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EFFECT OF VIRGIN OLIVE OIL SUPPLEMENTATION ON LIPID PROFILE AND OXIDATIVE STATUS IN RATS

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ABSTRACT

Abstract

The aim of the present study is to investigate the effect of virgin olive oil on some blood parameters in male Albino rats supplemented with normal diet. thirty male Sprague Dawley rats, (90-110 g), were used in the present study, and were divided into three groups (10 in each), 1st group (control), received basal diet and supplemented with 1ml saline. 2nd and 3rd groups received basal diet, and supplemented daily with 1ml/100 gm B.W and 2ml/100 gm B.W of virgin olive oil (VOO), respectively for 4 weeks. Blood samples were collected weekly from all rats. Serum samples was obtained for assay of lipid profile levels and hepatic lipid peroxidation (MDA) enzyme. Blood lysate was used for antioxidant enzymes activities SOD, GPx and CAT.

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Introduction:

Olive (*Olea europaea* L.) oil is a fundamental food stuffs and health care products. They play a component of the Mediterranean diet (Zhang *et al.*, leading role in human nutrition, and a source of 2013). In the last few decades there has been a many essential nutrients. Vegetable oils are generally significant increase in the global consumption of olive obtained from the seeds of plants like soya bean, oil, even in countries where it is not produced, such as sunflower, rape, palm, peanut and corn. Canada and Japan (Mili, 2006). This is due in large Nevertheless, the importance of olive oil, obtained part to its nutritional and health promoting effects from a drupe fruit, is increasing due to the biological (Solyanik *et al.*, 2004), which have been related to the properties of several of its components that preserve optimal balance between saturated, monounsaturated health and prevent many degenerative illnesses (MUFA), and polyunsaturated fatty acids (PUFA), as (Mackenbach, 2007). Effectively, olive oil has a well as to minor components such as chlorophyll, beneficial effect in controlling blood pressure and polyphenols and tocopherols (Lazzez *et al.*, 2008). improving the immune function by attenuating the inflammatory process (Wable *et al.*, 2004). The second and third group received basal diet, and

Many studies have been conducted to prove its potential through oil, whole fruit and leaf extract as anticancer, antimicrobial and antiviral effects (Covas, 2007 and Awney, 2010). Since olive oil is a wild oil commonly available in the world and especially in the Mediterranean and its leaves are used in folk medicine for treatment, it is therefore deemed interesting to examine the effect of virgin olive oil supplementation on lipid profile (TG, TC, LDL-C, VLDL-C, HDL-C and AI) parameters, glucose level and on oxidative status in albino rats, after oral gavages of different doses of virgin olive oil for a period of 30 days.

MATERIAL AND METHODS

Olive Oil:

oil in the present study was obtained from olive (*Olea europaea*; family Oleaceae), a traditional tree crop of Tarhuna city farms, Libya. The oil was identified by Dr. Salem M. Abd-Alsadiq. Senior Botanist, Department of Crops and Horticulture - Faculty of Agriculture – Tripoli University. Tripoli-Libya. Olive oil was administered in two doses by gastric tube for 4 weeks: Low dose (1 ml / 100g B.W) olive oil and high dose (2 ml / 100g B.W) olive oil (Nandakumaran *et al.*, 2012).

Animals:

The study was conducted in the Animal House of National Research Centre (NRC), Cairo, Egypt. Thirty Adult male rats (Sprague Dawley Strain) weighing between 90-110 g were used for the study. The animals used for the study were randomly selected. All rats were active, apparently healthy and free from abnormalities and disease and housed in commercial cages, equipped with automatic drinkers and feeders, at room temperature maintained at 25 °C, with alternating 12 hour light 12 hour dark cycle. The animals were kept for 10 days for acclimatization before the experiment.

Feeding regimen:

Basal diets were formulated to cover the requirements of rats as recommended in NRC (1977). Diets were subjected to chemical analysis according to AOAC (2012).

Experimental design:

The rats were equally and randomly divided into three groups (10 in each): The first group was considered as control group, and received basal diet with 1ml saline by gastric tube daily for 4 weeks. (1984), and expressed as U/mg.

supplemented with either 1ml/100g or 2ml/100g of virgin olive oil (VOO), respectively, administered by gastric tube for 4 weeks.

Blood collection and serum separation:

Blood samples were collected individually by orbital venus plexus technique under mild ether inhalation anaesthesia. Samples were obtained at the early morning before access to feed and water at the end of every week. Portion of blood samples was collected into heparinized tube for antioxidant parameters in whole blood cell lysate. The other portion of blood samples was collected into plain tubes and allowed to coagulate at room temperature and centrifuged at 1000 g for 20 min to obtain sera. The clear, non-haemolysed supernatant sera were quickly collected for each animal and stored at -20 °C for lipid profile and glucose.

Estimation of lipid profile and glucose levels:

Serum TC, TG and HDL-C levels were estimated colorimetrically using commercial reagent kits (Spectrum Diagnostic, Egypt) and expressed as mg/dl.

Serum Low Density Lipoproteins cholesterol (LDL-C) level was calculated according to the formula developed by Friedewald *et al.* (1972) using the following equation:

$$\text{Serum LDL-c} = \text{TC} - (\text{HDL-c} + \text{TGs} / 5)$$

Atherogenic index (AIX) was calculated according to the formula adopted by Hostmark *et al.* (1991), as follows: Atherogenic index = (TC - HDL-c) / HDL-c.

Serum glucose concentration: Was determined by enzymatic method explained by Trinder (1969), and expressed as mg/dl.

Estimation of antioxidants and oxidative markers:

Superoxide dismutase activity (SOD): was determined in blood cell lysate, according to the method described by Jewett and Rocklin (1993), and expressed as U/mg.

Glutathione peroxidase activity (GPx): was determined in blood cell lysate, according to method described by Paglia and Valentine (1967), and expressed as U/mg.

Catalse enzyme activity (CAT): was determined in blood cell lysate, according to the method of Aebi, group. Moreover, the values indicated significant

Malondialdehyde (MDA): Hepatic lipid peroxidation was determined in serum according to method Drapper and Hadley (1990), and expressed as nmol/ml.

Statistical Analysis:

All data are expressed as Means \pm SE and statistical analysis according to **Snedecor and Cochran (1980)**. was done using SPSS statistical package. Means were compared by the least significance difference test at 5% level of probability (Two way anova test).

Table (1): Fatty acid composition of dietary olive oil:

Fatty acid	g/100g
Palmitic acid	10.28
Palmitoleic acid	0.77
Stearic acid	3.39
Oleic acid	64.80
Linoleic acid	14.34
Linolenic acid	0.64
Arachidonic acid	0.74
Gadoleic acid	0.62
Behenic acid	2.84
SFA	17.28
MUFA	66.20
PUF	14.99

SFA: saturated fatty acids;

MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid

Results:

Effect of virgin olive oil on lipid profile and glucose in rats: The present study investigates the supplementation of two different doses of virgin olive oil; (low dose of virgin olive oil (LVOO) and high dose of virgin olive oil (HVOO) on lipid profile, glucose, antioxidant and oxidative stress marker in rats. In the present study, rats supplemented with either low dose of virgin olive oil (LVOO) or high dose of virgin olive oil (HVOO) showed significantly decreased serum TG, TC, LDL-C, VLDL-C, AI and glucose levels during 1st, 2nd, 3rd, and 4th weeks of the experimental period, when compared to the basal diet

decrease of serum TG, TC, LDL-C, VLDL-C, AI and glucose in rats supplemented with HVOO, during 1st, 2nd, 3rd and 4th weeks of the experimental period, when compared with rats supplemented to LVOO group.

On the contrary the results recorded in table (2) for HDL-C levels, showed significant increase in rats supplemented with LVOO, during 1st, 2nd, 3rd and 4th weeks of the experimental period when compared with BD group. Moreover, values indicated significant increase of HDL-C of rats supplemented with HVOO, during 1st, 2nd, 3rd and 4th weeks of the experimental period, when compared with rats supplemented with LVOO group.

Effect of virgin olive oil on antioxidant parameters in rats:

Data tabulated in (fig. 1) showed that rats fed basal diet and supplemented with low dose of virgin olive oil (LVOO) exhibited significant increase in the activities of SOD, GP_x and CAT during 1st, 2nd, 3rd and 4th weeks of the experimental period, when compared with BD group. Moreover, groups supplemented with HVOO, showed significant increase in SOD, GP_x and CAT activities, during 1st, 2nd, 3rd, and 4th weeks of the experimental period, when compared with BD group. Furthermore, the present results showed that rats supplemented with HVOO, caused significant improvement in serum SOD, GP_x and CAT activities values during 1st, 2nd, 3rd, and 4th weeks of the experimental period, when compared with rats supplemented with LVOO group.

On the contrary, results in (fig. 4) recorded for serum MDA values showed significant decrease in rats fed basal diet and supplemented with LVOO, during 1st, 2nd, 3rd and 4th weeks of the experimental period, when compared with BD group. Moreover, groups supplemented with HVOO, showed significant decrease in MDA values, during 1st, 2nd, 3rd, and 4th weeks of the experimental period, when compared with BD group. Furthermore, the present results showed that rats supplemented with HVOO, caused significant decrease in serum MDA values during 1st, 2nd, 3rd, and 4th weeks of the experimental period, when compared with rats supplemented with LVOO group.

Table2: Effect of Virgin olive oil supplementation on serum lipid profile and glucose levels in rats.

Data indicate mean \pm standard error at ($p \leq 0.05$), N= 10 rats, BD= Control, LVOO= low dose of virgin olive oil, HVOO =

Groups	Parameters	BD	LVOO	HVOO	LSD
TG (mg/dl)	I	2.80 \pm 152.20	150.60 \pm 0.65	147.40 \pm 0.80	0.87
	II	3.27 \pm 154.80	148.10 \pm 0.20	144.30 \pm 0.60	
	III	2.38 \pm 157.20	143.60 \pm 0.62	141.90 \pm 0.20	
	IV	1.67 \pm 159.60	141.40 \pm 0.45	136.10 \pm 0.26	
TC (mg/dl)	I	3.33 \pm 78.65	74.00 \pm 3.50	71.25 \pm 1.33	2.15
	II	2.00 \pm 81.46	73.50 \pm 1.74	70.46 \pm 1.50	
	III	2.77 \pm 83.83	72.60 \pm 1.31	69.85 \pm 0.56	
	IV	3.89 \pm 85.86	71.80 \pm 0.26	69.15 \pm 0.43	
HDL-C (mg/dl)	I	1.81 \pm 24.00	25.80 \pm 1.70	27.50 \pm 1.65	1.29
	II	1.04 \pm 27.60	29.50 \pm 0.26	31.70 \pm 0.62	
	III	1.58 \pm 29.00	31.00 \pm 0.30	32.80 \pm 0.36	
	IV	1.92 \pm 29.80	31.60 \pm 0.45	33.70 \pm 0.30	
LDL-C (mg/dl)	I	1.65 \pm 24.21	18.08 \pm 1.13	14.27 \pm 0.29	1.98
	II	1.97 \pm 22.90	14.38 \pm 1.59	9.90 \pm 0.95	
	III	1.63 \pm 23.39	12.88 \pm 1.03	8.67 \pm 0.85	
	IV	1.93 \pm 24.14	11.92 \pm 1.45	8.23 \pm 0.74	
VLDL-C (mg/dl)	I	0.45 \pm 30.44	30.12 \pm 0.13	29.48 \pm 0.16	0.17
	II	0.65 \pm 30.96	29.62 \pm 0.08	28.86 \pm 0.12	
	III	0.47 \pm 31.44	28.72 \pm 0.12	28.38 \pm 0.14	
	IV	0.33 \pm 31.92	28.28 \pm 0.09	27.22 \pm 0.10	
AI (mg/dl)	I	0.61 \pm 2.27	1.86 \pm 0.17	1.59 \pm 0.13	0.13
	II	0.28 \pm 1.95	1.49 \pm 0.13	1.22 \pm 0.10	
	III	0.20 \pm 1.89	1.34 \pm 0.19	1.12 \pm 0.04	
	IV	0.27 \pm 1.88	1.27 \pm 0.17	1.05 \pm 0.03	
Glucose (mg/dl)	I	91.00 \pm 0.18	89.49 \pm 0.08	88.60 \pm 0.68	0.79
	II	90.20 \pm 0.09	89.00 \pm 0.16	87.47 \pm 0.39	
	III	89.40 \pm 0.15	85.85 \pm 0.21	84.65 \pm 0.45	
	IV	89.50 \pm 0.32	84.95 \pm 0.18	84.14 \pm 0.34	

ANOVA

 $P \leq 0.05$

High dose of virgin olive oil , I= 1st week, II= 2nd week, III= 3rd week, IV= 4th week, LSD= (Least significant difference). TG= Triglyceride, TC= Total cholesterol, HDL-C= High density lipoproteins cholesterol, LDL-C= Low density lipoproteins cholesterol, VLDL-C= Very low density lipoproteins cholesterol, AI=Atherogenic index.

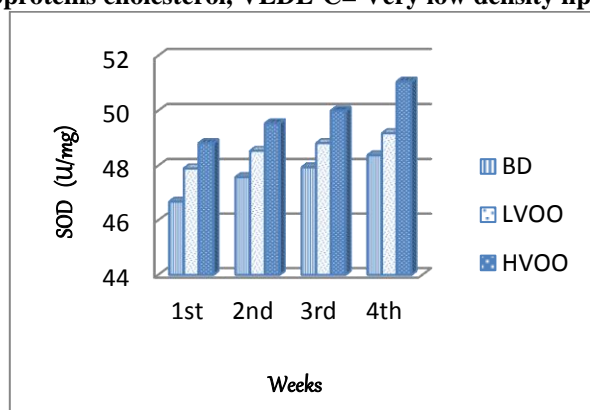


Fig.1: Effect of olive oil supplementation on SOD in blood cell lysate of rats. BD= Control, LVOO = low dose of virgin olive oil, HVOO = high dose of virgin olive oil. SOD = Superoxide dismutase.

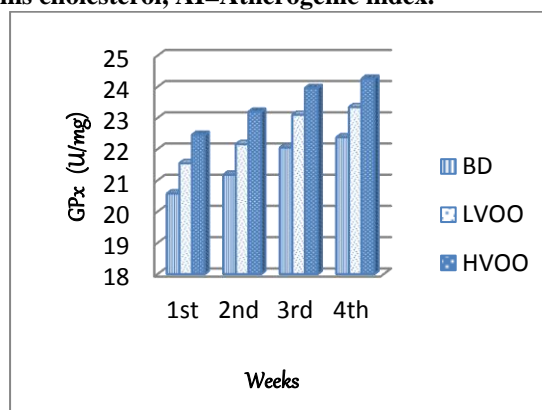


Fig.2: Effect of olive oil supplementation on GPx in blood cell lysate of rats. BD= Control, LVOO = low dose of virgin olive oil, HVOO = high dose of virgin olive oil. GPx = Glutathione peroxidase.

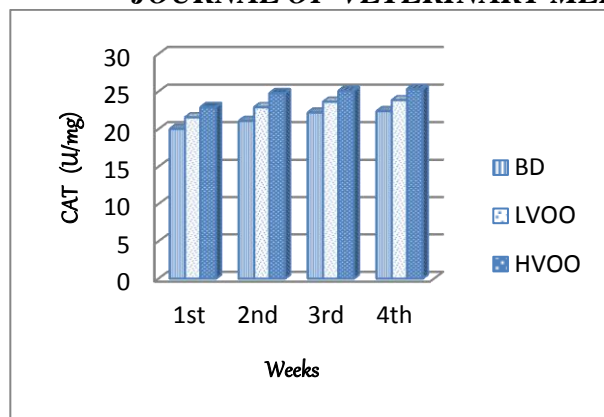


Fig.3: (18 c): Effect of olive oil supplementation on CAT in blood cell lysate of rats. BD= Control, LVOO = low dose of virgin olive oil, HVOO = high dose of virgin olive oil. CAT = Catalase.

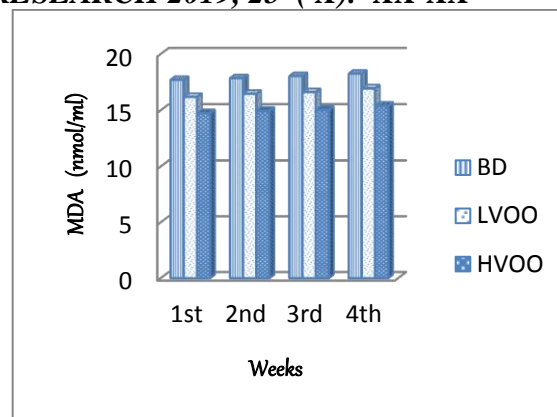


Fig.4: Effect of olive oil supplementation on MDA in serum of rats. BD= Control, LVOO = low dose of virgin olive oil, HVOO = high dose of virgin olive oil. MDA = Malondialdehyde.

Discussion:

The present study is an attempt to assess the hepatoprotective potential with either low dose of virgin olive oil (LVOO) and high dose of virgin olive oil (HVOO) in rats. The results of the present study showed that the oral supplementation of either LVOO or HVOO in rats caused significant decrease in the serum TG, TC, LDL-C, VLDL-C, AI and glucose. Meanwhile; a significant increase was seen in HDL-C values at 1st week from the beginning of the experiment. The possible explanation of these observed reduction may be attributed to the healthy effects of VOO on cardiovascular risk factors which have been attributed to its high content of MUFAs, such as oleic acid. In this context, MUFAs are suggested to be effective in improving serum lipid profile levels, through a decrease in TG, TC, LDL-C, VLDL-C and AI with increase in HDL-C. All former results confirm the finding of Moreno and Mitjavila, (2003); Perona *et al.* (2006); Rosa casas *et al.* (2017); Elias *et al.* (2017) and Khan *et al.* (2017), they reported that olive oil product reduced serum TG, TC, LDL-C, VLDL-C, AI and glucose levels. In addition Massimo *et al.* (2009) who suggested that the healthy effect of olive oil refer to MUFAs that may play role in modulate atherosclerosis by affecting vascular endothelium, through increasing the amount of oleic acid in the arterial wall and displacing saturated fatty acids (SFAs), while leaving polyunsaturated fatty acid (PUFAs). Thus, oleic acid may contribute in improving serum lipid

profile levels, through a decrease in TG, TC, LDL-C, VLDL-C and AI and increase HDL-C. Besides olive oil has been shown to lower blood glucose levels (Tahvonen *et al.*, 2005). This confirmed the improvement of blood lipids in the present study. Other components of olive oil such as oleic acid; a compound which belong to the class of MUFA, has a beneficial effect in the reduction of glycemic load which might be increased insulin sensitivity (Tahvonen *et al.*, 2005; Schwingshacki and Hoffmann, 2014; Qian *et al.*, 2016 and Elias *et al.*, 2017).

In this study, rats supplemented with either low dose of virgin olive oil (LVOO) or high dose of virgin olive oil (HVOO), exhibited significant increase in the activities of SOD, GP_x and CAT. Meanwhile; the results recorded for Serum MDA values showed significant decrease in rats supplemented with either low dose or high dose of virgin olive oil, when compared with control group. Through this increase in antioxidant enzyme activity, the high dose of virgin olive oil (HVOO) showed the best antioxidant enzyme activities. The mechanism proposed to explain the positive effect of HVOO may be attributed to its richness in MUFA, mainly oleic acid which has different effects on lipid profile levels and peroxidation in rabbit hepatic mitochondria (Ochoa-Herrera *et al.*, 2001). However, the obtained data showed that HVOO was more effective than LVOO in induced oxidative stress in the liver. In healthy humans, the short-term consumption of olive oil decreased serum oxidative stress (Weinbrenner *et al.*, 2004) and their lipoprotein fraction; LDL-C, where shown to be enriched with oleic

acid and resistant to oxidation (Sola *et al.*, 1997).

Moreover, PUFAs are more susceptible to peroxidation resulting in MDA formation (Esterbauer *et al.*, 1991). Because of their peculiar structure that is the presence of one or more double bonds-PUFA are more susceptible to free radical damage and thus could increase the susceptibility of LDL particles to oxidation. Most of studies comparing the effects of a MUFA-rich diet with PUFA-rich diet on LDL oxidation parameters have found a higher resistance of LDL particles to oxidation after the consumption of MUFA-rich diet (Kratz *et al.*, 2002). The healthy effects of the dietary MUFA, including lower endothelial activation (Massaro *et al.*, 2002) and susceptibility of LDL to oxidation (Aguilera *et al.*, 2004) are indeed to be considered.

Conclusion:

The results of the present study showed that virgin olive oil improved antioxidant enzymes activities by preventing excessive lipid peroxidation to increase MUFA composition and by improvement of serum lipid profiles and glucose levels.

References:

- Aebi, H. (1984):** Methods Enzymol. 105: 121- 126.
- Aguilera CM, Mesa MD, Ramirez-Tortosa MC, Nestares MT, Ros E, Gil A (2004):** Sunflower oil does not protect against LDL oxidation as virgin olive oil does in patients with peripheral vascular disease. *Clin Nutr*, 23:673-681.
- AOAC (2012).** Association official Analytical chemists International. Official Methods of Analysis, 16th revision, 2012, 41.1.36. AOAC international, Gaithersburg, MD.
- Awney, H. (2010):** The effect of green tea and olive oil on the mutagenic activity of heterocyclic amines extracted from common food consumed in Saudi Arabia. *International Journal of Food Sciences and Nutrition*, [Epub ahead of print].
- Covas, M.I. (2007):** Olive oil and the cardiovascular system. *Pharmacol Res.*;55:175-261.
- Draper, H.H. and Hadley, M. (1990):** Malondialdehyde determination as index of lipid Peroxidation. *Methods in enzymology*.186: 421-31.
- Elias, S.; Wisam, S.; Luai, A.; Massad, B.; Nimer, A. (2017):** Lipotoxicity in Obesity: Benefit of Olive Oil. *Obesity and Lipotoxicity*, Advances in Experimental Medicine and Biology 960, DOI 10.1007/978-3-319-48382-5-26.
- Esterbauer H, Schaur RJ, Zollner H (1991):** Chemistry and biochemistry of of 4-hydroxynonenal, malondialdehyde and related aldehydes. *Free Radic Biol Med*, 11:81-88.
- Friedewald, W.T., Levy R.I. and Fredrickson D. S. (1972):** Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin. Chem.*,18 (6): 499-502.
- Hostmark, A.; Berg, J.; Osland, A.; Simonsen, S. and Vatne, K. (1991):** Lipoprotein-related coronary risk factors in patients with angiographically defined coronary artery disease and controls: improved group separation by indexes reflecting the balance between low and high density lipoproteins coronary Artery Dis., 2(6): 679-684.
- Jewett, S.L. and Rocklin, A.M. (1993):** Variation of one unit activity with oxidation rate of organic substrate in indirect superoxide dismutase assays. *Analyt Biochem* 212, 555-559.
- Khan, T.M.; Iqbal, S. and Rashid, M.A. (2017):** Comparison of lipid lowering effect of extra virgin olive oil and atorvastatin in dyslipidaemia in type 2 diabetes mellitus. *J. Ayub. Med coll Abbottabad.*, 29(1): 83-6.
- Kratz M, Cullen P, Kannenberg F, Kassner A, Fobker M, Abuja PM, Assmann G, Wahrburg U (2002):** Effects of dietary fatty acids on the composition and oxidizability of low-density lipoprotein. *Eur J Clin Nutr*, 56(1):72-81.
- Lazzez, A., Perri, E., Caravita, M.A., Khelif, M. and Cossentini, M. (2008):** Influence of olive maturity stage and geographical origin on some minor components in virgin olive oil of the Chemlali Variety. *Journal of Agri- cultural and Food Chemistry*, 56, 982-988.
- Mackenbach, J.P. (2007):** The Mediterranean diet story illustrates that “why” questions are as important as “how” questions in disease explanation. *Journal of Clinical Epidemiology*, 60, 105-109.
- Massaro M, De Caterina R: Vasculoprotective effects of oleic acid (2002):** Epidemiological background and direct vascular antiatherogenic properties. *Nutr Metab Cardiovasc Dis*, 12(1):42-51.

- Massimo, C.; Lucio, T.; Jess, M.; Giovann, L. and Giuseppe, C. (2009):** Extra virgin olive oil and oleic acid Nutr. Clin. Diet, Hosp., 29 (3):12- 24.
- Mili, S. (2006):** Olive oil marketing in non-traditional markets: Prospects and strategies. *NewMedit*, 5, 27-37.
- Moreno, J.J. and Mitjavila, M.T. (2003):** The degree of unsaturation of dietary fatty acids and the development of atherosclerosis. *J. Nutr. Biochem.*, 14 (4): 182-195.
- Nandakumaran, M.; Angelaki, E. and Al- Azemi, N. (2012):** Influence of coconut oil administration on some hematologic and metabolic parameters in pregnant rats. *J. Mat-Fet Neonat Med*; 24: 1254-1258.
- NRC, (1977):** National Research Council. Nutrients Requirements of Rats (2nd). *National Academy of Science. Washington, DC., USA.* 1977.
- Ochoa-Herrera JJ, Huertas JR, Quiles JL, Mataix J (2001):** Dietary oils high in oleic acid, but with different non-glyceride contents, have different effects on lipid profiles and peroxidation in rabbit hepatic mitochondria. *J Nutr Biochem*, 12(6):357-364.
- Paglia, D.E. and Valentine, W.N. (1967):** Studies on the quantitative and qualitative characterization on erythrocyte glutathione peroxidase. *J Lab Clin Med.* 1967 Jul;70(1):158-69.
- Perona, J.S.; Cabello-Moruno, R. and Ruiz-Gutierrez, V. (2006):** The role of virgin olive oil components in the modulation of endothelial function. *J Nutr Biochem.* 17: 429-45.
- Qian, F.; Korat, A.; Malik, V. and Hu F. (2016):** Metabolic effects of monounsaturated fatty acid-enriched diets compared with carbohydrate or polyunsaturated fatty acid-enriched diets in patients with type 2 diabetes: A systemic review and Meta-analysis of randomized controlled trials. *J. Diabetes care* 39(8), 1448-1457.
- Rosa-Casas, R.; Urpi-Sarda, M.; Sacanella, E.; Arranz, S.; Corella, D.; Castaner, O.; Lamuela-Raventos, R.; Salas-Salvado, J.; Lapetra, J.; Portillo, M.P. and Estruch, R. (2017):** Anti-Inflammatory Effects of the Mediterranean Diet in the Early and Late Stages of Atheroma Plaque Development. *J Nutr*;146:1684–93.
- Schwingshack, L. and Hoffmann, G. (2014):** Monounsaturated fatty acids and Meta-analysis of cohort studies lipids in health and disease.; 13 (1), 154.
- Snedecor, G.W. and Cochran, W.G. (1980):** Statistical methods. 7th edition. Iowa state university press. Ames.
- Sola R, LaVille AE, Richard JL, Motta C, Bargallo MT, Girona J, Masana L, Jacotot B (1997):** Oleic acid rich diet protects against the oxidative modification of high density lipoprotein. *Free Radic Biol Med*, 22(6):1037-1045.
- Solyanik, G.I.; Fedorchuk, A.G.; Pyakovskaya, O.N.; Dasyukevitch, O.I.; Khranovskaya, N.N.; Aksenov, G.N. and Sobetsky, V.V. (2004):** Anticancer activity of aconitine-containing herbal extract BCI. *Exp Oncol*; 26: 307-311.
- Tahvonen, R.L.; Schwab, U.S.; Linderborg, K.M.; Mykkinen, H.M. and Kallio, H.P. (2005):** Black currant seed oil and fish oil supplements differ in their effects on fatty acid profiles of plasma lipids, and concentrations of serum total and lipoprotein lipids, plasma glucose and insulin. *J. Nutr. Biochem.*, 16: 353–359.
- Trinder, P. (1969):** Determination of blood glucose using 4-aminophenazone *Journal of Clinical pathology*, 22,246.
- Wable, K.W.J., Caruso, D., Ochoa, J.J. and Quiles, J.L. (2004):** Olive oil and modulation of cell signaling in disease prevention. *Lipids*, 39, 1223-1231.
- Weinbrenner T, Fito M, de la Torre R, Saez GT, Rijken P, Tormos C, Coolen S, Albaladejo MF, Abanades S, Schroder H, Marrugat J, Covas MI (2004):** Olive oils high in phenolic compounds modulate oxidative/antioxidative status in men. *J Nutr*, 134(9):2314-2321.
- Zhang Z. F., Zhou T. X. and Kim I. H. (2013):** Effects of Dietary Olive Oil on Growth Performance, Carcass Parameters, Serum Characteristics, and Fatty Acid Composition of Breast and Drumstick Meat in Broilers, *Asian-Aust. J. Anim. Sci.* Vol. 26, No. 3 : 416-422.

