



Effect of *Olea Europea*, *Allium sativum* and *Nigella sativa* oils on concentration of some biochemical parameters in serum of hyperlipidemic male rats

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Abstract:

The potential health benefits of various dietary oils in relation to the cardiovascular disease (CVD) recently receiving considerable attention. One of the risk factor for development of CVD is hyperlipidemia as a result of high fatty diet consumption. This study aimed to investigate the ameliorating effects of individual *Olea europea*, *Allium sativum* and *Nigella sativa* oils supplementation orally by gavage at 5 ml/ kg on lipid composition in serum of hyperlipidemic male wistar albino rats. Hyperlipidemia was induced by high intake of diet rich of fat 3% (HFD). Animals were randomly segregated into five groups (each of five) and treated daily for six weeks as follow: Group A was negative control group consumed normal basic diet, the group B was positive control group consumed HFD, the group C consumed HFD with *Olea europea* oil, the group D consumed HFD with *Allium sativum* oil, the group E consumed HFD with *Nigella sativa* oil. Blood was obtained at the day zero and at the end of 2nd, 4th and 6th weeks of treatment and allowed to clot and centrifuged to obtain serum for estimation of lipid fractions spectrophotometrically. It has been evaluated that the tested oils play a major role in lipid lowering capacities through the results of the oil supplementation for hyperlipidemic rats in group C, D, and E which recorded significant reduction ($P < 0.05$) in total cholesterol(TC), triglycerides(TG), low density lipoprotein(LDL), very low density lipoprotein (VLDL) and small size particles of low density lipoprotein (sdLDL) levels with significant decline in atherogenic index (AI) value from end of 2nd week of treatment when compared with the +ve control group (group B), while this significant reduction ($P < 0.05$) were recorded at the end of 6th weeks of treatment when compared with the -ve control group (group A). On other hand the level of high density lipoprotein (HDL) were recorded significant increase ($P < 0.05$) from end of 2nd week of treatment when compared with the +ve control group (group B) and after 6th weeks of treatment when compared with -ve control group (group A). These study reveals the beneficial effect of the tested oils to the treatment of hyperlipidemia and remarkable reduce of atherogenicity. This effect, may be attributed to the constituent of oils for unsaturated fatty acids, sulfhydryl group, polyphenolic compounds and flavonoids which they have possesses an ameliorating and lowering capacities in addition to antioxidant activities.

Keywords: *Olea europea* oil, *Allium sativum* oil, *Nigella sativa* oil, hyperlipidemia, lipid profile

تأثير زيت الزيتون، زيت الثوم وزيت الحبه السوداء على تراكيز بعض معايير الكيموحيوية في مصل ذكور الجرذان مفرطة دهون الدم

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الخلاصة:

ان الأهمية الكبرى للزيوت النباتية تعزى الى فوائدها الصحية خاصة فيما يتعلق بأمراض القلب والأوعية الدموية . ومن العوامل المهيمنة والخطرة لظهور وتطور امراض القلب والأوعية الدموية ناجمه من اضطرابات في صورة دهون الدم والنتيجة من كثرة تناول الاغذية الغنية بالدهون وخاصة المشبعة ذات منشأ حيواني . لذا صممت هذه الدراسة لايجاد تأثير تجريع ثلاثة انواع من الزيوت النباتية ؛ زيت الزيتون ، زيت الثوم و زيت الحبه السوداء على تراكيز دهون مصل الدم في ذكور الجرذان مفرطة الدهون . استحثت فرط الدهون في الجرذان تجريبيا من خلال تزويدهم بالعليقة الغنية بالدهون (3% دهن). تم عزل الجرذان عشوائياً الى خمسة مجاميع (5 جرذان في كل مجموعة) وتم معالجة الجرذان يوميا ولمدة ستة اسابيع كالاتى : مجموعة (أ) زودت بالعليقة الطبيعيه واعتبرت مجموعه السيطره السالبه. مجموعة (ب) زودت بالعليقة الغنية بالدهون واعتبرت مجموعه السيطره الموجبه. مجاميع (ج، د، هـ) زودت بالعليقة مفرطة الدهون وعولجت بزيت الزيتون ، زيت الثوم و زيت الحبه السوداء على التوالي. تم الحصول على الدم من جميع الجرذان في بداية التجربه وفي نهاية الاسبوع الثاني، الرابع والسادس من فترة المعالجة. تم فصل مصل الدم بالمنبده 3500 دوره/دقيقه وحفظت تحت التجميد لحين اجراء التحاليل البايوكيميائيه باستخدام جهاز قياس الطيف الضوئى على طول موجى 520 نانوميتر. بينت نتائج معالجة الجرذان مفرطة الدهون بالزيوت تحت الاختبار على كفاءة هذه الزيوت كمنظم وخافض لدهون مصل الدم غير المرغوبه في المجاميع (ج، د، هـ) وذلك من خلال انخفاض معنوى ($P < 0.05$) لتراكيز كل من $sdLDL$, $VLDL$, TG , TC , and LDL بالاضافه الى هبوط معنوى فى قيمة AI وذلك فى نهاية الاسبوع الثانى من المعالجة عند المقارنه مع مجموعه السيطره الموجبه (ب) ولكن هذا الانخفاض المعنوى سجلت فى نهاية الاسبوع السادس من المعالجة عند المقارنه مع مجموعه السيطره السالبه (أ) . ومن جانب اخر سجلت مستوى HDL زياده معنويه ($P < 0.05$) فى نهاية الاسبوع الثانى من المعالجة بالزيوت عند المقارنه مع مجموعه السيطره الموجبه (ب) وفى نهاية الاسبوع السادس من المعالجة عند المقارنه مع المجموعه السيطره السالبه (أ) . نستنتج من هذه الدراسه ، بأن الزيوت فى هذه الدراسه يتمتع بقابليتها على احداث التأثيرات الايجابيه على صورة دهون مصل الدم فى الجرذان مفرطة الدهون بالاضافه الى قابليتها على خفض قيمة AI وبالتالي تقليل من فرص احداث تصلب الشرايين، وقد يعزى هذا التأثير على احتواء هذه الزيوت على المركبات الحلقية المتعدده ومركبات كبريتيد الهيدريل والمركبات الفلافينويديه المتميزه بخصائصها المنظمه وخافضه لتراكيز دهون الدم بالاضافه الى نشاطها المضاده للاكسده.

الكلمات المفتاحية: زيت الزيتون ، زيت الثوم ، زيت الحبه السوداء ، فرط دهون الدم.

Introduction:

The Mediterranean diet was first popularized in the 1970s when studies showed that Mediterranean countries have diets associated with low incidence of cardiovascular disease and atherosclerosis (1). In fact, dietary fat composition is the primary determinant of serum triglyceride, total cholesterol, high density lipoprotein, low density lipoprotein and very low density

lipoprotein, which are the main blood lipid risk for coronary artery disease. Furthermore, it is well known that dietary polyunsaturated fatty acids lower serum cholesterol and conversely, saturated fatty acids elevated serum cholesterol in high fat diets, regardless of their fatty acid composition, were considered hypercholesterolemic compared to low fat diets (2). The Mediterranean diet

characterized by consumption of dietary fiber, fresh vegetables such as olive and garlic, seeds such as *Nigella sativa* and low intake of saturated fats and meat (3). Mediterranean diets produces favorable effects on blood lipids and protects against oxidative stress, the latter being thought to represent one of the mechanisms leading to atherosclerosis and cancer (4). *Olea europea* (olive) oil is alpha linoleic acid rich diet which improved by some authors that have ability for prevention of atherosclerosis (5,6); this diet decreases plasma cholesterol (7) and control blood lipid levels (8). Phenolic compounds of *Olea europea* inhibits platelet aggregation (9), also possess antioxidant activities (10). *Allium sativum* traditionally known as garlic has been considered as one of the blood lipid lowering agents and various studies confirmed this effect and others did not (11). The main component of volatile oils which contained in *Allium sativum* were allyl propyl disulfide and diallyl disulfide are the active agents for hypolipidemic and antiatherogenic (12,13). So, the garlic medicinally used for lowering blood cholesterol and blood pressure, preventive and treatment of cardiovascular disease by reducing platelet aggregation through inhibition prostaglandin E₂ and the release of fibrinogen degradation products (14).

Nigella sativa commonly known as black seeds belongs to family *Ranunculaceae*. It has been use in many Middle Eastern countries as a natural remedy (15). *Nigella sativa* seeds presented fixed and essential oils. Thymoquinone considered the major component of the essential oil, which possess several biological activities (16). Hence, fixed oil of the *Nigella sativa* produced a decrease in serum cholesterol in rats and an increase in glutathione level (17). Additionally, flavonoid compounds of both types of *Nigella* seeds (*sativa* and *arvensis*) have been reported to have a very crucial

role for scavenging of free radicals also possess antioxidant activity (10, 18). To clarify the effect of the oils in this study on the lipid fractions at the hyperlipidemic state within different periods, a further aim, the present study was proposed to investigate the influences of *Olea europea*, *Allium sativum*, and *Nigella sativa* oils supplementation on the concentrations of serum lipid profile of induced hyperlipidemic male rats.

Materials and Methods:

The experiment carried out on 25 healthy adult male albino wistar rats, twelve weeks old, weighing 160 ± 8 gm. Rats were acclimatized under environmental condition with 24 ± 3 °C, 12hr light/dark cycle and good ventilation with standard chow fed with water *ad libitum*. Following acclimatization for one week before use, the animals were randomly segregated into five groups each included (5) rats and labeled as A, B, C, D, and E and treated daily for six weeks with tested oils were purchased from local markets (Kirkuk City, Iraq) as follows:

Group A (-ve control group); was given normal diet and water.

Group B (+ve control group); was given high fatty diet with 3% fat (HFT) daily for six weeks to induce hyperlipidemia.

Group C: was given HFD with intubation of *Olea europea* oil 5 ml/ kg B.W. daily for 6 weeks.

Group D: was given HFD with intubation of *Allium sativum* oil 5 ml/ kg B.W. daily for 6 weeks.

Group E: was given HFD with intubation of *Nigella sativa* oil 5 ml/ kg B.W. daily for 6 weeks.

The blood samples were obtained in plan test tubes without anticoagulant from all rats of above groups after 8 hours fasting (water *ad libitum*) by retro-orbital sinus puncture under mild ether anesthesia at day zero and considered as a baseline data of all groups

and thereafter at the end of 2nd, 4th, and 6th weeks of treatment from all treated and control groups. Blood allowed to clot at room temperature for 30 min, and centrifuged for 15 min. at 3500 rpm. Serum was separated and stored at deep freeze for a maximum 7 days before analysis. Fractions of lipid concentrations were estimated spectrophotometrically and commercially available kit. Total cholesterol (TC) and triglyceride (TG) concentrations were estimated by enzymatic colorimetric test whereas the high density (HDL) and low density (LDL) level were estimated by precipitation technique as instructed by the manufacturer protocol provided. The values of very low density lipoprotein VLDL were calculated using the following formulas: $VLDL\text{-cholesterol} = TG / 2.175$. The atherogenic index (AI) was calculated by dividing the concentration of LDL to the HDL, whereas the small dense LDL particle size (sdLDL) was calculated by dividing the concentration of TG to the HDL (19).

Statistical analysis:

All data from this paper were expressed as mean \pm S.E. One-way analysis of variance (ANOVA) used the SigmaPlot 11 (Systat software, inc). Tukey post-tests were performed for multiple group comparison. In all data, statistical significance was set at $P < 0.05$.

Results:

Results from Tables.1-3 were showed the lipid fractions at day zero demonstrated a low baseline in control group. The group of rats which fed with high fatty diet (HFD) for six weeks, hyperlipidemia occurred in experimental rats and considered as +ve control group as indicated by significant increasing ($P < 0.05$) of TG, TC, LDL, VLDL, and sdLDL levels, but significant decreasing ($P < 0.05$) of HDL level at the end of 2nd weeks of treatment, this

significant effect became more obviously at the end of 4th and 6th weeks of treatment when compared with the same corresponding weeks of -ve control group. These results accompanied by AI value were recorded a significant increasing ($P < 0.05$) in the +ve control group when compared with the -ve control group.

On the other hand, the results of supplementation of *Olea europea*, *Allium sativum*, and *Nigella sativa* oils to hyperlipidemic rats for six weeks recorded a favorable effect in improving serum lipid parameters as shown by significant decreases ($P < 0.05$) in the levels of TG, TC, LDL, VLDL, and sdLDL, whilst a significant increasing ($P < 0.05$) in the HDL level after 2nd, 4th and 6th weeks of treatment were compared with the +ve control group and after 6th week when compared with the same corresponding weeks of -ve control group. The results of the study also showed that the *Olea europea*, *Allium sativum*, and *Nigella sativum* oil treated groups exhibited significant decline ($P < 0.05$) in AI value after 2nd, 4th, and 6th weeks of treatment when compared with +ve control group and after 6th weeks of treatment when compared with -ve control group. While the +ve control group increases significantly ($P < 0.05$) in concentration of all lipid fractions and AI value within 2nd, 4th, and 6th weeks of treatment and the increment was highly significant at the end of 6th weeks of treatment when compared with day zero and with the other weeks of treated and control groups. Whereas other three groups which treated by *Olea europea*, *Allium sativum*, and *Nigella sativa* oils were recorded significant decrease ($P < 0.05$) in concentration of all lipid fractions and AI value at the end of 6th week of treatment when compared with 2nd and 4th weeks of treatment within each oil treated group and with the baseline of -ve control group.

Table 1: The effect of *Olea europea*, *Allium sativum*, and *Nigella sativa* oils supplementation for two weeks on the levels of serum TG, TC, HDL, LDL, VLDL, sdLDL, and AI value in hyperlipidemic rats (N=5).

Treated groups	Weeks	Triglyceride (mmol/L)	Total cholesterol (mmol/L)	High density lipoprotein (mmol/L)	Low density lipoprotein (mmol/L)	Very Low density lipoprotein (mmol/L)	Small dense low-density lipoprotein (mmol/L)	Atherogenic index (AI)
Base line	Zero	0.88±0.01 ^Ø	1.88±0.07 ^Ø	0.88±0.08 ^Ø	0.77±0.01 ^Ø	0.40±0.04 ^Ø	1.01±0.12 ^Ø	0.87±0.12 ^Ø
Group A -ve control	2	0.88±0.01 ^Ø	2.02±0.12 ^Ø	0.88±0.03 ^Ø	0.76±0.01 ^Ø	0.40±0.04 ^Ø	1.0±0.33 ^Ø	0.86±0.33 ^Ø
Group B (HFD) +ve control	2	1.38±0.03 [¤]	2.63±0.04 [¤]	0.55±0.08 [¤]	1.44±0.08 [¤]	0.63±0.01 ^Ø	2.51±0.37 [¤]	2.62±1.03 [¤]
Group C HFD + <i>Olea europea</i> oil	2	0.80±0.01 ^Ø	1.81±0.01 ^Ø	0.97±0.03 ^Ø	0.72±0.05 ^Ø	0.37±0.04 ^Ø	0.82±0.33 ^Ø	0.74±1.6 ^Ø
Group D HFD + <i>Allium sativum</i> oil	2	0.83±0.07 ^Ø	1.80±0.01 ^Ø	0.89±0.05 ^Ø	0.77±0.05 ^Ø	0.38±0.03 ^Ø	0.93±1.4 ^Ø	0.86±1.02 ^Ø
Group E HFD + <i>Nigella sativa</i> oil	2	0.99±0.04 ^Ø	1.90±0.01 ^Ø	0.74±0.01 ^Ø	0.76±0.07 ^Ø	0.45±0.01 ^Ø	1.34±0.4 ^Ø	1.02±0.7 ^Ø

Data in the table are represents as mean ± SE.

§, Ø, ¤ Different letters indicates to significant between groups in the same columns at same weeks.

Table 2: The effect of *Olea europea*, *Allium sativum*, and *Nigella sativa* oils supplementation for four weeks on the levels of serum TG, TC, HDL, LDL, VLDL, sdLDL, and AI value in hyperlipidemic rats (N=5).

Treated groups	Weeks	Triglyceride (mmol/L)	Total cholesterol (mmol/L)	High density lipoprotein (mmol/L)	Low density lipoprotein (mmol/L)	Very Low density lipoprotein (mmol/L)	Small dense low-density lipoprotein (mmol/L)	Atherogenic index (AI)
Base line	Zero	0.88±0.01 Ø	1.88±0.07 Ø	0.88±0.08 Ø	0.77±0.01 Ø	0.40±0.04 Ø	1.01±0.12 Ø	0.87±0.12 Ø
Group A -ve control	4	0.82±0.07 Ø	1.81±0.03 Ø	0.95±0.01 Ø	0.85±0.01 Ø	0.38±0.03 Ø	0.86±0.7 Ø	0.89±1.01 Ø
Group B (HFD) +ve control	4	1.55±0.01 ²	2.87±0.02 ²	0.42±0.08 ²	1.62±0.03 ²	0.71±0.04 ²	3.69±0.12 ²	3.85±0.3 ²
Group C HFD + <i>Olea europea</i> oil	4	0.73±0.01 Ø	1.82±0.02 Ø	1.16±0.01 Ø	0.71±0.07 Ø	0.33±0.04 Ø	0.63±1.04 Ø	0.60±0.7 Ø
Group D HFD + <i>Allium sativum</i> oil	4	0.74±0.03 Ø	1.71±0.02 Ø	1.01±0.02 Ø	0.67±0.06 ²	0.34±0.01 Ø	0.73±1.5 Ø	0.66±0.3 Ø
Group E HFD + <i>Nigella sativa</i> oil	4	0.83±0.08 Ø	1.78±0.03 Ø	0.83±0.08 Ø	0.65±0.06 Ø	0.38±0.04 Ø	1.0±1.02 Ø	0.78±0.75 Ø

Data in the table are represents as mean ± SE.

², Ø, ² Different letters indicates to significant between groups in the same columns at same weeks.

Table 3: The effect of *Olea europea*, *Allium sativum*, and *Nigella sativa* oils supplementation for six weeks on the levels of serum TG, TC, HDL, LDL, VLDL, sdLDL, and AI value in hyperlipidemic rats (N=5).

Treated groups	Weeks	Triglyceride (mmol/L)	Total cholesterol (mmol/L)	High density lipoprotein (mmol/L)	Low density lipoprotein (mmol/L)	Very Low density lipoprotein (mmol/L)	Small dense low-density lipoprotein (mmol/L)	Atherogenic index (AI)
Base line	Zero	0.88±0.01Ø	1.88±0.07 Ø	0.88±0.08 ^Ø	0.77±0.01 Ø	0.40±0.04 Ø	1.01±0.12 Ø	0.87±0.12 Ø
Group A -ve control	6	0.96±0.04Ø	2.0±0.05Ø	1.09±0.04Ø	0.90±0.09 Ø	0.44±0.02 Ø	0.88±1.02 Ø	0.83±2.2 Ø
Group B (HFD) +ve control	6	1.80±0.03§	3.02±0.04 §	0.31±0.05 §	1.79±0.07 §	0.82±0.01 §	5.81±0.6 §	5.77±1.4 §
Group C HFD + <i>Olea europea</i> oil	6	0.61±0.08α	1.76±0.01 α	1.36±0.01α	0.62±0.05 α	0.28±0.03 α	0.44±0.8 α	0.45±0.5 α
Group D HFD + <i>Allium sativum</i> oil	6	0.60±0.04 α	1.65±0.01 α	1.19±0.09 α	0.61±0.05 α	0.27±0.01 α	0.50±0.44 α	0.51±0.55 α
Group E HFD + <i>Nigella sativa</i> oil	6	0.65±0.03 α	1.75±0.01 α	0.96±0.09 Ø	0.61±0.05 α	0.30±0.01 α	0.68±0.33 α	0.63±0.5 α

Data in the table are represents as mean ± SE.

§, Ø, α Different letters indicates to significant between groups in the same columns at same weeks.

Discussion:

In this study, highly fatty diet with 3% fat (HFD) for six weeks loaded to experimental rats could generate hyperlipidemia. The results of the serum lipid profile of group (B) revealed in tables 1-3, that the serum TC, TG, LDL, sdLDL, and VLDL to have increased at the end of 2nd week till end of experiment when compared with the baseline levels of control group, whereas HDL concentration showed significant decrease. The results of the present study are consistent with that from previous study (19). Lipid profile changes are associated with the phenomenon that excessive load of fat fraction (cholesterol) to the liver above the acceptable level of its normal physiological limit causes the liver to be unable in metabolizing the lipids, therefore resulting in high cholesterol return to the blood circulation (20). Studies in both animals and humans have demonstrated that prolonged high cholesterol concentration in the circulating blood positively correlates with developing atherosclerosis (21,22). In this study, however the treatment of hyperlipidemic rats with *Olea europea*, *Allium sativum*, and *Nigella sativa* oils for six weeks were not only recorded a remarkable reduction of lipid profile, but also a protective effect against atherosclerosis as indicated by a reduced *AI* value (Tables 1-3). So, the present data demonstrated that the supplementation of studied oils for hyperlipidemic rats were inhibited the elevation of serum lipid fractions. The lipid lowering effects of the studied oils possesses lipid lowering properties. The mechanism on how exactly the oils could lower blood lipid fractions requires further investigation, but it was postulated that high polyphenolic, flavonoids and sulfhydryl compounds concentrated in the studied oil preparations could partly explain the underlying mechanism of its lowering properties. The mechanism of

serum lipid lowering belonged to delayed lipid absorption from gastrointestinal tract (GIT) and diminished LDL-C synthesis by the liver (23). In vitro study, the hepatocytes treated by garlic-derived organosulfur compounds inhibited for synthesis of cholesterol (24), via inhibition of 3-hydroxy-3-methylglutaryl-coenzyme A reductase, a critical enzyme in the cholesterol biosynthesis pathway (25). Garlic-derived compounds may also inhibit other enzymes in this pathway, including sterol 4-alpha methyl oxidase (26-29).

Dry and wet garlic extract contents of total phenolic compounds were moderate in garlic while high in green and black oils (10). There was considerable interest in the potential health benefits of oil seeds such as *Nigella sativa*, flaxseeds and soybean especially regarding to cardiovascular diseases and cancer. This interest in oil seeds relates to their high content of polyunsaturated fatty acids (30), flavonoids and related polyphenolic compound, which may possess cholesterol-lowering and antioxidant activities (10, 31).

Other investigators stated that, the diabetic rats fed with ground nuts oil or olive oil showed a significant reduction in the levels of TG-TC - LDL- VLDL-and elevation in HDL level when compared with corresponding controls (32, 33). Furthermore (35), observed that TG,TC plasmatic levels did not changed, whereas levels of LDL decreased significantly, as well as levels of PUSFA and levels of apoprotein B. The HDL increased significantly as well as levels of apoprotein A₁ and apoprotein E also increased in olive oil or *sunflower oil fed men*. Elevated concentrations of plasma HDL protect the arterial wall from the development of atherosclerotic plaque facilitated by reverse cholesterol transport (35). In plasma, HDL-c concentrations are modulated in a number of

ways including the uptake of entire HDL particle, the selective uptake of cholesterol ester by the liver and steroidogenic organs via scavenger receptor B class 1 (SR-B₁) (36). Any disturbance in lipoprotein metabolism is reflected in the lipid profiles of blood plasma and liver. Since the liver has a major role in the metabolism of lipoprotein. Fat accumulation in the liver may also occur if there is any derangement in the production of lipoprotein, especially its apoprotein part (36). Another aspect that can be used in assessing the risk of CVD is the estimation of the sdLDL particles. In this study the sdLDL particles recorded significant elevation ($P < 0.05$) due to an increased TG to HDL ratio in high fat diet group which was significantly reduced ($P < 0.05$) upon supplementation with tested oils (Tables 1-3). Particles of sdLDL are thought to be more susceptible to oxidative modification and subsequent uptake by scavenger receptors on active macrophages leading to the development of lipid-laden foam cells (37).

The observed increase of sdLDL concentration is mainly belonged to high TG to HDL ratio. The intrinsic properties of sdLDL particles have been suggested to be biologically responsible for increasing the developing CVD (38) with numerous studies reporting that the presence of sdLDL particles is associated with a more than three-fold increase in the risk of coronary artery disease (39), through the ability of sdLDL for penetration the arterial wall more easily and have a higher capacity to bind to intimal proteoglycans, these all properties that are associated with great atherogenicity (40).

So the results of this study revealed the supplementation of the tested oils improved the level of sdLDL particles to control level (Tables 1-3), therefore brings the experimental rats protected from atherogenic elements, which was indicated by significant

decline ($P < 0.05$) in the AI value in oil treated groups when compared to the +ve and baseline of -ve control groups. So the other important application of plasma lipid markers that is relevant to CVD risk is the association between the LDL to HDL ratio known as atherogenic index (AI). This point also demonstrated from the results of the study which showed the supplementation of the studied oils to the hyperlipidemic rats had a strong hypolipidemic effects with reduction of serum LDL level and an increase of HDL level (Tables 1-3) moreover, the AI markedly decreasing due to significant decrease of LDL level in oil treated groups (Tables 1-3). The observed increase of HDL is one of the most important criteria of antisclerotic agents. Numerous studies have demonstrated with a lower incidence of CVD (38). The increase in HDL levels observed in our study might be belonged to the stimulation of pre- β HDL and reverse cholesterol transport (41), whereas decreases the atherogenic markers. From this point of view, it is interesting that the studied oils brought down the elevated levels of TG, TC, LDL, VLDL, and sdLDL in hyperlipidemic rats to normal level after treatment for six weeks. Also, there is an increase in HDL which is a desirable feature, for reducing the AI value and protecting from incidence of atherogenic problems. Finally, these interesting finding suggest further investigations for the possible use of different doses of oil or combination of different oils for ameliorating of hyperlipidemic conditions and to elucidate their mechanism of action.

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