

## **EFFECT OF DIETS CONTAINING VIRGIN OLIVE , CANOLA OR LINSEED OILS ON SERUM LIPID AND LIPOPROTEIN LEVELS OF RATS**

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### **ABSTRACT**

Three vegetable oils (virgin olive, crude canola, or linseed oils) were used as diet additives to compare their effects on lipid profile of blood serum of experimental rats in the presence of egg yolk as a source of cholesterol. Corn meal (1.6% fat) was used as control diet, the positive control diet composed of corn meal plus 9% egg yolk (about 0.15% cholesterol). The other three diets composed of positive control plus 14% olive, canola or linseed oils. Lipid parameters were determined in rat's blood serum after 21, 36 and 46 days from feeding . Obtained data revealed that both canola and linseed oils containing diets significantly decreased total cholesterol (TC), triacylglycerol(TG) and low-density lipoprotein cholesterol (LDL-c) and increased high-density lipoprotein cholesterol (HDL-c) levels in relation to positive control diet. Data of olive oil containing diet showed a significant increase in TC, TG, and HDL-c at the end of nutrition experiment. Whereas no significant difference in LDL-c between positive control and olive oil containing diet.

### **INTRODUCTION**

Lipoproteins are large molecules that facilitate the transport of non polar fats in a polar solvent, the blood stream. Low-density lipoproteins (LDL) are the major carriers of cholesterol in the plasma, and thus a strong relationship exists between elevated LDL levels and cardiovascular disease (Martin *et al.*, 1986). High density lipoproteins are the most dense particules with the highest protein and phospholipids content (Jonas, 2002), their levels are inversely associated with atherosclerosis, i.e high levels are protective (Williams *et al* ,1990; Brown and Fuster ,1996)

For good cardiovascular health, the concentration of total cholesterol in blood must be kept low with a low level of LDL. The drugists are concerning with developing new medications to solve the problem of elevated cholesterol and triacylglycerol levels in blood stream of humans to minimize the risk factors of coronary heart disease. On the other hand, nutritionalists are meditating on improving lipid profile of blood serum and liver of the individuals by controlling the composition of the daily diets.

Several publications dealt with the desirable effect of vegetable oils on modulating hyperlipoproteinemias in animals and humans (Kris-Etherton *et al.*, 1999; Wilson *et al.*, 2000; Mangas-Cruz *et al.*, 2001).

Dietary fat selection is known to exert a major influence on circulating cholesterol levels, they are raised with consumption of fats containing saturated fatty acids and reduced with fats rich in monounsaturated and polyunsaturated fatty acids (Mattson and Grundy, 1985; Wilson *et al*, 2000) .The studies which have demonstrated the effects of dietary fatty acids on serum and liver lipid levels have not always been consistent. Some studies have shown that monounsaturated fatty acids reduce serum lipid levels,

others showed that they have neutral effect (Keys *et al.*, 1957; Hegsted *et al.*, 1965). Other studies have shown that all polyunsaturated fatty acids reduce effectively serum lipid levels ( Harris *et al.* 1983; Nestel 1990). However, others have shown that the degree of unsaturation is what affects more potentially serum and liver lipids ( Ide *et al.*, 1978). There has been also other studies which did not show any significant effects of dietary PUFA on serum lipid levels, and some studies showed that they have adverse effects on serum lipid profile ( Leaf and Weber 1988; Nelson *et al.*, 1989). So, there is still need for consensus on these effects. Therefore, three oils were used in this investigation as additives to rat's diet to compare their effects on lipid profile of blood serum of Wistar male rats in the presence of egg yolk as a cholesterol source. These oils are, virgin olive, crude canola and linseed oils. These oils are differ from each other in their content of fatty acids and degree of unsaturation.

## **MATERIALS AND METHODS**

### **Sampling**

- Virgin olive oil was obtained from a farm - Sewa Oasis, Egypt.
- Crude canola oil was obtained from Ministry of Agriculture, Cairo, Egypt.
- Crude linseed oil was purchased from local oil mill in Mehalla El-kobra city, Egypt.
- Corn meal (the backbone of all experimental diets) was purchased from the local market.
- Egg yolk was separated from egg white, and then stirred and air dried for 24 hours. The air dried egg yolk (moisture about 7%) was used as a cholesterol source.

### **Experimental diets**

Low fat corn meal was used as a control diet, other four different diets were prepared. The first one was prepared by mixing the corn meal with the air-dried egg yolk in percentage of 9% to get a diet with about 6% fat (positive control diet). The second diet was composed of positive control supplemented with 14% virgin olive oil to get a diet with total fat about 20%. The third and the fourth diets were consisted of the positive control supplemented with 14% canola or linseed oil, respectively.

Moisture, protein, lipids, carbohydrates, fibers and ash contents of corn meal and air dried egg yolk were determined according to AOAC (2000).

### **Identification and determination of total fatty acids**

Fatty acid methyl esters of the oils were determined according to AOAC(2000)using Varian gas liquid chromatograph instrument.

### **Nutrition experiment**

A number of thirty five Wistar male rats were divided into five groups (7 animals for each), and fed ad-libitum one of the forementioned diets for forty six days. Blood samples were taken from the orbital plexus in the eyes of rats after 21, 36 and 46 days from feeding. Serum was separated from blood samples in centrifuge tubes and centrifuged at 4000 rpm for 20 min. to separate serum which were kept frozen till analysis.

**Serum lipids analysis**

Serum was analyzed by *human kits* for total cholesterol (TC), triacylglycerol (TG) and high density lipoprotein cholesterol (HDLc) according to Rosclau *et al.* (1974) ; Schettler and Nussel (1975); Friedewald *et al.* (1972) , respectively . LDL-c was calculated by the equation of *Friedewald et al.* (1972). \*LDL-c = TC - [TG/5 + HDL-c] \*

**Statistical analysis**

All statistical analyses were carried out using the statistical SAS program( SAS,1996), and p value of <0.05 was selected as a limit of statistical significance.

**RESULTS AND DISCUSSION**

**Chemical composition of corn meal and air dried egg yolk**

The corn meal diet contained moisture, lipids, protein, carbohydrates, fibers and ash in percentages of 10.60, 1.60 19.00, 56.20, 3.15 and 9.40 , respectively (table 1). Whereas air dried egg yolk contained 7.10, 59.11, 30.3 1.30, 0.00 and 2.04 for the same constituents, respectively.

**Table (1): Chemical composition of corn meal and air dried egg yolk .**

Component %	Moisture	Lipids	Proteins	Carbohydrates	Fiber	Ash
Corn meal	10.60	1.60	19.00	56.20	3.15	9.40
Dried egg yolk	7.10	59.11	30.30	1.30	0.00	2.04

Air dried Egg yolk contained cholesterol range between 19.10 and 23.30 mg/g egg yolk ( *Pasin et al.*,1998; Nutrition data, 2008). In other words ,diet which contain 9% egg yolk should contain about 0.15% cholesterol .

**Table ( 2): Fatty acid composition of dietary oils .**

Fatty acid \ Oil type	Olive oil	Canola oil	Linseed oil
C 12 : 0	0.72	0.00	0.00
C 14 : 0	10.57	0.55	0.56
C 16 : 0	14.66	4.39	5.93
C 16 : 1	0.11	0.1	0.1
C 17 : 0	0.00	0.00	0.03
C18 : 0	2.15	1.35	2.89
C 18 : 1	51.14	68.44	20.27
C 18 : 2	11.35	17.92	16.37
C 18 : 3	1.54	6.24	53.22
C 20 : 0	0.12	0.15	0.00
C 20 : 1	0.45	0.00	0.00
C 20 : 4	0.00	0.77	0.00
C 22 : 0	1.63	0.00	0.00
C 22 : 1	2.49	0.00	0.00
Total saturated fatty acids	29.85	6.44	9.38
Total monounsaturates	54.19	68.54	20.37
Total polyunsaturates	12.89	24.16	69.59

**Serum lipids**

Tables (3), (4) and (5) show data of serum lipids of the experimental animals after 21, 36 and 46 days, respectively. Total cholesterol of the first group(C) of animals was 46.87 mg/dl after 21 days from feeding, this value increased to 58.08 mg/dl and 64.33mg/dl after 36 and 46 days, respectively. Although the used control diet contains a very low percentage of fat (1.6%), blood serum of this group of animals contained a considerable quantity of cholesterol. This may due to the ability of the animal body to synthesize cholesterol from acetate, as reported by (Jonas, 2002).

Incorporation of egg yolk into the corn meal [ positive control ,(PC)] resulted in higher value of serum total cholesterol, this value increased as feeding period increased. In other words, total cholesterol was 71.52 mg/dl after 21 days, it reached to 83.11 and 87.52 mg/dl after 36 and 46 days, respectively.

Feeding experimental animals corn meal diet supplemented with a mixture of egg yolk and virgin olive oil, canola oil or linseed oil for 21 days resulted in significant higher values of serum total cholesterol when compared to those of control diet. On the other hand these values still lower than those of animals fed corn meal diet mixed only with egg yolk (PC). In other words incorporation of vegetable oils(olive, canola or linseed oils) into the diet decreased serum total cholesterol. Extending the nutrition experiment for 36 and 46 days, similar results were obtained expect for the diet contained egg yolk and olive oil ; serum total cholesterol of rats fed this diet was little higher than those fed diets containing egg yolk only as shown in tables (4) and (5) . Figure (1) showed also the values of serum total cholesterol and triacylglycerol of experimental animals fed the forementioned diets for the periods mentioned before.

**Table (3): Serum lipids of rats after 21 days from feeding diets containing one of the tested oils in the presence of egg yolk.**

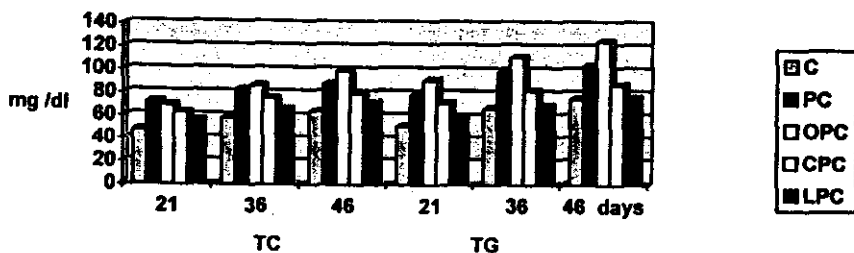
Diets		C	PC	O PC	C PC	L PC
Serum lipids						
TC	(mg/dl)	46.87 <sup>(b)</sup>	71.52 <sup>(a)</sup>	68.51 <sup>(a)</sup>	63.44 <sup>(b)</sup>	55.99 <sup>(c)</sup>
TG	(mg/dl)	51.28 <sup>(d)</sup>	77.8 <sup>(b)</sup>	91.3 <sup>(a)</sup>	71 <sup>(b)</sup>	59.9 <sup>(c)</sup>
HDL-c	(mg/dl)	21.83 <sup>(b)</sup>	26.71 <sup>(b)</sup>	26.71 <sup>(b)</sup>	29.22 <sup>(a)</sup>	31.1 <sup>(a)</sup>
LDL-c	(mg/dl)	14.79 <sup>(d)</sup>	29.25 <sup>(a)</sup>	23.54 <sup>(b)</sup>	20.01 <sup>(c)</sup>	12.91 <sup>(d)</sup>
HDL-c/LDL-c		1.48 <sup>(b)</sup>	0.91 <sup>(c)</sup>	1.13 <sup>(c)</sup>	1.46 <sup>(b)</sup>	2.41 <sup>(a)</sup>
HDL-c/TC		0.46 <sup>(b)</sup>	0.37 <sup>(c)</sup>	0.39 <sup>(c)</sup>	0.46 <sup>(b)</sup>	0.55 <sup>(a)</sup>

Mean values followed by different letters are significantly different ( $p < 0.05$ ). [diets: C (control corn meal); PC, corn meal + egg yolk (positive control); OPC , (positive control) + olive oil. ; CPC, (positive control) + canola oil; LPC, (positive control) + linseed oil]

Table (4): Serum lipids of rats after 36 days from feeding diets containing one of the tested oils in the presence of egg yolk .

Diets*		C	PC	OPC	CPC	LPC
<b>Serum lipids</b>						
TC	(mg/dl)	58.08 <sup>(d)</sup>	83.11 <sup>(a)</sup>	85.67 <sup>(a)</sup>	74.99 <sup>(b)</sup>	66.39 <sup>(c)</sup>
TG	(mg/dl)	67.2 <sup>(d)</sup>	99.8 <sup>(b)</sup>	111.4 <sup>(a)</sup>	81.62 <sup>(b)</sup>	69.0 <sup>(c)</sup>
HDL-c	(mg/dl)	23.89 <sup>(d)</sup>	29.81 <sup>(c)</sup>	32.9 <sup>(b)</sup>	38.09 <sup>(a)</sup>	38.63 <sup>(a)</sup>
LDL-c	(mg/dl)	18.75 <sup>(b)</sup>	33.34 <sup>(a)</sup>	30.48 <sup>(a)</sup>	20.56 <sup>(b)</sup>	13.95 <sup>(c)</sup>
HDL-c/LDL-c		1.27 <sup>(b)</sup>	0.89 <sup>(c)</sup>	1.08 <sup>(c)</sup>	1.85 <sup>(a)</sup>	2.77 <sup>(a)</sup>
HDL-c/TC		0.41 <sup>(c)</sup>	0.35 <sup>(d)</sup>	0.38 <sup>(d)</sup>	0.50 <sup>(b)</sup>	0.58 <sup>(a)</sup>

Mean values followed by different letters are significantly different ( $p < 0.05$ ). [\*diets: C (control corn meal); PC, corn meal + egg yolk (positive control); OPC, (positive control) + olive oil. ; CPC, (positive control) + canola oil; LPC, (positive control) + linseed oil]



Fig(1): Serum total cholesterol (TC) and triacylglycerol (TG) of rats fed different diets for different periods .

[diets: C (control corn meal); PC, corn meal + egg yolk (positive control); OPC, (positive control) + olive oil. ; CPC, (positive control) + canola oil; LPC, (positive control) + linseed oil]

Concerning serum triacylglycerol, the type of diet affected their values significantly. When egg yolk was added to the diet, triacylglycerol increased to 77.8, 99.8 and 103.6 after nutrition periods of 21, 36 and 46 days, respectively. Incorporation of olive oil into the positive control diet(OPC) resulted in a significant increase of TG to be 91.3, 111.4 and 124.6, after the same periods of nutrition, respectively. On the other hand incorporation of canola or linseed oils into the positive control diet(CPC and LPC) caused a significant decrease in serum triacylglycerol. In case of canola oil, TG values were 71.00, 81.62 and 86.80 mg/dl after feeding periods of 21, 36 and 46 days, respectively. The lowest TG values were obtained when linseed oil was added to the diet, where they decreased to be 59.90, 69.00 and 76.05 mg/dl after the forementioned periods of feeding, respectively.

Table (5): Serum lipids of rats after 46 days from feeding diets containing one of the tested oils in the presence of egg yolk.

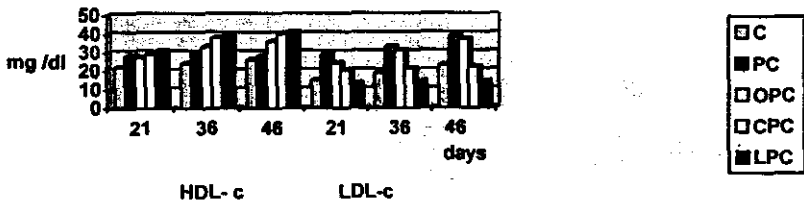
Diets*	C	PC	OPC	CPC	LPC
TC (mg/dl)	64.33 <sup>(d)</sup>	87.52 <sup>(b)</sup>	98.85 <sup>(a)</sup>	79.23 <sup>(c)</sup>	70.35 <sup>(d)</sup>
TG (mg/dl)	75.4 <sup>(d)</sup>	103.6 <sup>(b)</sup>	124.6 <sup>(a)</sup>	86.8 <sup>(c)</sup>	76.05 <sup>(d)</sup>
HDL-c (mg/dl)	25.91 <sup>(e)</sup>	27.53 <sup>(e)</sup>	36.23 <sup>(b)</sup>	39.6 <sup>(a)</sup>	40.86 <sup>(a)</sup>
LDL-c (mg/dl)	23.34 <sup>(b)</sup>	39.27 <sup>(a)</sup>	37.7 <sup>(a)</sup>	22.26 <sup>(b)</sup>	14.18 <sup>(c)</sup>
HDL-c/LDL-c	1.11 <sup>(e)</sup>	0.70 <sup>(c)</sup>	0.96 <sup>(c)</sup>	1.78 <sup>(b)</sup>	2.88 <sup>(a)</sup>
HDL-c/TC	0.40 <sup>(c)</sup>	0.31 <sup>(e)</sup>	0.36 <sup>(d)</sup>	0.50 <sup>(b)</sup>	0.58 <sup>(a)</sup>

Mean values followed by different letters are significantly different ( $p < 0.05$ ). [\*diets: C (control corn meal); PC, corn meal + egg yolk (positive control); OPC, (positive control) + olive oil. ; CPC, (positive control) + canola oil; LPC, (positive control) + linseed oil]

The obtained results for serum total cholesterol and triacylglycerol agreed to a large extent with those obtained by several researchers. For instance, Dullo *et al* (1995) found that, rats fed high level of olive oil showed a significant increase of serum cholesterol and triacylglycerol levels as compared to sunflower oil. Yaqoub *et al* (1995) found that rats fed high fat diets containing olive oil and hydrogenated coconut oil had higher serum triacylglycerol concentrations than those fed low fat or high fat diets containing evening primrose oil, menhaden fish oil or sunflower oil. The high cholesterol value obtained by addition of olive oil to the diet (OPC) may be due to the high content of squalene; a direct precursor of cholesterol; in the unsaponifiable fraction of olive oil. In this respect Perez-Jimenez *et al*. (1995) reported that squalene was 17 times higher in olive oil than in oleic acid rich sunflower oil.

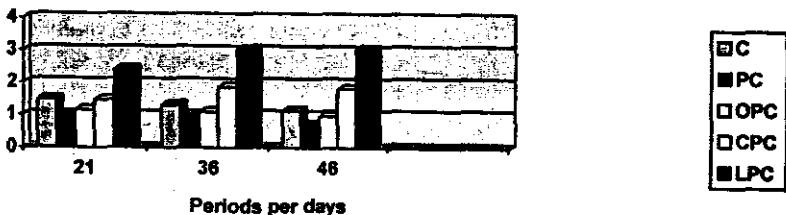
Addition of vegetable oils (olive, canola or linseed oils) to the diet resulted in a desirable effect on serum lipoproteins of the experimental animals when compared to the other two diets (C, PC). In other words, high density lipoprotein cholesterol, HDL-c, (the protective lipoprotein) increased, whereas low density lipoprotein cholesterol, LDL-c, (the harmful lipoprotein) decreased. Tables (3), (4) and (5) and figure (2) showed an increase in HDL-c values as a result of incorporation of olive, canola or linseed oils into the diet. On using olive oil(OPC), HDL-c were 26.71, 32.9 and 36.23mg/dl after 21, 36 and 46 days of feeding, respectively. Canola oil had more desirable effect on HDL-c, i.e., its values were higher than those of olive oil (29.22, 38.09 and 39.6 mg/dl, respectively). The most desirable effect was achieved when linseed oil was incorporated into the diet. HDL-c were 31.1, 38.63 and 40.86 mg/dl after 21, 36 and 46 days of feeding, respectively.

In case of LDL-c (the undesired lipoprotein), the used vegetable oils led to lower values of LDL-c when compared to the positive control diet (PC). The lowest values of LDL-c were obtained when linseed oil was used (tables 3,4,5 and fig.2 ).

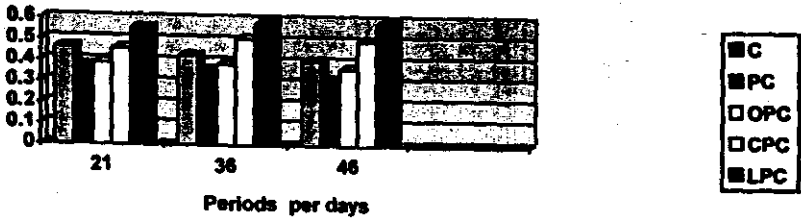


**Fig (2): HDL-c and LDL-c of rats fed different diets for different periods .**  
 [diets: C (control corn meal); PC, corn meal + egg yolk (positive control); OPC , (positive control) + olive oil. ; CPC, (positive control) + canola oil; LPC, (positive control) + linseed oil]

In order to intensify the difference between lipid sources of the diets, HDL-c/LDL-c and HDL/TC ratios were calculated (tables 3, 4, 5 and figures 3 and 4). It could be seen that, the highest ratios were achieved when linseed oil was used followed by canola and olive oils, respectively. HDL-c/LDL-c and HDL-c/TC ratios give an idea about the potency of the used oil as hypocholesterlemic and antiatherosclerotic nutrient . It means that the higher values of HDL-c/LDL-c and HDL-c/TC ratios ascertain the more desirable effect of the used oil .



**Figure(3): HDL-c / LDL-c ratio of rats fed different diets for different periods**  
 [diets: C (control corn meal); PC, corn meal + egg yolk (positive control); OPC , (positive control) + olive oil. ; CPC, (positive control) + canola oil; LPC, (positive control) + linseed oil]



**Figure (4): HDL-c / TC ratio of rats fed different diets for different periods.**

[diets: C (control corn meal); PC, corn meal + egg yolk (positive control); OPC , (positive control) + olive oil. ; CPC, (positive control) + canola oil; LPC, (positive control) + linseed oil]

Our results for serum lipoproteins were in accordance with those obtained by other researchers. In the present investigation, it was mentioned that olive oil had desirable effect on rat's serum lipoprotein, but canola oil had more favourable one. These findings agreed with Baba *et al.*(2000) who showed that rats received high fat diet containing olive oil , had a significantly high serum triacylglycerol and a significantly HDL-c/TC ratio compared with those received high fat diets containing canola or soybean oils. Also, Pedersen *et al.* (2000) showed that rapeseed and sunflower oils had more desirable effects on blood lipids compared with olive oil. In other reports, several investigators attributed the desirable effect of both olive and canola oils to the high percentage of monounsaturated fatty acids exist in both oils ( Baba *et al.* , 1999; Nardini *et al.* 1992). These reports agreed with our results,i.e, the percentage of monounsaturated fatty acids were determined in the present investigation(table 2) , and their amounts were 54.14% and 68.54% for olive and canola oils , respectively. Moreover, it can be seen from table (2) that canola oil contained higher level of linoleic acid which has a hypocholesterolemic and hypolipidemic potential as stated by(Renaud *et al.*,1986 ; Hunter ,1990).

As mentioned before, linseed oil had the best results as hypocholesterolemic and hypotriacylglycerolemic nutrient. It might be due to its high content of linolenic acid. In this respect, Ihara-Watanabe *et al.*(2000) showed that  $\alpha$ -linolenic acid had higher hypocholesterolemic ability than linoleic acid .

Generally, the three vegetable oils, used in the present investigation had desirable effect on lipid profile of rats , but with different potencies.



The activity of these oils may be due to the combination of monounsaturated and polyunsaturated fatty acids in addition to their contents of unsaponifiable fraction. In this respect, Kris-Etherton *et al.* (1993) showed that diets high in polyunsaturated and monounsaturated fatty acids promote reduced fat accumulation and lower plasma cholesterol. Table (2) showed the fatty acid composition of the used oils along with the calculated values of total monounsaturated and polyunsaturated fatty acids.

Olive oil contained high level of monounsaturated fatty acids (54.19%) and lower level of polyunsaturated fatty acids (12.89%) of which linoleic acid is the most abundant (11.35%), therefore, its activity may firstly be due to its high content of monounsaturated fatty acids, and secondly to polyunsaturated fatty acids.

Canola oil contained higher level of monounsaturated fatty acids (68.54%) and polyunsaturated fatty acids (24.16%). So, as expected, canola oil had higher potency as hypolipidemic and hypocholesterolemic nutrient. Our findings agreed with several reports, for instance Baba *et al.* (1999) showed that canola oil was more effective than olive oil. Another factor; that made canola oil more preferable, was its lower content of saturated fatty acids (6.44%) than that of olive oil (29.85%). In this respect, Jin (2003), reported that palm oil (rich in saturated fatty acids) caused undesirable effect on cholesterol and lipid profile when compared with other oils rich in monounsaturated or polyunsaturated fatty acids.

Linseed oil contained the highest level of polyunsaturated fatty acids (69.59%) mainly linolenic acid, with considerable amount of monounsaturated fatty acids (oleic acid, 20.27%). In the same time, it had the best results in lowering total cholesterol and improving lipid profile of blood serum of rats received diet containing this oil. These findings confirmed several reports of other researchers. For instance Baba *et al.* (1999) demonstrated that  $\alpha$ -linolenic acid enriched virgin olive oil had better results than virgin olive oil in lowering plasma total cholesterol and serum triacylglycerol and increasing HDL-c/TC ratio. Ihara-Watanabe (2000) stated that  $\alpha$ -linolenic acid had hypocholesterolemic ability than oleic acid. Furthermore, Akila and Masoud (2002) reported that linseed oil, a rich source of n-3 fatty acids, caused a decrease in the level of serum total cholesterol of rats fed a diet containing this oil. They added that, such reduction was also important as it was accompanied with an increase in HDL-c and decrease in LDL-c.

The mode of action of vegetable oils as hypolipidemic agent could be interpreted by their effects on the enzymes responsible for lipid metabolism (lipogenesis and liponeogenesis). In this respect Girard *et al.* (1994) reported that, the activity of lipogenic enzymes is regulated by changes in hormonal and nutritional conditions. Much of the literature has reported a potent inhibitory effect of polyunsaturated acids on hepatic fatty acids and triacylglycerol synthesis, whereas saturated and monounsaturated fatty acids exhibit little or no inhibitory capability (Toussant *et al.*, 1981; Clarke, 2000). Lipoprotein lipase activity was also affected by nutrition conditions, inverse relation between serum triacylglycerol levels and lipoprotein lipase activity was reported by VanHeek and Zilversmit (1991) and Lottenberg *et al.* (1992). It has also been shown that rats fed oleic acid rich oils had lower activities of

lipoprotein lipase relative to rats fed linoleic acid rich oils, (Groot *et al* ,1988). Levy *et al.*, (1991) found that rats fed olive oil demonstrated a decreased activity of lipoprotein lipase and an increased triglycerides biosynthesis and release by the liver. In the same study, the researchers showed that a diet rich in PUFAs caused an increase of adipose tissue lipoprotein lipase (LPL) activity with a concomitant decrease in serum triacylglycerol. Also, n-3 PUFA could exert the positive effects through increasing  $\beta$ -oxidation rates. In this respect, (Ide *et al.*, 2000), reported that linseed oil could have exerted its protective effects probably as a better substrate for mitochondria and peroxisomal  $\beta$ -oxidation. (Murase *et al.*, 2005), demonstrated that  $\alpha$ -linolenic rich diets reduce hepatic lipid accumulation by both stimulating  $\beta$ -oxidation and by suppressing fatty acid synthesis. .Morise *et al.*, (2004), stated that  $\alpha$ -linolenic rich linseed oil resulted 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.

From the previous results it could be noticed that diets rich in polyunsaturated fats had the most desirable effect on lipid parameters of serum of experimental rats . On the other hand, it well known that PUFA are more susceptible to lipid peroxidation than MUFA. The oxidation hypothesis of atherosclerosis suggests that circulating LDL is oxidized in vivo which leads to its enhanced uptake by macrophages inside the arterial system and is belived to subsequently result in foam cell formation , one of the first stages of atherogenesis (Witztum and Steinberg1991;Liu et al 1992) . Therefore, one have to keep in mind that diets containing oils rich in PUFA should also enriched with antioxidants in addition to the antioxidants naturally occurred in the oils; as they play an important role in preventing lipid oxidation and slowing the progression of atherosclerotic lesions(Kita *et al.* ,1987) .

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تأثير وجبات محتوية على زيت الزيتون البكر أو زيت الكانولا أو زيت بذرة الكتان على مستويات الليبيدات والليپوپروتينات في دم فئران التجارب  
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تم دراسة تأثير ثلاثة من الزيوت الغذائية وهي زيت الزيتون البكر، زيت بذرة الكانولا الخام وزيت بذرة الكتان الخام ( في وجود صفار البيض كمصدر للكوليستيرول ) على مستويات ليبيدات الدم المختلفة في فئران التجارب . تم تحضير ثلاثة وجبات تتكون أساسا من علف الذرة المنخفضة الدهن (١٠,٦%) مضاف إليه ٩% من وزنه صفار بيض مجفف + ١٤% من وزن الوجبة واحد من الزيوت الثلاثة . استخدم علف الذرة بدون إضافات كوجبة مقارنة كما جهزت وجبة أخرى محتوية على ٩% صفار البيض كوجبة مقارنة موجبة ، بهذه الطريقة نكون قد حصلنا على خمس وجبات غذيت عليها خمس مجموعات من فئران التجارب كل مجموعة تحتوي على ٧ فئران ، وقد تم تقدير الليبيدات المختلفة في سيرم الدم للفئران بعد ٢١ ، ٣٦ ، ٤٦ يوم من التغذية . وقد أظهرت النتائج قدرة زيت الكانولا والكتان على خفض مستويات الكوليستيرول الكلى (TC) والجليسريدات الثلاثية (TG) وليپوپروتينات الكوليستيرول منخفض الكثافة (LDL-C) كذلك زيادة ليپوپروتينات الكوليستيرول مرتفع الكثافة (HDL-C) معنويا خلال الفترات الثلاثة بالمقارنة بمثلاتها في وجبة المقارنة الموجبة ( المحتوية على صفار البيض ) . بينما أظهرت نتائج مجموعة للفئران المغذاة على الوجبة المحتوية على زيت الزيتون زيادة معنوية في الكوليستيرول الكلى والجليسريدات الثلاثية و ليپوپروتينات الكوليستيرول مرتفع الكثافة وذلك في نهاية مدة التغذية بالمقارنة بالوجبة الموجبة ، مع عدم وجود فروق معنوية بينهما في مستوى ليپوپروتينات الكوليستيرول منخفض الكثافة .