Lecumberri et al. (2007) reported that rats fed high cholesterol diet showed significant increase in body weight thus leads to secondary complications clinically. Body weight gain of hypercholesterolemic rats was significantly (P≤0.05) reduced by flaxseed oil at different replacement levels. This effect may be responsible for the beneficial action of flaxseed oil on body weight gain. Body weight gain of rats fed flaxseed oil diets was significantly (P≤0.05) lower than negative control rats with the exception of rats fed 50% flaxseed oil diets which was similar (P>0.05) to negative control rats. Flaxseed oil at 100% replacement level was more effective (P≤0.05) in reducing body weight gain than 50 and 75% replacement of flaxseed oil levels. Body weight gains in hypercholesterolemic rats fed 50, 75 and 100% replacement levels of flaxseed oil were reduced by 10.51, 13.35 and 19.95%, respectively as compared to positive control rats.

These results agree well with those reported by Rasmy (2007) who reported that linseed oil prevent the increase in body weight gain. However, EL-Sahar and Abed EL- Rahman (2014) reported that rats fed flaxseed oil (20, 30 and 40 mg/kg diet) had higher body weight gain as compared to positive and negative control rats.

Positive control rats had higher (P≤0.05) feed intake than negative control rats and hypercholesterolemic rats fed flaxseed oil diets. Feed intake of hypercholesterolemic rats fed 50, 75 and 100% replacement levels of flaxseed oil was significantly (P≤0.05) reduced by 6.07, 14.10 and 16.36%, respectively as compared to positive control rats.

No significant (P>0.05) difference in feed efficiency ratio among rats fed flaxseed oil, negative control rats and positive control rats. Also within flaxseed diet groups feed intake showed no significant (P>0.05) difference.

Effect of flaxseed oil on the liver and kidney weights:

Liver and kidney weights of normal rats and hypercholesterolemic rats fed different replacement levels of flaxseed oil are shown in Table (2). Data showed that positive control rats had higher (P≤0.05) Liver and kidney weights than negative control rats and rats fed flaxseed oil diets. Lecumberri et al. (2007) reported that rats fed high cholesterol diet showed significant increase in organ weights. Flaxseed oil at different replacement levels resulted

Table 1: Effect of flaxseed oil on body weight gain, feed intake and feed efficiency ratio of hypercholesterolemic rats

Groups	Body weight gain	Feed intake	Feed efficiency ratio
		(g)	
Negative control	31.28b ±8.92	14.89c ±3.65	2.10a ±0.22
Positive control	34.24a ±7.05	16.81a ±4.28	2.03a ±0.17
Flaxseed oil 50%	30.64b ±10.50	15.79b ±3.13	1.87a ±0.18
Flaxseed oil 75%	29.67c ±6.37	14.44c ±4.47	2.12a ±0.24
Flaxseed oil 100%	27.41d ±5.90	14.06c ±3.62	1.94a ±0.20
LSD	0.90	0.82	0.31

Means ± standard deviations in the same column with different letters are significantly different (P ≤ 0.05).

Table 2: Effect of flaxseed oil on the organ weight of hypercholesterolemic rats

Treatments	Liver weight	Kidney weight
	(g)	
Negative control	3.15b ±0.30	0.65c ±0.05
Positive control	3.42a ±0.38	1.07a ±0.09
Flaxseed oil 50%	2.88c ±0.54	0.80b ±0.08
Flaxseed oil 75%	2.80c ±0.35	0.77b ±0.09
Flaxseed oil 100%	2.70c ±0.21	0.70b ±0.14
LSD	0.25	0.14

Means ± standard deviations in the same column with different letters are significantly different (P ≤ 0.05).

in significant (P≤0.05) reduced in liver and kidney weights. This effect might be attributed to the reduction of fat tissue in liver and kidney. Liver and kidney weights of rats fed 100% flaxseed oil diets were reduced by 21.05 and 34.58%, respectively as compared to positive control rats. Liver weight in hypercholesterolemic rats fed different replacement levels of flaxseed oil was significantly (P≤0.05) lower than negative control rats. On the contrary, kidney weight in hypercholesterolemic rats fed different replacement levels of flaxseed oil was significantly (P≤0.05) higher than negative control rats. There were no significant (P>0.05) difference in liver and kidney weights among any of the flaxseed oil treatments.

Table-3. Effect of flaxseed oil on the blood glucose level of hypercholesterolemic rats

Treatments	Glucose
	Normal range (mg/dl) (50–135)
Negative control	90.88d ±3.37
Positive control	107.61a ±2.31
Flaxseed oil 50%	97.09c ±4.15
Flaxseed oil 75%	101.19b ±4.90
Flaxseed oil 100%	103.37b ±5.17
LSD	2.43

Means ± standard deviations in the same column with different letters are significantly different (P ≤ 0.05).

These results are in agreement with Rasmy (2007) who reported that linseed oil prevent the increase in liver weight. Barakat and Mahmoud (2011) found that relative organ weights of hypercholesterolemic rats were decreased significantly upon treatment with flax/pumpkin seed mixture. On contrary, EL-Sahar and Abed EL-Rahman (2014) reported that flaxseed oil caused significant increased in liver and kidney weights.

Effect of flaxseed oil on the blood glucose level:

Blood glucose level of normal rats and hypercholesterolemic rats fed different replacement levels of flaxseed oil are shown in Table (3). Blood glucose levels of all rats under this study were within the normal and safe range (50 -135 mg/dl). Within the normal range, positive control rats had higher (P≤0.05) blood glucose level (107.61 mg/dl) than negative control rats (90.88 mg/dl) and hypercholesterolemic rats fed different replacement levels of flaxseed oil (97.09 - 103.37 mg/dl). Blood glucose levels in hypercholesterolemic rats fed different replacement levels of flaxseed oil were higher (P≤0.05) than negative control rats.

Within flaxseed oil treatments, rats fed 50% replacement level of flaxseed oil had lower (P≤0.05) blood glucose level than other replacement levels of flaxseed oil. Blood glucose levels of rats fed 50, 75 and 100% replacement levels of flaxseed oil were reduced (P≤0.05) by 9.78, 5.97 and 3.94%, respectively as compared to positive control rats. Likhodii et al., (2000) reported that flaxseed oil has been shown to slow the rise in blood glucose levels due to a ketogenic diet which had a 4:1 ratio by weight of fat to protein plus carbohydrate.

Effect of flaxseed oil on the liver functions:

Several hepatic enzymes in serum were used for the biochemical markers to understand the early hepatic injury, such as ALT, AST and ALP. Table (4) showed the effect of different replacement levels of flaxseed oil on the ALT, AST and ALP in hypercholesterolemic rats. ALT, AST and ALP values of all rats under this study were within the normal and safe range. Negative control rats had lower (P≤0.05) ALT, AST and ALP enzymes than positive control rats and hypercholesterolemic rats fed different replacement levels of flaxseed oil. Positive control rats had higher (P≤0.05) ALT, AST and ALP enzymes than hypercholesterolemic rats fed different replacement levels of flaxseed oil.

ALT, AST and ALP enzymes were affected (P≤0.05) by flaxseed oil replacement levels. Flaxseed oil at 100% replacement level was more effective (P≤0.05) in reducing ALT, AST and ALP enzymes than 50 and 75% replacement levels. At 100% replacement level of flaxseed oil, ALT, AST and ALP enzymes were reduced (P≤0.05) by 23.5%, 20.21% and 8.63%, respectively as compared to positive control rats. These data supported by Al-Bashri (2013) who reported that flaxseed supplemented diet

Table 4: Effect of flaxseed oil on the liver functions of hypercholesterolemic rats

Treatments	ALT	AST	ALP
	Normal range (u/l)		
	(12 –32)	(45 –80)	(57-128)
Negative control	12.35d ±0.55	48.15d ±0.18	71.84d ±0.37
Positive control	23.96a ±0.18	79.26a ±0.37	90.45a ±1.51
Flaxseed oil 50%	19.27b ±0.33	66.54b ±0.01	86.54b ±0.14
Flaxseed oil 75%	18.68c ±0.48	66. 39b ±0.02	85.62b ±0.36
Flaxseed oil 100%	18.33c ±0.30	63.24c ±0.37	82.64c ±0.67
LSD	0.52	0.33	1.02

Means ± standard deviations in the same column with different letters are significantly different (P ≤ 0.05)

Table 5: Effect of flaxseed oil on the kidney functions of hypercholesterolemic rats

Treatments	Urea	Uric acid	Creatinine
	Normal range (mg/dl)		
	(24 – 52)	(1.85 – 3.50)	(0.2 – 0.95)
Negative control	37.58b ±0.44	1.92c ±0.13	0.85a ±0.05
Positive control	45.6a ±0.20	3.94a ±0.25	0.93a ±0.03
Flaxseed oil 50%	24.82c ±0.69	2.55b ±0.24	0.84a ±0.06
Flaxseed oil 75%	24.86c ±0.66	2.58b ±0.33	0.88a ±0.04
Flaxseed oil 100%	25.04c ±0.52	2.67b ±0.23	0.86a ±0.03
LSD	0.70	0.32	0.06

Means ± standard deviations in the same column with different letters are significantly different (P ≤ 0.05).

Table 6: Effect of flaxseed oil on the triglyceride and total Lipid of hypercholesterolemic rats

Treatments	Triglyceride	Total Lipids
	Normal range (mg/dl)	
	(55– 76)	(210 – 300)
Negative control	74.92e ±2.63	253.27e ±0.40
Positive control	159.16a ±10.73	327.41a ±0.39
Flaxseed oil 50%	98.28b ±2.21	280.36b ±0.42
Flaxseed oil 75%	92.74c ±2.53	274.13c ±0.23
Flaxseed oil 100%	86.50d ±3.98	271.65d ±0.37
LSD	3.20	0.49

Means ± standard deviations in the same column with different letters are significantly different (P ≤ 0.05).

Table 7: Effect of flaxseed oil on the lipoproteins of hypercholesterolemic rats

Treatments	Total-cholesterol	LDL	VLDL	HDL
	Normal range (mg/dl)			
	(40 – 130)	(30 – 39)	(11 – 17)	(43 – 69)
Negative control	87.15e ±1.66	28.00e ±1.55	14.98e ±1.92	44.17a ±0.33
Positive control	264.84a ±5.35	209.99a ±6.60	31.83a ±2.96	23.02e ±0.17
Flaxseed oil 50%	102.08b ±0.54	52.54b ±4.97	19.65b ±3.16	29.89d ±0.23
Flaxseed oil 75%	95.67c ±0.58	45.59c ±2.85	18.54c ±2.22	31.54c ±0.19
Flaxseed oil 100%	92.31d ±1.45	40.54d ±2.63	17.30d ±1.22	34.47b ±0.39
LSD	3.24	3.47	1.17	0.36

Means ± standard deviations in the same column with different letters are significantly different (P ≤ 0.05).

significantly lowered the plasma level of liver functional markers including ALT and AST in hypertensive rats.

Although ALT, AST and ALP enzyme values were reduced in the hypercholesterolemic rats fed different replacement levels of flaxseed oil, but their values were still higher (P≤0.05) than those values of the negative control rats.

Effect of flaxseed oil on the kidney functions:

Kidney removes metabolic wastes such as urea, uric acid and creatinine. The concentrations of the metabolites increase in blood during renal diseases or renal damage may due to high activities of xanthine oxidase, lipid peroxidation, and increased triacylglycerol and cholesterol levels (Anwar and Meki, 2003).

Kidney functions of normal rats and hypercholesterolemic rats fed different replacement levels of flaxseed oil are shown in Table (5). Urea, uric acid and creatinine values of rats under this study were within the normal and safe range with the exception of uric acid values of positive control rats which were higher than the normal and save range. Positive control rats had higher (P≤0.05) urea and uric acid than negative control rats and hypercholesterolemic rats fed different replacement

levels of flaxseed oil. Barakat and Mahmoud (2011) reported that feeding rats with cholesterol-enriched diet caused a significant increase in serum urea.

Flaxseed oil at different replacement levels resulted in significant (P≤0.05) reduce in urea and uric acid as compared with positive control rats. The means reduction in urea and uric acid of rats fed different replacement levels of flaxseed oil were 45.33 and 34.01%, respectively as compared to positive control rats. There were no significant (P>0.05) difference in urea and uric acid among any of the flaxseed oil treatments. These results were supported by EL-Sahar and Abed EL- Rahman (2014) who reported that flaxseed oil (20, 30 and 40 g/kg diet) improved kidney functions in rats. Flaxseed (3, 5 and 7 g/100g diet) reduced urea and uric acid values in rats suffer from nephropathy (El-Sayed et al, 2014). Al-Bashri (2013) reported that flaxseed supplemented diet significantly lowered the plasma level of kidney functional markers including urea, uric acid, creatinine and renin in hypertensive rats.

Hypercholesterolemic rats fed different replacement levels of flaxseed oil had lower (P≤0.05) urea values than negative control rats. In contrary to, they had higher (P≤0.05) uric acid values than negative control rats. Data indicated that feeding rats with different replacement levels of flaxseed oil returned the uric acid values in hypercholesterolemic rats to the normal and save range value.

No significant (P > 0.05) difference in the creatinine values among all treatments under this study. Creatinine values were not affected (P>0.05) by High cholesterol diet (positive control rats) and flaxseed oil at different replacement levels. These results were differed from those reported by El-Sayed et al, (2014) and Barakat and Mahmoud (2011).

Effect of flaxseed on the triglyceride and total lipids:

Triglyceride and total lipids of normal rats and hypercholesterolemic rats fed different replacement levels of flaxseed oil are shown in Table (6). The results showed that positive control rats had (P≤0.05) higher triglyceride and total lipids values than negative control rats and rats fed different replacement levels of flaxseed oil. FadlAlla et al, (2014) reported that high cholesterol fed diet rats showed a significant increase in triglyceride and total lipids in serum compared to control rats.

Triglyceride and total lipids values of positive control rats were higher than the normal and save range. Flaxseed oil at different replacement levels resulted in significant (P≤0.05) decrease in triglyceride and total lipids as compared with positive control rats. Triglyceride and total lipids were significantly (P≤0.05) decreased by increasing the replacement level of flaxseed oil in the hypercholesterolemic rat diets.

Although Flaxseed oil at different replacement levels reduced triglyceride and total lipids values in the hypercholesterolemic rats, but their values still higher than negative control rats. The reduction in triglyceride and total lipids in hypercholesterolemic rats fed 100% replacement level of flaxseed oil were 45.65 and 16.93%, respectively as compared to positive control rats. These results agree well with those reported by Rasmy (2007) who reported an increase in triglyceride and total lipid in hyperlipidemic rats fed linseed oil as compared with those feeding normal diet. EL-Sahar and Abed EL-Rahman (2014) reported that flaxseed oil (20, 30 and 40 g/kg diet) decreased triglycerides values in rats.

Effect of flaxseed oil on the lipoproteins:

Lipoproteins of normal rats and hypercholesterolemic rats fed different replacement levels of flaxseed oil are shown in Table (7). The results showed that positive control rats had higher (P≤0.05) total cholesterol, LDL and VLDL values than negative control rats and rats fed different replacement levels of flaxseed oil. However, HDL values had an opposite trend. Cholesterol-enriched diet resulted in a significant increase in total cholesterol, total lipids, phospholipids and triacylglycerols in plasma this accompanied by increased serum LDL level, with decreased circulating HDL, thus providing a model for dietary hyperlipidemia (Cohen et al., 2005). The high cholesterol level in plasma may be due to increased uptake of exogenous cholesterol and subsequent deposition and decreased cholesterol catabolism as evidenced by a reduction in bile acid production and turnover of bile acids. The metabolism of free and ester cholesterol are impaired in liver and spleen tissue and the rate of turnover was specifically decreased in all tissues of hyperlipidemic rat (Shah et al., 2001).

Total cholesterol, LDL and VLDL values of positive control rats were higher than the normal and save range. Also HDL values had an opposite trend. Flaxseed oil at different replacement levels resulted in significant (P≤0.05) decreased in total cholesterol, LDL and VLDL values and a significant (P≤0.05) increased in HDL values as compared with positive control rats. Total cholesterol, LDL and VLDL values were significantly (P≤0.05) decreased by increasing the replacement level of flaxseed oil in the hypercholesterolemic rat diets. However, HDL values were significantly (P≤0.05) increased by increasing the replacement level of flaxseed oil in the hypercholesterolemic rat diets. The reduction in total cholesterol, LDL and VLDL in hypercholesterolemic rats fed 100% replacement level of flaxseed oil were 65.14, 80.69 and 45.65%, respectively as compared to positive control rats. On the other hand, HDL value was increased by 49.74%. Rahman et al., (2014) reported that flaxseed oil (50ml/kg body weight) has strong and significant anti-cholesterol effects on hypercholesterolemic rats. Hussein et al., (2014) reported that flaxseed oil in rats fed high cholesterol

diet resulted in significant decrease in serum total cholesterol, LDL and VLDL level as compared to control rats.

Although total cholesterol, LDL and VLDL values were reduced in the hypercholesterolemic rats fed different replacement levels of flaxseed oil, but their values were still higher (P≤0.05) than those values of the negative control rats.

CONCLUSION

From the above mentioned results it could be concluded that flaxseed oil at different replacement levels resulted in significant improved in lipids profile, liver and kidney functions and glucose levels in serum of hypercholesterolemic rats.

Conflict of Interests:

The authors declare that there is no conflict of interests regarding the publication of this paper.

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