The Ameliorative Effect of Olive Oil in The Biochemical And Histopathological Changes of The Rat Kidney Induced By Hyperlipidemia

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ABSTRACT

Hyperlipidemia has been recognized as a risk factor for cardiovascular diseases of atherosclerosis, and is now emerging as a contributing factor for the progression of renal diseases. Olive oil is well known to reduce the cholesterol and triglyceride. Nephroprotective effects of olive oil are inconsistent. So, the objective of this study is to investigate such role against biochemical and histopathological changes, which may occur in the rat kidney fed with high fat diets. Material and Methods: 24 adult male albino rats (200-250gm) were divided into three groups: Group1: animals served as control. They were fed standard diet along with saline. Group 2: animals were fed high SFD (lightly heated butter) at a dose of 6 ml along with standard diet. Group 3: animals were fed high SFD (6.0 ml) with fresh Olive oil (1.5 ml) for 10 weeks. After finishing the experiment, blood samples were collected and assessed for lipid profile and kidney functions. Then, rats were sacrificed after anesthetized by ether. Both kidneys were extracted and slices of them were processed for histopathological examination. The statistical analysis of the data using the appropriate statistical tests were also conducted. Results: in the present study, histological examination of renal tissue of the rats fed on SFD for 10 weeks showed various degrees of degeneration and necrosis of glomeruli and renal tubules with areas of hemorrhage between the renal tubules. Histological examination of the renal tissue fed on SFD and olive oil showed less affection of the glomeruli and renal tubules with less areas of hemorrhage.

Conclusion and Recommendations: From this study, it is concluded that olive oil ameliorates the kidney injury induced by hyperlipidemia. Daily consumption of olive oil in the diets is recommended, as it is a well-known fact that atherosclerosis and cardiovascular disease can be avoided or delayed by using unsaturated fatty acids and olive oil is the best source of mono-unsaturated fatty acids.

Key Words: hyperlipidemia, olive oil, kidney injury , high fat diets

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INTRODUCTION

With today's hectic lifestyles, people pay no attention to the consumption of fresh fruits and green vegetables that boost their antioxidant status [1]. Adding to rich cholesterol feeding and lack of sufficient physi
cal activity, all these factors contribute to the increase of low density lipoprotein cholesterol [2] which leads to induction of atherosclerosis and many cerebrovascular disease and 56% of ischemic heart disease [3, 4].

Hyperlipidaemia is a condition in which the levels of lipoproteins cholesterol, triglycerides are raised in the plasma, which can be related to high lipids in the body. Hyperlipidaemia is contributed to high fat diet,

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sedentary lifestyle, etc. [5]

In 2012, cardiovascular diseases were the second causes of death [6]. According to 7 WHO [7], Ischaemic heart disease and stroke became the chief first killers worldwide.

Hyperlipidaemia causes atherosclerosis, and this leads to development of kidney disease [3, 8].

High lipid diets are rich in saturated fatty acids and responsible for development of hyperlipidaemia. Olive oil is rich in monounsaturated fatty acids and it is a well source of phytochemicals. Many studies have been shown the various effects of olive oil on glucose and lipid profile. They mentioned that olive oil was significantly increased plasma concentration of low-density lipoprotein cholesterol and high-density lipoprotein cholesterol [9, 10].

Treatment with olive oil reduced the low - density lipoprotein cholesterol and triglycerides (11, 12).

Olive oil is an essential food in the Mediterranean diet. Most results revealed that it reduces the risk of coronary heart diseases and prevents some malignant tumors [13, 14, 15].

It is known that the health effects of dietary consumption of monounsaturated fatty acids were related to the decrease in endothelial activation [16] and the susceptibility of low-density lipoprotein cholesterol to oxidation [17, 18].

Since the studies on the effect of olive oil on lipid profile are variable, the aim of this work is investigating the possible ameliorative effects of olive oil in hyperlipidemia induced renal injury.

MATERIAL AND METHODS

Twenty-four adult male rats, 90-120 days old, and weighing from 200-250 gm. were selected for the present study. They were purchased and maintained under the consent ethical rules of animal house of King Fahd Medical Research Center - Jeddah, Saudi Arabia.

In this study, high saturated fat diet (SFD) was used in the form of lightly heated butter at a dose of 6ml [19]. A dose of 1.5 ml/ Kg olive oil was used and obtained from the local market [20]. The animals were divided into 3 groups: Group1: animals served as control group. They were fed with standard diet alongside saline. Group 2: animals were fed with high SFD (lightly heated butter) at a dose of 6ml alongside standard diet. Group 3: animals were fed with high SFD (6.0 ml) alongside fresh Olive oil (1.5 ml)

Statistical Analysis

At end of the experiment, blood samples were collected and assessed for lipid profile and kidney functions. The statistical analysis of the data was conducted. Statistical Package for Social Science (SPSS) version 20 for windows program was applied to analyse the present data. The data were expressed as means ± standard deviation (SD). Comparison of variables between groups was performed using one-way analysis of variance (ANOVA).Statistical significances were considered at P-value < 0.05.

Histological Examination

The animals were sacrificed after 10 weeks, the kidney tissues were processed for histological examination. Each group of sections was stained by Hematoxylin and Eosin stain and Periodic acid-Schiff stain [21].

RESULTS

A. STATASTICAL RESULTS

Table (1) and Graph (1) showed that the body weights in G2 were significantly higher than G1 in all weeks of experiment (P =0.0001,).

Table (2) and Graph (2) showed that in the 4th and 5th weeks, the percentage change in body weights of G4 was significantly lower than G1 (P =0.004 & P =0.015, respectively). From the 6th to 10th week, the percentage change in body weights of G3 was insignificantly lower than G1.

Table (3) and Graph (3) showed that serum level of triglyceride in G3 was insignificantly lower than G1 (1P=0.073). Table (4) and Graph (4) showed that serum level of uric acid in G4 was insignificantly higher than G1 (1P=0.442). Serum Creatinine was insignificantly lower in G3 compared to G1 (1P=0.234). Serum level of urea in G3 was insignificantly lower in G3 compared to G1 (1P=0.435).

B. HISTOLOGICAL RESULTS

Group 1: control group

Microscopic examination of renal sections from control group showed the glomerulus consisted of capillaries network set within a small amount of connective tissue. The basement membranes of the capillaries are continuous with the Bowman's capsule of the glomerulus, and is separated from it by Bowman's space. The renal tubules are lined throughout a single-layered epithelium. The cells appeared cubical having eosinophilic cytoplasm and centrally basophilic nuclei (Figs.1, 2&3). In section stained by PAS, renal tissue gives moderate positive reaction (Figs. 4&5)

Group 2: SFD (Butter) group

Microscopic examination of transverse sections from the kidney of group 2 (rats fed with SFD) showed affection of the glomeruli in the form of widening of Bowman's space (urinary space) with congestion of the capillaries. Areas of hemorrhage appeared between the renal tubules (inter-tubular hemorrhage). The cells of the renal tubules showed various degrees of degeneration and disruption of the tubular epithelium (Figs.1, 2&3).In the section stained by PAS, renal tissue gives nearly negative reaction (Figs.4 & 5).

Group 3: SFD (Butter) + Olive oil

Microscopic examination of transverse sections from the kidney of group 3 (rats fed on SFD and olive) showing less widening of Bowman's space as compared with group 2. Most of the glomerular

capillaries still appear congested but not dilated. Most of the cells of renal tubules appeared regenerated. Less areas of intertubular hemorrhage were present (Figs.1, 2 &3). In the section stained by PAS, renal tissue gives mild positive reaction (Figs. 4&5).

DISCUSSION

In the present study, the body weights in rats fed on SFD were significantly higher than control group in all weeks of experiment. This result agreed with Altunkaynak et al.[22], who mentioned that a fatty diet was responsible for the rats' obesity and might lead to renal histopathological changes.

In the present study , the insignificancy of the changes in the lipid profile could be the result of SFD- induced hepatitis [23] or as a result of using refined oils with no phenolic content, these were agreed with many reports [12, 24, 25].

In this study, microscopic examination of renal tissue of the rats fed with SFD for 10 weeks showed affection of the glomeruli in the form of dilatation of Bowman's space and congestion of glomerular capillaries. The cells of the renal tubules showed various degrees of degeneration and disruption of the tubular epithelium. Areas of haemorrhage appeared between the renal tubules. Microscopic examination of the renal tissue fed with SFD and olive oil showed less affection of the glomeruli and renal tubules with less areas of haemorrhage.

Table (1) : Comparison of body weights (grams) in different studied groups.

Groups	1st week	2nd week	3rd week	4th week	5th week	6th week	7h week	8th week	9th week	10th week
G1 (control group)	194.75 ±3.59	205.75±5.75	228.50±6.40	245.50±9.03	258.50±7.85	276.25±14.52	280.00±9.63	289.25±20.27	306.50±31.51	310.00±41.35
G2 (Butter group)	240.00 ±8.68	261.50±15.50	277.00±19.24	287.00±22.32	315.25±19.00	327.00±19.61	345.25±21.09	355.75±24.74	371.50±27.93	382.75±29.51
Significance	1P= 0.0001	1P= 0.0001	1P= 0.0001	1P= 0.002	1P= 0.001	1P= 0.002	1P= 0.001	1P= 0.002	1P= 0.004	1P= 0.001
G4 (Butter & olive oil group)	201.25 ±5.97	215.25±5.68	225.00±9.02	225.75±17.15	237.00±25.39	260.75±22.44	275.50±25.63	282.75±36.40	306.33±19.14	308.67±17.21
Significance	1P= 0.149	1P= 0.183	1P= 0.724	1P= 0.109	1P= 0.164	1P= 0.298	1P= 0.796	1P= 0.746	1P= 0.994	1P= 0.951

Data are expressed as mean+/- standard deviation. 1P: significance versus G1

Table (2): Comparison of percentage changes in body weights (%) in different studied groups.

Groups	2nd week	3rd week	4th week	5th week	6th week	7h week	8th week	9th week	10th week
G1 (control group)	5.66±1.20	17.34±2.87	26.06±3.78	32.79± 5.61	41.96± 9.52	43.86± 7.22	48.70± 13.16	57.63± 19.13	59.51 ±24.39
G2 (Butter group)	8.93±4.15	15.34±4.55	19.48±5.92	31.30±4.72	36.20± 4.96	43.82± 6.22	48.15± 6.74	54.68± 7.46	59.37 ±8.26
Significance	1P= 0.104	1P= 0.540	1P= 0.139	1P= 0.796	1P= 0.388	1P =0.996	1P= 0.954	1P= 0.768	1P= 0.989
G3 (Butter & olive oil group)	7.00±3.31	11.92±6.72	12.29±9.89	18.01±14.89	2970±12.56	37.06± 14.44	40.59± 18.84	51.45± 14.02	52.58 ±13.12
Significance	1P= 0.495	1P= 0.105	1P= 0.004	1P= 0.015	1P= 0.072	1P =0.416	1P= 0.402	1P= 0.569	1P= 0.527

Data are expressed as mean+/- standard deviation. 1P: significance versus G1.

Percentage change in body weight (%) = Body weight – initial body weight / initial body weight X 100. 1P: significance versus control group) .

Table (3) : Comparison of lipid profile in different studied groups.

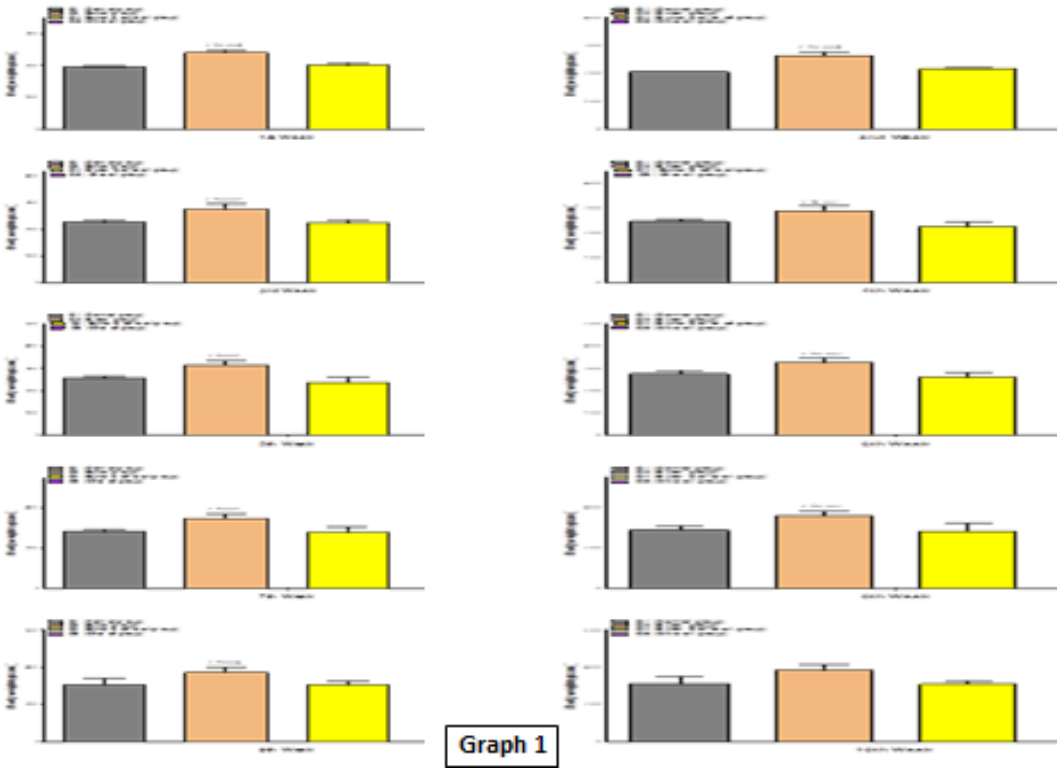
Groups	Cholesterol (mmol/L)	Triglyceride (mmol/L)	Low density lipoprotein cholesterol (U/L)
G1 (Control group)	1.38±0.11	0.89±0.60	327.50±266.16
G2 (Butter group)	1.30±0.00	0.47±0.46	592.00±471.30
Significance	1P= 0.531	1P= 0.087	1P= 0.230
G3 (Butter & olive oil group)	1.40±0.13	0.45±0.23	561.75±372.66
Significance	1P= 0.909	1P= 0.073	1P= 0.286

Data are expressed as mean+/- standard deviation. 1P: Significance versus G1 (Control group).

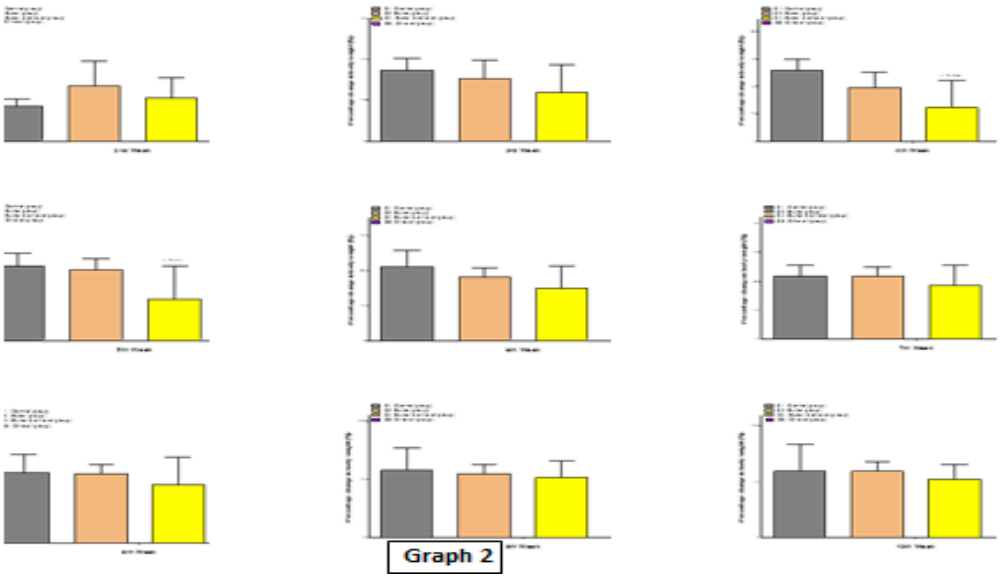
Table (4): Comparison of Kidney functions in different studied groups

Groups	Uric acid (µmol/L)	Creatinine (µmol/L)	Blood urea nitrogen (mmol/L)
G1 (control group)	67.50±28.36	47.50±6.14	6.65±0.75
G2 (Butter group)	80.25±24.41	46.75±3.77	5.54±1.71
Significance	1P=0.433	1P=0.859	1P=0.216
G3 (Butter & olive oil group)	80.00±25.70	42.00±1.73	5.90±1.70
Significance	1P=0.442	1P=0.234	1P=0.435

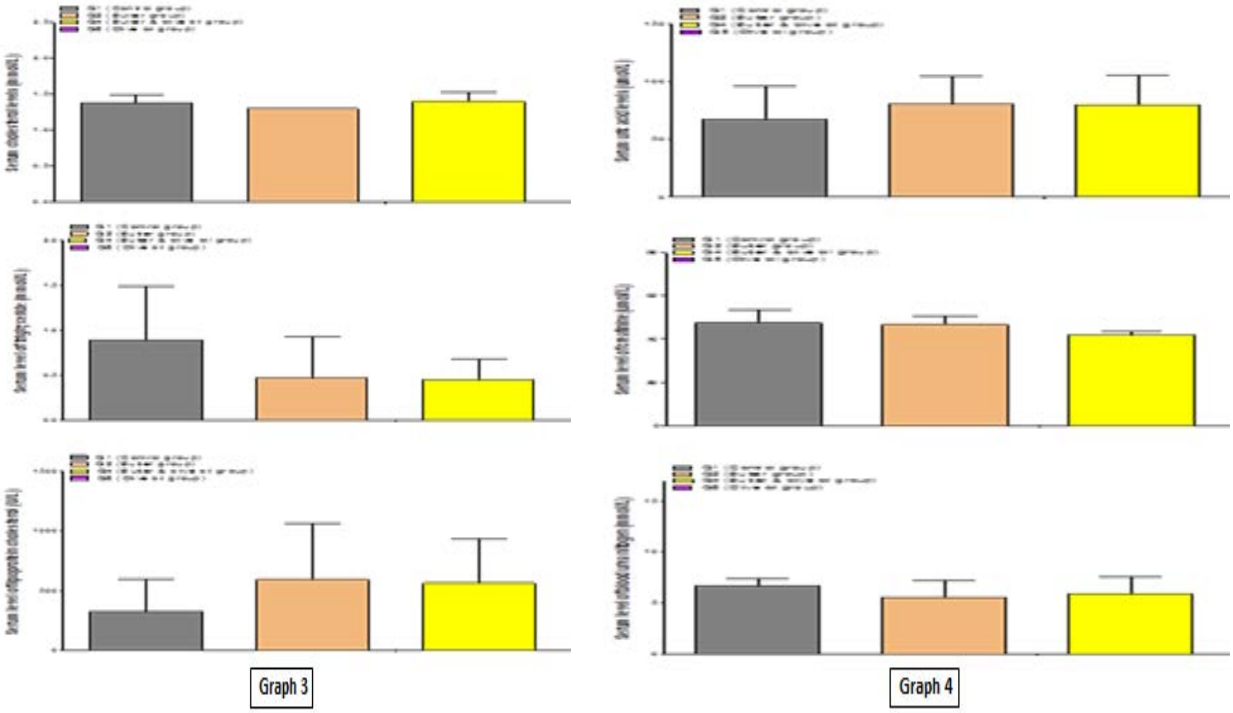
Data are expressed as mean+/- standard deviation. 1P: Significance versus G1 (Control group).



Graph (1): Comparison of body weights (grams) in different studied groups.
1P: Significance versus G1



Graph (2) : Comparison of percentage changes in body weights in different groups.
1P: Significance versus G1



Graph (3): Comparison of lipid profile in different studied groups.
1P: Significance versus G1

Graph (4): Comparison of Kidney functions in different studied groups.
1P: Significance versus G1

Fig. 1

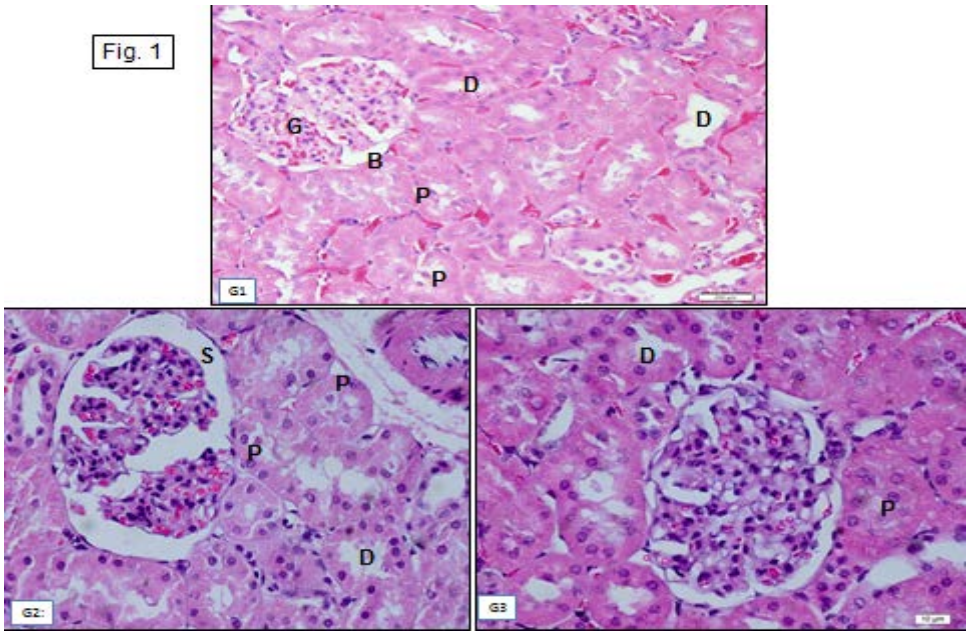


Fig.(1): Photomicrographs of transverse sections from the cortex of the kidney of :

G1: Renal corpuscle of a control rat showing intact glomeruli (G) and Bowman's capsules (B). Portions of intact proximal (P) and distal (D) convoluted tubules are appeared.

G2: Renal corpuscle of a rat fed on SFD showed a marked dilatation of the Bowman's spaces (S).
Variable degrees of degeneration are present in proximal (P) and distal (D) convoluted tubules

G3: Renal corpuscle of a rat fed on SFD and olive showed less dilatation of the spaces of Bowman's capsules compared with that of rat of group 2 . Improvement of the cells of proximal (P) and distal (D) convoluted tubules are appeared (Hx &E). Scale bar = 50um

Fig.2

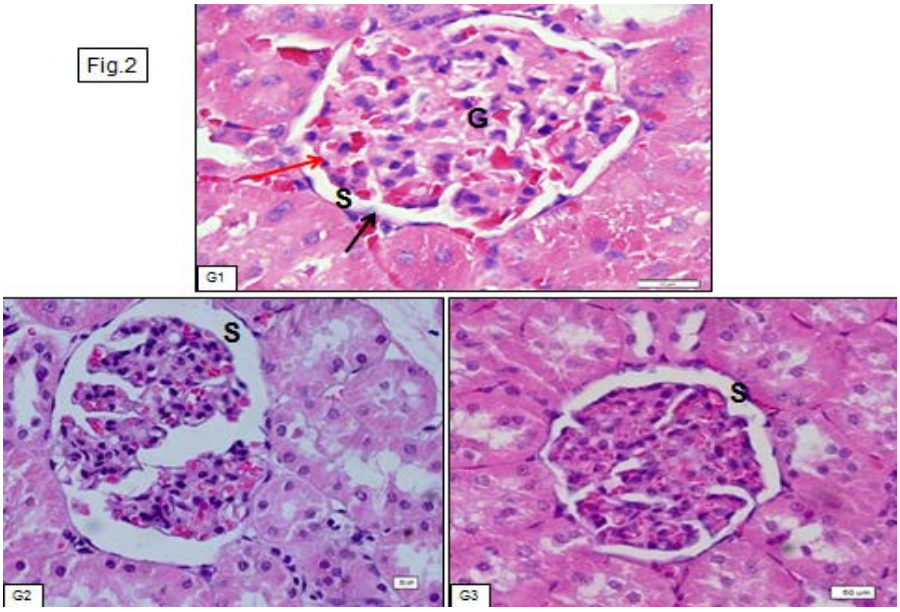


Fig. (2): Photomicrographs of higher magnification of the previous figure showing the renal corpuscles of:

G1: It appears intact and consists of Bowman's capsule enclosing the glomerulus (G). The Bowman's capsule is formed of parietal (black arrow) layer and visceral layer (red arrow) separated by glomerular capsular space (S). The glomerulus is formed of a network of glomerular capillaries.

G2: It showed a marked dilatation of the spaces of Bowman's capsules (S) with congestion of glomerular capillaries.

G3: It has less widening of Bowman's space (S) as compared with that of rat of group 2 but congestion of the glomerular capillaries still present. (Hx & E). Scale bar = 50 um

Fig. 3

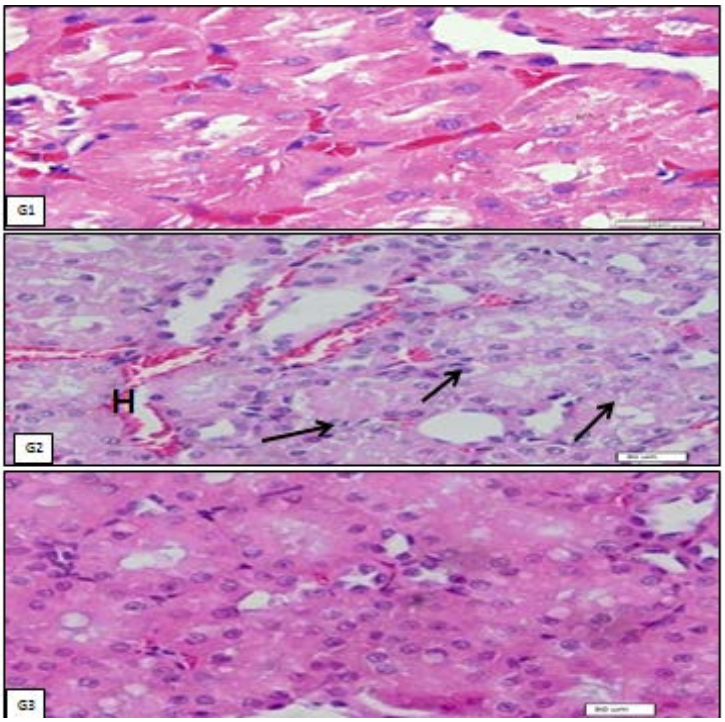


Fig. (3) : Photomicrographs of transverse sections from cortex of the kidney showing the renal tubules of :

G1: they appear normal
G2:. they showed marked degenerative changes and disrupted epithelium (arrows) . Areas of haemorrhage (H) are appeared between the renal tubules.
G3: they appear normal and to a great extent similar to those of G1, no intertubular haemorrhage is detected (Hx & E). Scale bar = 50 um

Fig. 4

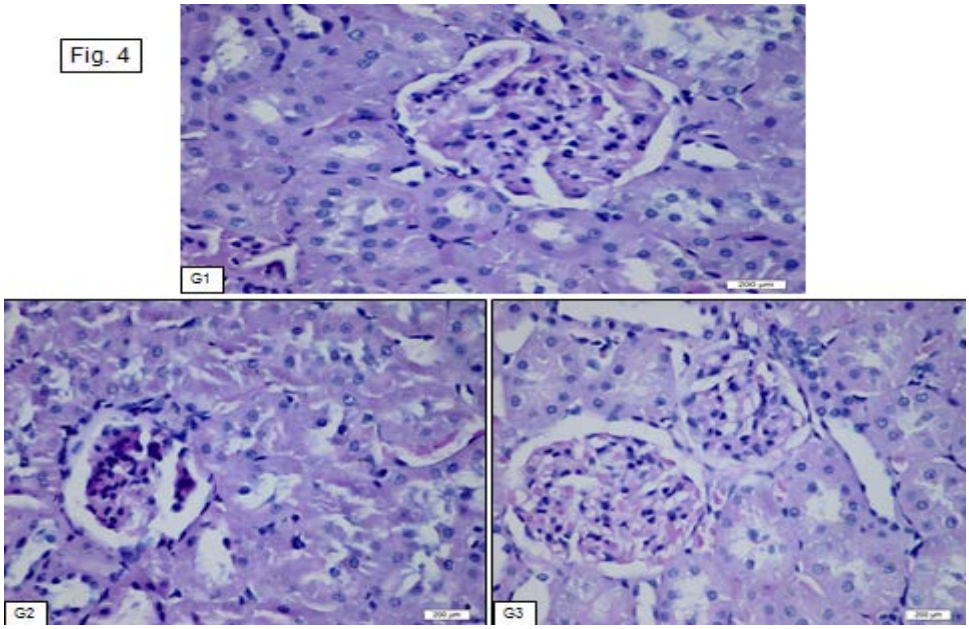


Fig. (4) : photomicrographs of renal cortical tissues of the rats stained with periodic acid Schiff showing

G1 : Moderate positive reaction of the outer border of the Bowman's capsule , basement border and brush border of proximal convoluted tubules and the basement border only of the distal convoluted tubules
G2: Mild positive reaction of the outer border of the Bowman's capsule . Negative reaction of the distorted proximal convoluted and distal convoluted tubules
G3 : Mild positive reaction of the outer layer of the Bowman's capsule , basement border and brush border of proximal convoluted tubules and the basement border only of the distal convoluted tubules.

Fig. 5

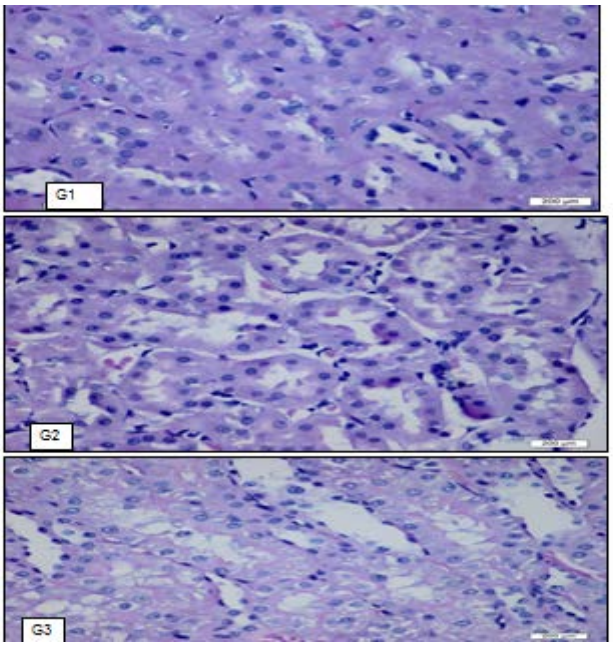


Fig. (5) : photomicrographs of the renal cortical tissues of the rats stained with periodic acid Schiff showing the renal tubules of :

G1: Moderate positive reaction of basement border and brush border of proximal convoluted tubules and only the basement border of the distal convoluted tubules.

G2: Negative reaction of basement border and brush border of proximal convoluted tubules and only the basement border of the distal convoluted tubules

G3: Mild positive reaction of basement and brush borders of proximal convoluted tubules and the basement border only of the distal convoluted tubules. PAS: scale bar = 200 um

These results are in agreement with many studies [26]which mentioned the role of lipids in progressive renal diseases.

In this study, microscopic examination of renal tissue of the rats fed with SFD and olive oil for 10 weeks showed improvement of the renal tissues as less widening of the Bowman's capsules, no intertubular haemorrhage and regeneration of most cells of proximal and distal convoluted tubules. These results coincided many studies; one study reported a connection between better health and consumption of olive oil. It had been also reported in another study that olive oil with fish oil supplement leads to a decrease in the oxidative changes in low-density lipoprotein cholesterol [26, 27].

The intake of olive oil reduces the incidence of cardiovascular diseases, as it is the best source of mono-unsaturated fatty acids [28].

Another study depicted that the consumption of two tablespoons of olive oil, for six weeks, significantly lowered the concentration of LDL cholesterol [29]. Low-density lipoprotein oxidation seems to have an important effect on atherogenesis [30].

CONCLUSION

From this study, it is concluded that olive oil ameliorates the renal tissue from the changes induced by hyperlipidaemia. So, it is recommended the substitution of dietary lipids with olive oil in daily consumption in the diets.

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