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The effect of flaxseed, sesame and chia oils on lipid profile, oxidative stress, body weight and histopathological parameters in rats fed normal and high fat diets

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Abstract

Hyperlipidemia is the major risk factor for cardiovascular disease which is one of the main cause of death. Some oils have the ability to control hyperlipidemia. This study aimed to evaluate the effect of sesame, flaxseed and chia oils on lipid profile, histophathological parameters, body weight and oxidative stress in rats fed basal diet as well as the effectiveness of these oils in preventing hyperlipidemia and its damage when eating high fat diet (HFD) rats were divided into two mine groups, one fed basal diet and the other groups fed high fat diet (HFD), each group was divided into four 4 subgroups, one served as control and the other three subgroup received flaxseed, sesame or chia oils instead of corn oil, lipid parameters, histopathological stream of liver and kidney, weight as well as oxidative stress of liver were monitored. Our results revealed that experimental oils had a remarkable effect in controlling increment of triglycerides (TG) total cholesterol, Low density lipoprotein (LDL) and furthermore improve liver and kidney histopathology tissues as nearly close to normal and also ameliorate oxidative stress.

1. Introduction

Hyperlipidemias defined as increase concentration of lipid on blood which are considered one of the major factor for others a sclerosis which lead to death as mentioned by **Hill and Bordoni [1]**, gene, eating pattern especially High 12 fat diet as well as lifestyle are a major causes of hyperlipidemia **as discussed elsewhere [2,3,4].**

High fat consumption aid to the formation of free radicals and decrease antioxidant levels which cause imbalance and oxidative stress **as noted by Yang et al., [5]and Jarukamjorn et al.[6])**. Oxidative stress have been linked to several diseases such as cardiovascular diseases Alzheimer, diabetic, depression and Cancer 17 **[7]** chia is a high nutritive value seed, it contain 47% fat rich in omega3 and α linolenic acid which are considered important for maintaining health and preventing many diseases, **as showed by Munir et al., [8] [8]** furthermore.

Chia oil have been reported to possess anti-inflammatory effect that can reverse atherosclerosis damages.

Silva et al., [9] mentioned that chia oils is rich in ALA and polyunsaturated fatty acids that create omega 3 thus, help to improve heart health **[10]** and reduce cardiovascular risk factors as well as prevent cancer **as declared by Kaur; et al.[11].**

It was reported that omega 3 possess a neuroprotective effect on brain that can help treating depression and Alzheimer's disease **as noted elsewhere [12,13].**

Sesame seeds named as queen of oil seeds that contain a balance ratio between omega 6 to omega 3 **Guimaraes et al., [14].** Sesame oil has many health benefits such as preventing all damages caused by free radical due to its high content of sesamol and sesaminol antioxidants as declared **by Pizzino et al., 15]**, protect 31 heart and decrease oxidative stress **[16]**, possess proinflammacory functions **as discussed by Khorrami, et al. [17]** which help treating and preventing atherosclerosis Moreover, a consumption of 3.5-4.5 g 33 sesa~~me~~ oil daily for 2 months was found to decrease cholesterol as well as triglyceride levels in blood **as noted by Jennifer, [18]**.

Flaxseed oil is an important source of nutritive compounds that improve health and also help preventing many diseases, from such compounds we can mention Omega 3 and alpha- linolenic fatty acid Studies have showed the effectivity of this oil in the

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treatment of atherosclerosis **as discussed by Haldar, et al., [19].and Ali, et al., [20]**.

Flaxseed oil had been also reported to help in the treatment of hyperlipidemia and cancer **as mentioned by Eliman and Ramadan, [21]; Buckner et al., [22]**.

Corn oil is the most abundant oil, in fact it contain a very poor portion of Omega 3 and a very high portion of Omega 6 which is considered inflammatory agent and resulting with a very risk ratio of Omega 6 : Omega 3.

Thus, corn oil is not considered a healthy fat, finding alternative healthy sources of oil became an 47 important challenge. **[23]**

From those studies it can be deduced that quality of fat used in food is an important factor that affect 49 health and is a risk factor for many diseases.

This study aimed to access the protective effect of some oils reach in omega 3 and linoleic acid (Sesame, chia and flaxseed oils) on hyperlipidemia parameters and the effect of such oils on alleviating high fat diet damage on blood profile, oxidative stress and histophathological features as well as their ability to control the increase in body weight caused by high fat diet.

2. Materials And Methods

Animals:

Fifty six adult male Sprague – Dawley rats of a local strain weighing 180-200g were used in this study. Animals were obtained from National Research Center, Dokki, Egypt. Rats were housed in a well-ventilated animal room under controlled hygienic conditions of 24oC temperature, 50% relative humidity and 12h light/ 12h dark cycles. Basal diet and water were provided ad Libitum. The experiment on rats was carried out in accordance with the recommendations of the National regulations on animal we fare and. Institutional Animal Ethical committee (I.A.E.C).

Procurement of material corn oil, Sesame seed oil and flaxseed oil were obtained from the local market. While Chia seed oil was extracted through the oil extraction, 50g chia seed powder was extracted by petroleum ether at 50oC for 8 hours. Chia seed oil was recovered in a rotary evaporator by evaporating solvent

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Experimental design and study plan

Mature male Sprague- Dawley rats were randomized into 8 groups of 7 rats each. Group from 1 to 4 were fed basal diet (10% oil) while groups from 5 to 8 were hyperlipidemia groups fed with high fat diet (13% 16 oil + 7% vegetable ghee).

Group 1 served as control and was fed basal diet (10% corn oil). In group (2), (3), (4) corn oil was substituted by chia, seasam and flax oils (10%) respectively. Group 5 was high fat diet control (with corn oil) in groups 6-7-8 corn oil was also substituted by chia, 21 sesame and flax oils in respective order.

Blood sampling and Lipid profile:

Serum high-density lipoprotein (HDL), total cholesterol (T.C.) and triglycerides (TG) was examined.

At the end of experiment blood samples were collected (6 weeks) in capillary tubes from the eye plexuses under diethyl ether anesthesia and then centrifuged at 3000 pm for 20 min to obtain plasma, which was kept frozen until analysis, the total cholesterol was analyzed calorimetrically according to **(Kim et al., 2006). [24]** Method, triglycerides (TG) was determid according to **Alshatwi et al., [25].** Serum LDL cholesterol levels were calculated from the levels of TC, HDL, cholesterol and triglycerides using the fried wald equation: LDL cholesterol (mg/dL = TC- HDL - TG/5) according to **Ahmadi et al..[26]**

Histology

Liver and kidney samples were prepared for histological examinations by light microscopy according to 39 the methods described by **Drury and Wallington [27]**

Statistical analysis

The information obtained from the present study were statistically analyzed according to **Snedecor and Cochran. [28]**

RESULTS AND DISCUSSION

The effect of sesame, chia, flaxseed oils on the serum lipid level in rats fed normal diet for six weeks was shown in table (1) from this table it could be concluded that adding flaxseed, sesame and chia oils instead of corm oil showed a positive effect in lipid profile as TC, TG and LDL were decreased while HDL was increased when compared with rat fed diet with corn oil. We could noticed that chia seed oil had a great potential hypocholestiremic effect through reducing TC level followed by flaxseed then came sesame oil. TG showed a marked decrease in group of rats fed flaxseed oil compared with BDC (17.04%) with regard to HDL cholesterol, chia and sesame groups showed almost the same increment (about 14%) when compared with rat fed basal diet with corn oil. Flaxseed oil showed also 11.45% increase compared with BDC group.

These results are in agreement with those found by (Asturn ft al., 2020) [29], Who noted that sesame 25 oil had an effect on lowering TC. LDL and such decrease was depended on the increase in the dose of sesame oil 26 and they also found that 8% sesame oil had the great effect on lowering TC, LDL and TG.

Table (1) :The effect of flaxseed oil ,sesame oil and chia oil on lipid profile of rats fed basal diet :

Group	B.D.C	Flax B.D		Sesame B.D		Chia B.D	
	mg/dL	mg/dL	%BDC	mg/dL	%BDC	mg/dL	%BDC
T.C	78.91	70.93	10.11	71.18	9.8	68.75	12.9
T.G	61.03	50.63	17.04	57.25	6.2	59.32	2.8
HDL	59.13	65.90	11.45	67.27	13.78	67.75	14.58
LDL	21.85	1.88	-	6.47	-	11.25	-
LDY HDL	0.37	0.03	-	0.1	-	0.17	-

T.C: Total Cholesterol **T.G: Triglycerides** **BDC : basal diet control**
HDL: High-density lipoprotein **LDL: Cholesterol** **BD : basal diet**

Table (2) :The effect of flaxseed oil ,sesame oil and chia oil on lipid profile of rats fed high fat diet:

Group	HFDC%		Flax HFD%		Sesame HFD%		Chia HFD%	
	mg/dL	%BD	mg/dL	%HFD	mg/dL	%HFD	mg/dL	%HFD
T.C	234.45	197.1	138.24	41	180.25	23.1	169.26	27.8
T.G	131.06	114.8	88.12	32.8	105.10	19.8	106.91	18.4
HDL	43.38	26.6	56.77	30.9	54.1	24.9	49.80	14.8
LDL	164.86	-	68	56.9	105.1	33.5	98.1	37.9
LDL / HDL	3.8	-	1.2	-	1.9	-	1.97	-

T.C: Total Cholesterol **T.G: Triglyccriiks** **HFDCihif-li till did control**
HDL: **LDL: Cholesterol** **HFD: high far diet**

Table (2) showed the effect of flaxsccd, sesame and chia seeds oil an lipid profile of rats fed high fat diet for six weeks. From this table it eould be concluded that feeding HFD led to increase in lipid profile when compared with basal diet groups. TC and TG bevels were markedly increased in HFD then came normal control 30 group such increment reached 197.1% and I 14.8% respectively. Il is worthy to mention that replacement of corn 31 oil with our experimental oils had a significant effect on lowering blood lipids on rats. Regarding (TC). llaxsced 32 oil had the highest decrease effect followed by chia seed oil then came sesame oil (41%. 27.8 and 23.1%) when 33 compared with high fat diel control f HFDC).

With regard to TG level, a decrease ranging between 18.4% (chia group) to 32.8% (flaxseed group) was 35 showed comparing to HFDC.

With respect to HDL a decrement reaching 26.6% was showed in HFDC group compared with BDC, while experimental oil caused an increase in HDL level compared with HFDC, it is worthy to say that HDL 39 values in flaxseed and sesame oil groups fed HFD were closed to that of group fed normal diet (56.77 mg/dL 40 54.17 versus 59.13mg/dL).

In this respect Han et al. [2] noted an increase in TC, TG and LDL levels in HFD group while a decrease in HDL level occurred they also found that groups fed with chia seed oils had marked reduction in 43 lipid parameter with a great increase in HDL level.

Results of LDL cholesterol were shown in the same table . from these results we could noted that our experimental oils led to marked decrease in LDL both for rats fed either normal or high fat diet when compared to control group.

LDL/HDL ratio is an indicator to risk factor of atherosclerosis diseases. The higher the ratio, the higher the risk. To assess the risk factor for arteriosclerosis LDL/HDL ratio was calculated (Tables 1 and 2).

It is worthy to mention that LDL/HDL ratio when substitution corn oil by experimental oils showed values below than 52 in basal diet groups while such ratio fluctuated between 1.2 to 1.97 in high fat diet groups compared to 3.8 in high fat diet control group.

It can be concluded that feeding sesame, flaxseed and chia oils led to minimize the risk of heart diseases even when consuming high fat diet.

Our results are in agreement with those obtained by **Aslam et al.** [29] who found that sesame oil caused a marked reduction in TG, LDL and TC while increased HDL, such effects is proportional to the used dose in experimental rats. Similar results was also showed by **Fili et al.** [30] who found that sesame seed oil supplementation led to an increase in HDL cholesterol with a corresponding decrease in TG, TC and LDL cholesterol in hypercholesterolemic rats .

In this respect **Iqbal et al.** [31] mentioned that sesame oil is used to care diseases and aide to decrease cholesterol level, furthermore led to improve blood profile, growth and immunity in rabbits.

Our results concerning chia oil are closed to that obtained by **Alarcon et al.** [32] . Who found that 3% only chia oil supplemented to HFD (8% lard 7% corn oil) fed to rabbits caused a reduction in TG level as well as the percentage of omega 3 omega 6.

Haldar et al. [19] declared that consuming a blend of flaxseed, sesame oils and rice bran can 11 improve lipid parameter in hyperlipidemiac patients.

The effectiveness of both chia seed or oil on hyperlipidemias as well as lowering TC, TG and LDL are also demonstrated in studies conducted by **Han et al.** [2] **Martinez et al (2019)** [33].

In a study conducted by **Ayerza and Coats** [34] on rats fed either chia seed or chia oil for 16 one month, it was found that both of them had a lowering effect on TC, TG due the high content of α linolenic acid.

In the study of **Munir et al.** [8] on the effect of mix aqueous and methanol extracts of chia seed 200 they found that TC, TG and LDL were significantly decreased by increasing the dose of chia, they also declared that this effect was due to the high content of Omega 3.

Our results on the effect of flaxseed oil on lipid profile of rats fed high fat diet are closed with those 21 obtained by **Ali et al.** [20] **and Eliman et al .** [21] who proved the potential effect of flaxseed on decreasing LDL, TC and TG levels in rats fed HFD. Similar observation was showed in an study 23 done by **Sadat et al** [35].

Table (3) showed the body weight for rats fed basal diet and table (4) those fed HFD, from this table we could showed that final weight of rats (after 6 weeks) fed basal duet increase by 48.8% , while the increase 26 was 28.7% in both sesame and chia oils groups, meanwhile such percentage in flaxseed oil group was 36.4%. 27 with concern to rats fed High fat diet (20% fat) an increase of body weight reached 93.1% found in HFD control 28 group, such increase was almost twice as that of basal diet control.

Although rats fed high fat diet, our experimental oils caused parentage of increase in rats weight closed to those of rats fed basal diet.

It is worthy to mention that the increase of weight in experimental oils groups fed high fat diet almost one third that of control group fed same diet. Such percentage in high fat diet groups 36% in sesame group, 28.3% in flaxseed group and 27.2% in chia group compared with an increase of 28.7%, 36.4% and 28.7% in groups with some oils fed basal diet.

The lowering effect of experiment oils may be due to their hight content of ALA and omega 3.

The current study was in agreement with **Aslam et al.[29]** who found that feeding rats sesame oil at a different concentration for 42 days caused a marked decrease in the body weight of rats.

Table (3): Percent of change in body weight of rats fed high fat diet (HFD) , and those fed HFD experimental oils:

	BDC	Flax BD	Sesame BD	Chia BD
Zero (g)	202.6	183.4	183.8	200.2
Final (g)	301.4	250.2	257.4	257.6
Zero (%)	48.8	36.4	28.7	28.7

BDC: basal diet control **BD: basal diet**

Table (4): Percent of change in body weight of rats fed high fat diet (HFD) , and those fed HFD experimental oils:

	HFDC	Flax HFD	Sesame HFD	Chia HFD
Zero (g)	200.2	201.6	188.8	197.2
Final	286.6	258.6	256.8	250.8
Zero %	93.1	28.3	36	27.2

FDC: high fat diet control **HFD: high fat**

Yahyaei et al.[36] also found that sesame oils had a role in decreasing weight moreover 11 improving liver function and histopatholigical parameters.

Han et al. [2], noted that chia seed oil when added to HFD lowered body weight gain of mice 13 when compared with HFD control .

Eliman and Ramadan [21] noted that flaxseed oil had an effect on lowering body weight of rats 16 fed HFD, they noted that such effect was done either before or after taking HFD.

Same observation was noted by **Munir et al.[8]** concerning the effect of flaxseed oil on body 18 weight of rats. Oxidative stress is commonly linked with the imbalance between free radicals and the protective effect of antioxidant as well as the formation of highly reactive OH linked to oxidative damage of the cell's components like proteins, lipids as well as DNA **as mentioned by Betteridge,D.J[37]**.

araoxonase 1(PON1) is an enzyme that is synthesized in the liver then transported through! blood. It is associated with protection against exposure to some organophosphates (such as those from insecticides) and also preventing the development of atherosclerosis and in the inactivation **of** oxkialive stress and 26 inflammation.**(Mackness,ct 2006[38] and Furlong ct ill 2016[39]).**

Decrease of PON activity is linked with a risk of many diseases specially cardiovascular diseases **(Shunmoogam et al 2018)[40].**

Table (5): Ciimnarison between Paraoxonase l (PON) KU/I, in liver of rats fed basal diet and high fat diet when using experimental oils:

	Basal diet	High fat diet
Control	36.2 ±1.33	21.33 ±1.25
Flaxsscd oil	35.28 ±1.38	30.61 ±1.29
Sesame oil	36.52 ± 0.79	26.92 ±1.09
Shea oil	36.114 ± 0.79	25.72 ±1.03

Table (6): The effect of experimental oils on the nitric oxide NO(nmol/g.tissue) in liver of rats fed basal diet and high fat diet:

	Basal diet	High fat diet
Control	32.76 ± 0.86	54.22 ± 0.8
Flaxseed oil	34.3 ± 1.31	41.00 ± 1.04
Sesame oil	33.84 ± 0.93	45.6 ± 1.01
Chia oil	33.34 ± 1.25	46.32 ± 0.92

With regard to the enzymatic or non-enzymatic antioxidant levels,(table 5) the present study revealed significant reduction in PON1 in HFD treated rats. Treatments oils ,specially flaxseed, controlled that decrease. These findings were in agreement with **Aslam et al** [29], who reported the same disturbance in the antioxidant levels after HFD induction of damage.

Concerning nitric oxide (NO) , data in table (6) revealed that NO in basal diet fed groups fluctuated between 32.76± 0.86 (in basal control group).

Feeding high fat diet caused a marked increase in NO . That increase reached 65.5% in high fat diet control group compared with basal diet control group.

From same table it could be seen that experimental oils controlled that increase as it was 19.5 % in 11 flaxseed oil group (fed high fat diet) compared with flaxseed oil group fed basal diet.

It can be concluded that in rats fed high fat diet , flaxseed oil had the better ameliorating effect in NO 13 followed by sesame oil then shea oils . Treatment with experimental OILS recorded improvement of the PON1 and NO. Protective effects of these oils against HFD which induced oxidative stress could be referred to the high level of polyphenol compounds that have a high antioxidant activity . High content of Omega 3 could be another factor that caused this protective effect .These compounds could scavenge the free radicals of HFD formed through P450 enzyme system and diminish the oxidative damages. Oils used in this stud may also impair HFD-mediated lipid.

Histological changes

Kidney

Histological examination of the cortical tissue from the kidney of basal diet control rats show renal corpuscles and renal tubules, proximal convoluted tubules and distal convoluted tubules. The glomeruli, urinary spaces and Bowman's capsules are noticed (Fig. 1).

Microscopic investigation of the cortical tissue form kidney of rats supplemented with basal diet and Flaxseed oil indicated the renal corpuscles and renal tubules appeared more or less nearly the normal shape (Fig. 2).

The cortical tissue form kidney of rat supplemented with basal diet and Sesame oil showed renal corpuscles and renal tubules appeared more or less like normal (Fig. (3). On the other hand, some rats showed 46 normal renal corpuscles and renal tubules. While, some cellular debris in the lumens of renal tubules was noted (Fig. 4).

In rats supplemented with basal diet and Shea oil, renal corpuscles and both proximal convoluted tubules and distal convoluted tubules appeared more or less like normal (Fig. 5).

With regard of rats supplemented with high fat diet, mild hemorrhagic areas were present in the interstitium. Atrophy of renal corpuscles associated with dilated urinary space were seen (Fig. 6). Moreover, in kidney of rats supplemented with high fat diet inflammatory infiltration and hemorrhagic areas were found in the interstitium of the cortical tissue form kidney. Necrosis of some cells of the proximal convoluted tubules was also seen (Fig. 7). On the other hand, intraglomerular congestion and narrow urinary spaces were indicated (Fig. 8).

Supplementation with high fat diet and flaxseed oil caused mild atrophy of renal corpuscles and wide urinary spaces (Fig. 9). Inflammatory infiltration and hemorrhagic areas present in the interstitium (Figure 10). Also, the cortical tissue form kidney appeared almost nearly to normal structure (Fig. 11).

In case of rats supplemented with high fat diet and Sesame oil, the cortical tissue form kidney of showed that the corpuscles and tubules exhibit almost normal structure. Some tubules show desquamation of its Statistical Results.

Results in table (7) showed that a strong, positive association between total cholesterol , triglyceride , HDL and LDL in rats fed high fat diet with each of flaxseed ,sesame and chia oils with same blood parameters in control group of rats fed high fat diet.

Results in table (8) showed that a strong, positive association between total cholesterol , triglyceride , HDL and LDL in both control groups as well as between group fed basal diet with sesame and control .With regard to group fed chia oils high correlation with control group were found regarding TG and LDL while middle positive correlation were showed regarding TC and LDL. Negative correlation was showed between TG of flaxseed oil groups and that of control group of rats fed basal diet.

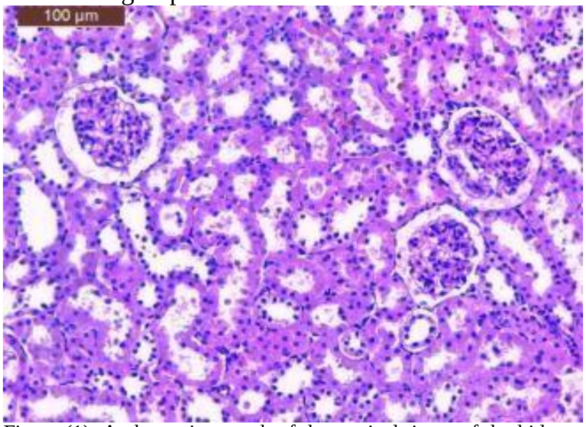

Figure (1): A photomicrograph of the cortical tissue of the kidney of basal diet control rat showing renal corpuscle and renal tubules, proximal convoluted tubules (PCT) and distal convoluted tubules (DCT). Notice the glomeruli (G), urinary space (US) and Bowman's capsule (BC) (H & E stain, Scale bar: 100 µm).

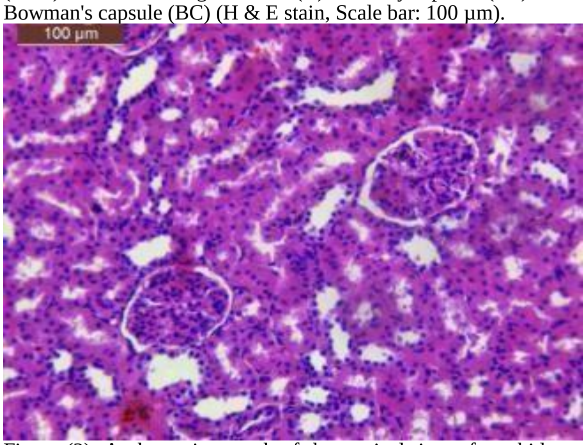

Figure (2): A photomicrograph of the cortical tissue form kidney of rat supplemented with basal diet and Flaxseed oil showing renal corpuscle and renal tubules, proximal convoluted tubules (PCT) and distal convoluted tubules (DCT) appeared more or less nearly normal (H & E stain, Scale bar: 100 µm).

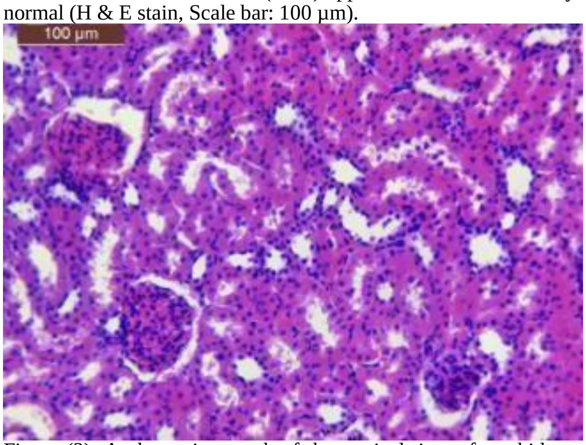

Figure (3): A photomicrograph of the cortical tissue form kidney of rat supplemented with basal diet and Sesame oil showing renal corpuscle and renal tubules appeared more or less like normal (H& E stain, Scale bar: 100 µm).

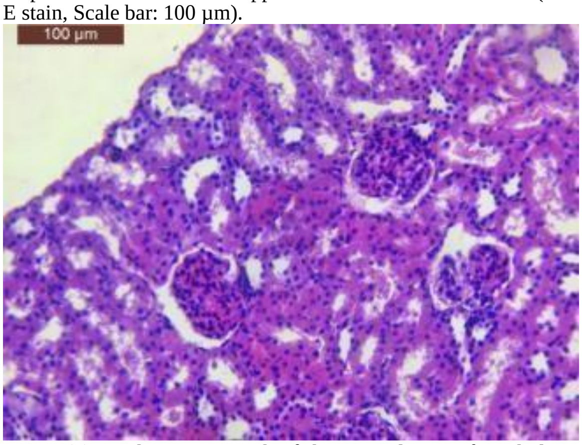

Figure (4): A photomicrograph of the cortical tissue form kidney of rat supplemented with basal diet and Sesame oil showing renal corpuscle and renal tubules, proximal convoluted tubules and distal convoluted tubules appeared more or less nearly normal. Notice, some cellular debris in the lumens of renal tubules (arrow) (H & E stain, Scale bar: 100 µm).

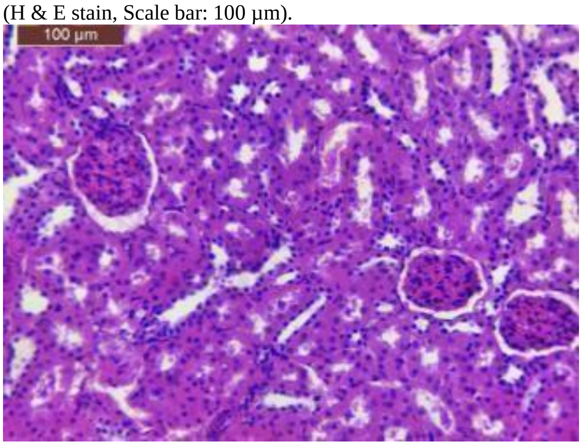

Figure (5): A photomicrograph of the cortical tissue form kidney of rat supplemented with basal diet and Shea oil showing renal corpuscle an d both proximal convoluted tubules and distal convoluted tubules renal tubules, appeared more or l ess like normal (H & E stain, Scale bar: 100 µm).

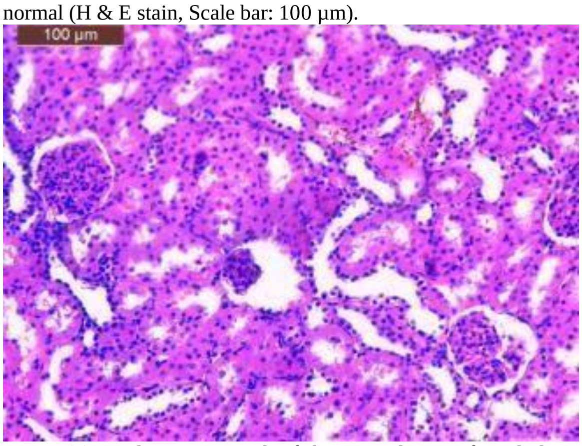

Figure (6): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet showing mild hemorrhagic area present in the interstitium. Atrophy of renal corpuscle (arrow) associated with dilated urinary space (arrow head) (H & E stain, Scale bar: 100 µm) (H & E stain, Scale bar: 100 µm).

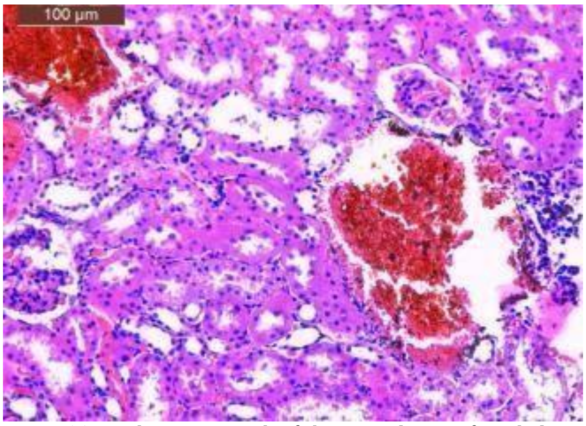

Figure (7): A photomicrograph of the cortical tissue form kidney of rat supplemented high fat diet showing inflammatory infiltration (arrow) and hemorrhagic areas present in the interstitium. Notice necrosis of some cells of the proximal convoluted tubules (arrow head) (H & E stain, Scale bar: 100 µm).

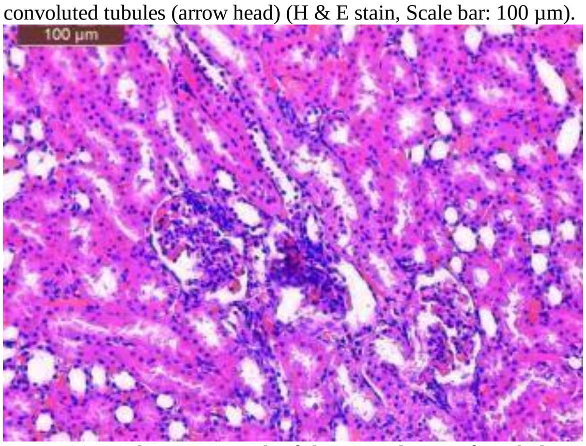

Figure (8): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet showing intraglomerular congestion and narrow urinary spaces (arrow) (H & E stain, Scale bar: 100 µm).

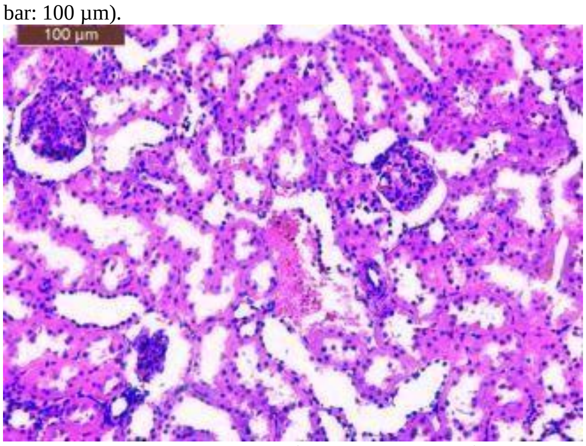

Figure (9): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet and flaxseed oil showing mild atrophy of renal corpuscles and wide urinary spaces (arrow) (H & E stain, Scale bar: 100 µm).

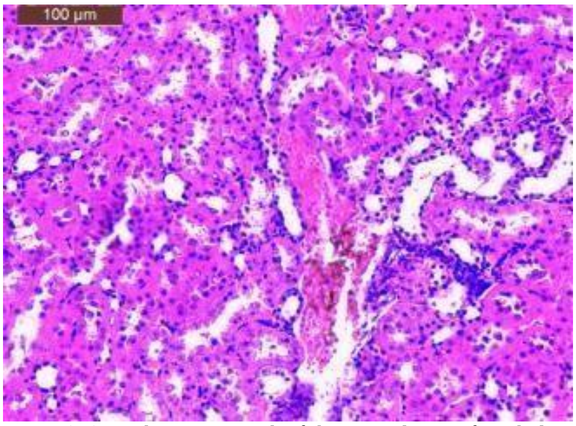

Figure (10): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet and flaxseed oil showing inflammatory infiltration (arrow) and hemorrhagic areas present in the interstitium (arrow) (H & E stain, Scale bar: 100 µm).

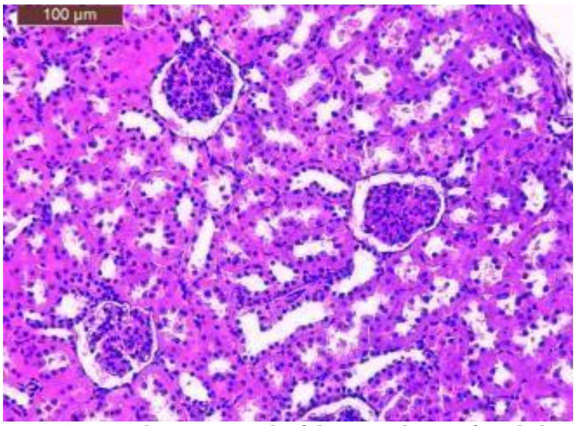

Figure (11): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet and flaxseed oil showing the corpuscles and tubules exhibit almost normal structure (arrow) (H & E stain, Scale bar: 100 µm).

Table (7): The correlation between blood parameters in both control groups and between blood parameters in each of flaxseed ,sesame and chia oils groups with control group of rats fed high fat diet:

	Control HFD Corr. With Control BD	flax HFD Corr. With control HFD	sesame HFD Corr. With Control HFD	Chia HFD Corr. With Control HFD
TC	0.982748	1	0.974326	0.967095
TG	1	1	0.999943	0.994725
HDL	1	1	0.90857	0.91004
LDL	1	1	0.986012	0.976853

Table (8): The correlation between blood parameters in both control groups and between blood parameters in each of flaxseed ,sesame and chia oils groups with control group of rats fed basal diet:

	Control BD Corr. With Control HFD	flax BD Corr. With control BD	sesame BD Corr. With Control BD	Chia BD Corr. With Control BD
TC	0.982748	1	0.923153	0.555045
TG	1	-1	0.90759	0.94792
HDL	1	1	0.864687	0.410583
LDL	1	1	0.821932	0.623087

Table (9) : The correlation between weight in treatments and control groups of rats fed either high fat diet or basal diet:

	flax HFD Corr. With Control final wt	sesame HFD Corr. With Control	Chia HFD Corr. With Control
HFD	0.829009	0.737005	0.757374
BD	0.098998	1	0.994395

Results in table (9) showed strong, positive association between weight, in rats fed high fat diet with each of flaxseed ,sesame and chia oils , and weight in control group of rats fed high fat diet.

Correlation of oxidative stress PON and NO between treatments and control groups are presented in tables (10) and (11) respectively .From results in both tables it can be noted that except for PON of Chia group fed HFD; a strong, positive association between experimental groups and control groups of rats fed either basal or high fat diet regarding PON and NO epithelial cells (Fig. 12). In other rats, the renal corpuscles and tubules exhibit almost normal structure (Fig. 13). Microscopic examination of kidney of rats supplemented with high fat diet and Shea oil showed that the renal corpuscles and tubules exhibit almost normal structure (Fig. 14). In some cases, intraglomerular congestion and narrow urinary spaces were seen (Fig. 15).

Oxidative stress

Table (10): The correlation between oxidative stress in liver (PON) in both control groups and between PON in each of flaxseed ,sesame and chia oils groups with control group of rats fed basal as well as high fat diet:

PON	Control HD Corr. With Control	flax HFD Corr. With control HFD	sesame HFD Corr. With Control HFD	Chia HFD Corr. With Control HFD
HFD	1	1	0.987933	0.130616
BD		1	0.975723	0.952106

Table (11): The correlation between oxidative stress in liver (NO) in both control groups and between NO in each of flaxseed ,sesame and chia oils groups with control group of rats fed basal as well as high fat diet:

NO	Control HD Corr. With Control	flax HFD Corr. With contro HFD	sesame HFD Corr. With Control HFD	Chia HFD Corr. With Control HFD
HFD	0.995865917	1	0.955169959	0.949361287
BD		1	0.622810434	0.689228959

Photomicrographs of sections of liver from the basal diet control rats showed the architecture of a hepatic lobule. The central vein lies at the centre of the lobule surrounded by the hepatocytes with strongly eosinophilic granulated cytoplasm, and distinct nuclei. Between the strands of hepatocytes the hepatic sinusoids are shown (Fig. 16). The architecture of the portal tracts, triangular unit included hepatic portal vein, hepatic portal artery and bile duct are seen (Fig, 17).

Histological investigation of liver form rats supplemented with basal diet and Flaxseed oil showed the hepatic lobules and portal tracts that exhibit normal architecture (Fig. 18, 19, respectively).

Examination of sections of the liver tissue form rats supplemented with basal diet and Sesame oil showed structure of hepatic lobules and portal tracts appeared nearly to the normal form (Figure 20, 21, respectively).

On the other hand, rats supplementation with basal diet and Shea oil exhibit the liver tissue form 19 showing structure of hepatic lobules and portal tracts appeared nearly to the normal form (Fig, 22, 23, respectively).

Liver of rats supplemented with high fat diet showed destructive changes within the liver tissue in the form of vacuolated cytoplasm and pyknotic nuclei (Fig. 24). Moreover, congested blood vessels and mononuclear inflammatory cells infiltration were also found (Fig. 25). the tissue form liver of rats supplemented with high fat diet and flaxseed oil showed the hepatic lobules appeared more or less like normal (Fig. 26). On the other hand, congested blood vessels and mononuclear inflammatory cells infiltration in the portal tracts were seen. The thickening of the interlobular connective tissue and necrosis of the hepatocytes that surround the portal area were notices (Fig. 27). Also supplementation with high fat diet and flaxseed oil caused mild congestion in the portal tract (Fig. 28).

Examination of the liver tissue of rats supplemented with high fat diet and Sesame oil indicated that hepatic lobules appeared more or less like normal (Fig. 29), mild congestion in the portal tracts and dilated hepatic sinusoids (Fig. 30).

Finally, the liver tissue of rats supplemented with high fat diet and Shea oil showed that hepatic lobules and portal tracts appeared more or less like normal (Fig. 31, 32, respectively).

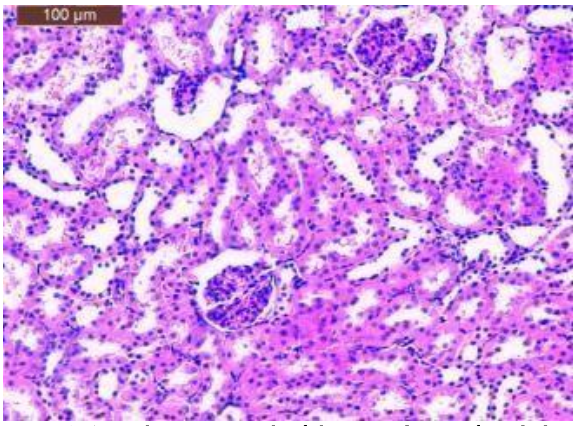

Figure (12): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet and Sesame oil showing the corpuscles and tubules exhibit almost normal structure. Some tubules show desquamation of its epithelial cells (arrow) (H & E stain, Scale bar: 100 µm).

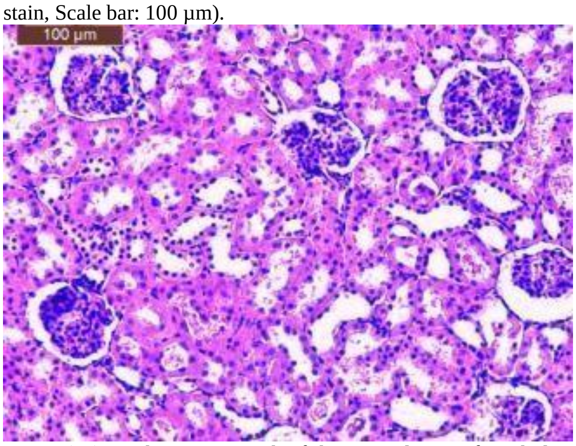

Figure (13): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet and Sesame oil showing the corpuscles and tubules exhibit almost normal structure (H & E stain, Scale bar: 100 µm).

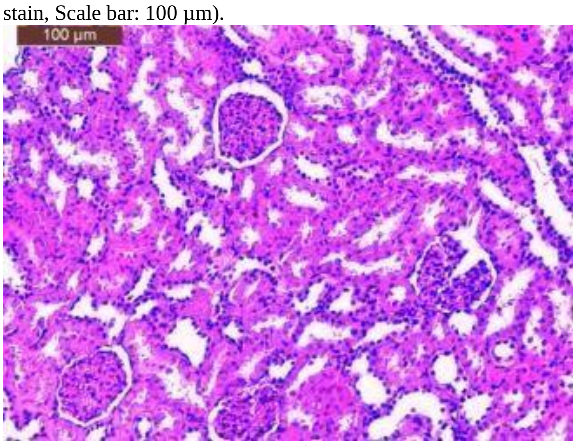

Figure (14): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet and Shea oil showing the corpuscles and tubules exhibit almost normal structure (H & E stain, Scale bar: 100 µm).

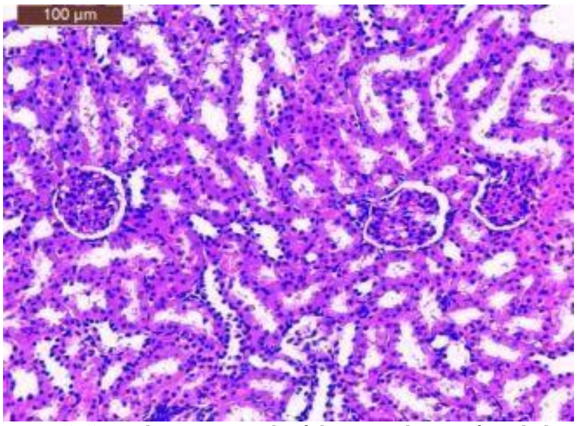

Figure (15): A photomicrograph of the cortical tissue form kidney of rat supplemented with high fat diet and Shea oil showing intraglomerular congestion and narrow urinary spaces (arrow) (H &E stain, Scale bar: 100 µm).

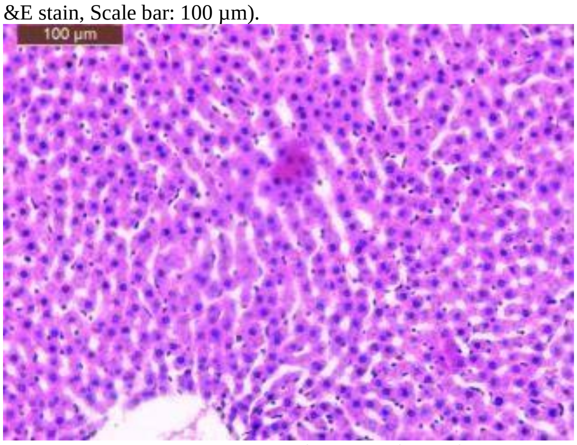

Figure (16): A photomicrograph of section of liver from the basal diet control rat showing the architecture of a hepatic lobule. The central vein (arrow) lies at the centre of the lobule surrounded by the hepatocytes (arrow) with strongly eosinophilic granulated cytoplasm (arrowheads), and distinct nuclei (yellow arrow). Between the strands of hepatocytes the hepatic sinusoids are shown (blue arrow) (H & E stain, Scale bar: 100 µm).

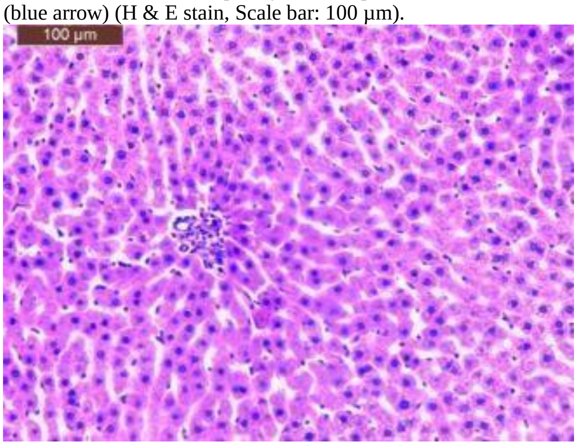

Figure (17): A photomicrograph of section of liver from the basal diet control rat showing the architecture of the portal tract, triangular unit included hepatic portal vein, hepatic portal artery and bile duct (H & E stain, Scale bar: 100 µm)

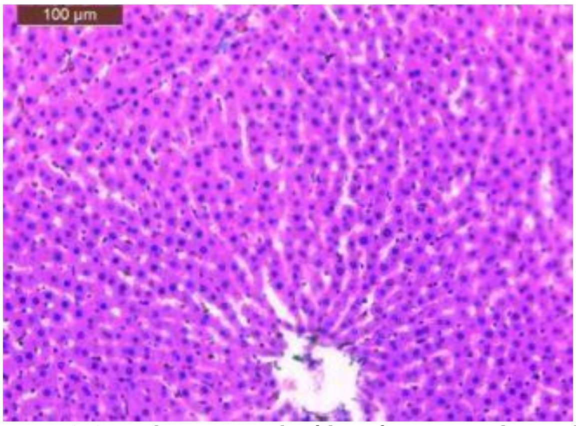

Figure (18): A photomicrograph of liver form rat supplemented with basal diet and Flaxseed oil showing hepatic lobule that exhibit normal architecture (H & E stain, Scale bar: 100 µm).

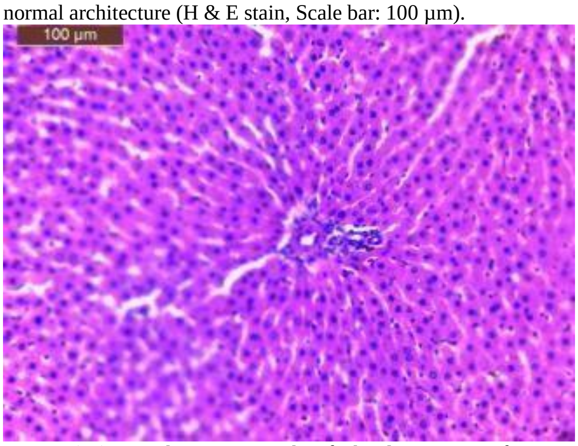

Figure (19): A photomicrograph of the liver tissue form rat supplemented with basal diet and Flaxseed oil showing normal structure of portal tract (H & E stain, Scale bar: 100 µm).

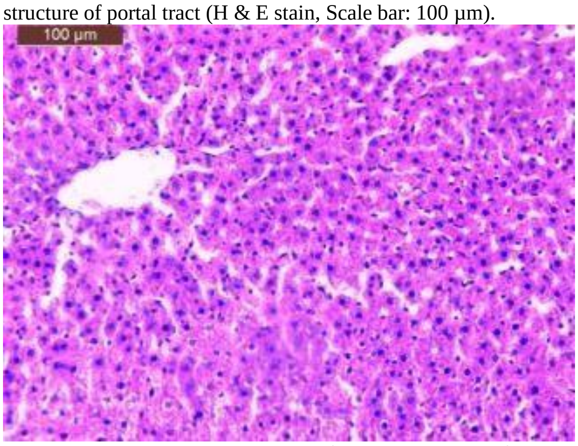

Figure (20): A photomicrograph of the liver tissue form rat supplemented with basal diet and Sesame oil showing structure of hepatic lobule that appeared nearly to the normal form (H & E stain, Scale bar: 100 µm).

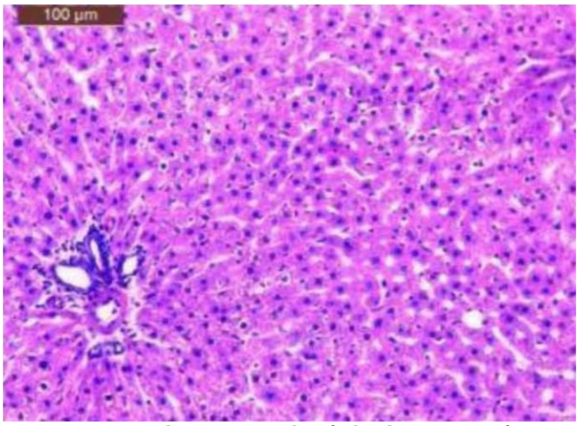

Figure (21): A photomicrograph of the liver tissue form rat supplemented with basal diet and Flaxseed oil showing normal structure of portal tract (H & E stain, Scale bar: 100 um)

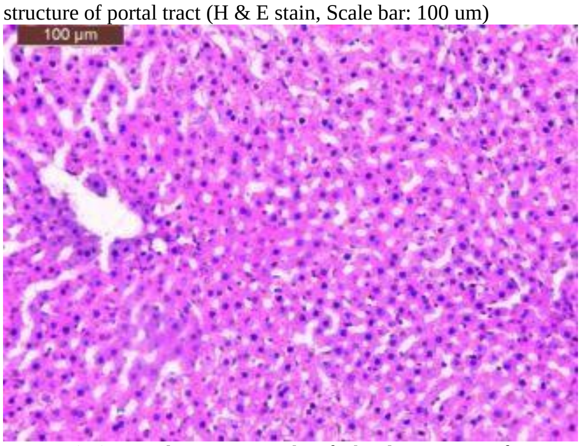

Figure (22): A photomicrograph of the liver tissue form rat supplemented with basal diet and Shea oil showing structure of hepatic lobule that appeared nearly to the normal form (H & E stain, Scale bar: 100 µm).

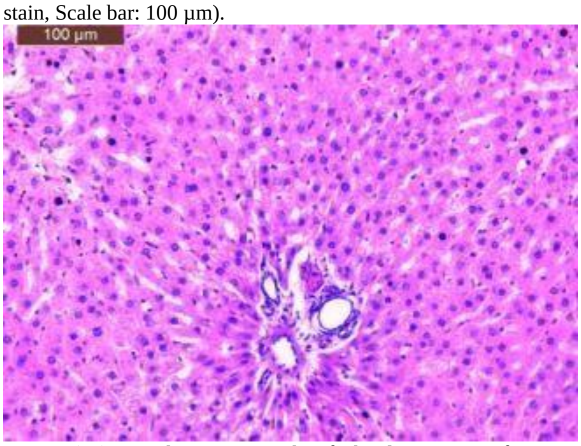

Figure (23): A photomicrograph of the liver tissue form rat supplemented with basal diet and Shea oil showing normal structure of portal tract (H & E stain, Scale bar: 100 µm).

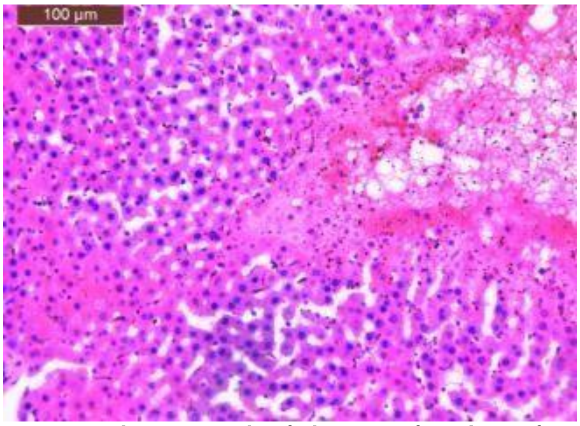

Figure 24 photomicrograph of the tissue form liver of rat supplemented with high fat diet showing destructive changes within the liver tissue in the form of vacuolated cytoplasm and pyknotic nuclei (arrow) (H & E stain, Scale bar: 100 µm).

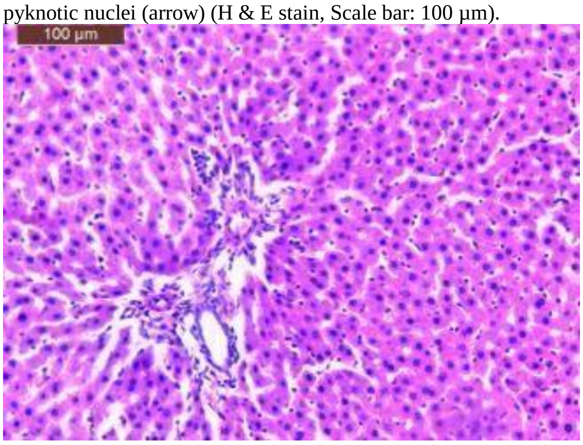

Figure (25): A photomicrograph of the tissue form liver of rat supplemented with high fat diet showing congested blood vessels and mononuclear inflammatory cells infiltration and (arrow) (H & E stain, Scale bar: 100 µm).

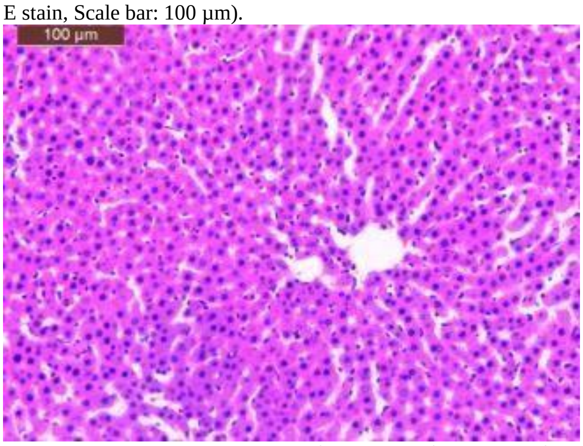

Figure (26): A photomicrograph of the tissue form liver of rat supplemented with high fat diet and flaxseed oil showing the hepatic lobule appeared more or less like normal (H & E stain, Scale bar: 100 µm).

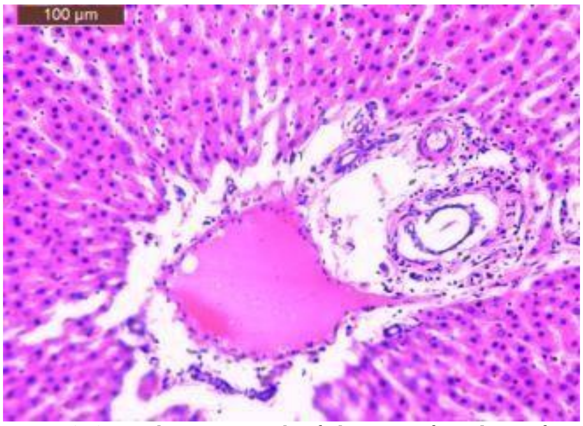

Figure (27): A photomicrograph of the tissue form liver of rat supplemented with high fat diet and flaxseed oil showing congested blood vessels and mononuclear inflammatory cells infiltration in the portal tract. Notice, the thickening of the interlobular connective tissue and necrosis of the hepatocytes that surround the portal area (arrow) (H & E stain, Scale bar: 100 µm). 4

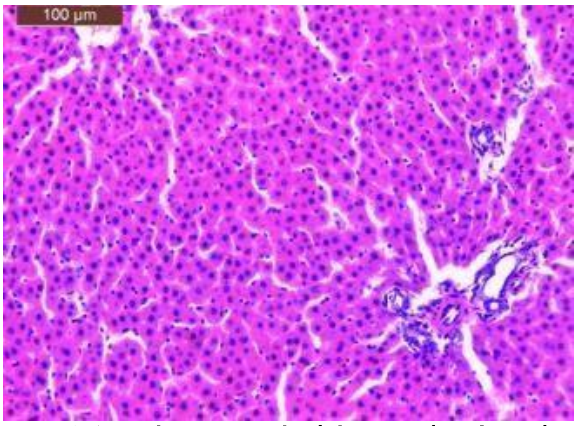

Figure (28): A photomicrograph of the tissue form liver of rat supplemented with high fat diet and flaxseed oil showing mild congested in the portal tract (arrow) (H & E stain, Scale bar: 100 µm).

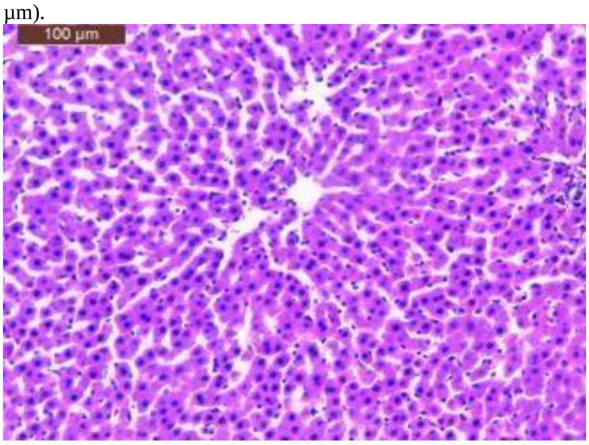

Figure (29): A photomicrograph of the tissue form liver of rat supplemented with high fat diet and Sesame oil showing the hepatic lobule appeared more or less like normal (H & E stain, Scale bar: 100 µm). 3

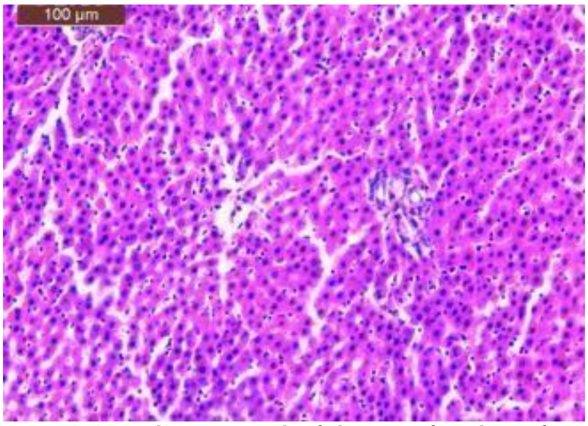

Figure (30): A photomicrograph of the tissue form liver of rat supplemented with high fat diet and Sesame oil showing mild congested in the portal tract. Notice the dilated hepatic snusoids (arrow) (H & E stain, Scale bar: 100 µm). 3

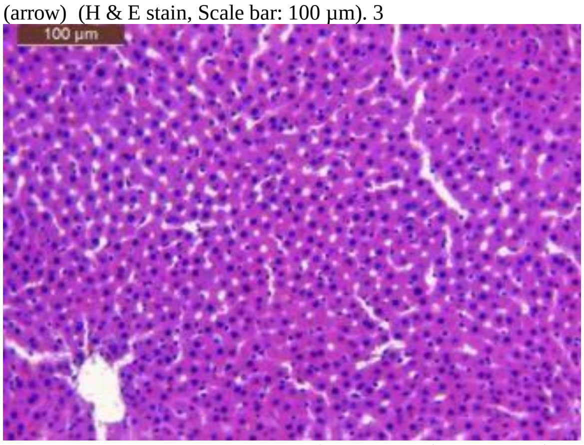

Figure (31): A photomicrograph of the tissue form liver of rat supplemented with high fat diet and Shea oil showing the hepatic lobule appeared more or less like normal (H & E stain, Scale bar: 100 µm).1

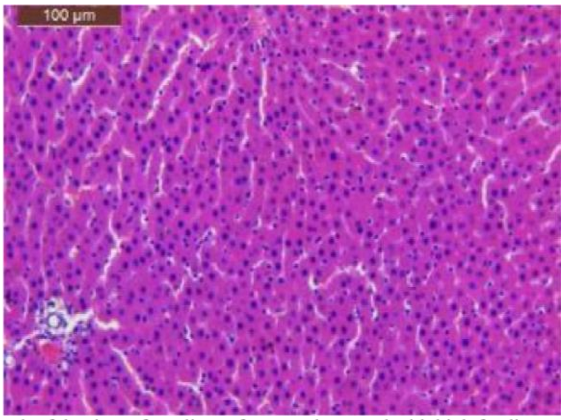

Figure (32): A photomicrograph of ihe tissue form liver of ral supplemented with high fat diet and Shea oil showing normal structure of portal tract (H & E stain, Scale bar: 100 um).

4.Conclusion

From results of the study we are can deduce the effectiveness of our study oils riche in flavonoids and Omega 3 in controlling hyperlipidemia and its damages on liver tissue and oxidative stress specially while consuming high fat diet rich in these oils.

5.Acknowledgments:

We are thankful and grateful After Allah to prof. Dr. Wafaa Ahmed Hussein to her continuous supports and helps.

Our results are in agreement with that obtained by **Munir et al [8]** and **Han et al [2]** who found that treatment with Chia seeds extract showed normal pattern of cellular structure. And ameliorate hepatic steatosis with no sign of toxicity.

Martinez et al [33] also noted a preventing steatohepatitis effect of chia seed.

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