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The Promising Effect of Some Essential Oils on the Brain Health: Biochemical and Pathological Studies

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Abstract

The brain is the most complex and important organs that control all the body functions. Quantity and quality of fat consumed play an important role in maintaining brain health, thus affect brain functions. The aim of this study was to assess the harmful effect of high intake of unhealthy source of fat as well as to detect the role of healthy oils on brain function from chemical and histological point of view. This study was conducted on (56) adult male rats divided into two major groups: the first was normal diet group ND (fed normal diet) that include 4 subgroups (7 rats each group) the first served as control with corn oil as fat source while in the other (3) groups corn oil was substituted by sesame, flaxseed and chia oils. The second major group was high fat diet group divided into 4 subgroups fed high fat diet (H.F. D ,13% oil + 7% vegetable shortening). In high fat control group oil used was corn oil while in the remaining (3) groups corn oil was substituted by sesame, flaxseed and chia oils. After 6 weeks' brain was separated for biochemical analysis of neurotransmitters and oxidative stress. Samples were also prepared for histological examination. Experimental oils were also used in the preparation of salad and cake that help maintaining healthy brain. Chemical analysis and sensory evaluation were conducted for those products. Our results revealed that diet rich in corn oil and vegetable shortening (rich in high saturated fatty acid) caused disturbances in both neurotransmitters and oxidative stress. Damage was also detected in histological sections from brain cortex. It is worthy to mention that using sesame, flaxseed and chia oils instead of corn oil had a protective effect on brain. In addition, those oils were highly acceptable in our products. It could be concluded that adding those healthy oils to daily meals could have a protective effect on brain injury.

Keywords: brain cortex- high fat- oils- saturated fat- oxidative stress- neurotransmitters- sesame oil- flaxseed oil- chia oil- cake- salad- brain health

1. Introduction

The brain needs energy much more than other organs, it is highly enriched in lipids, which represent 50% of its dry weight [1]. It was reported that dietary lipids affect brain lipidome which in turn influence brain functions [2]. Healthy and adequate nutrient intake has a great impact on cognitive, behaviour neuroendocrine and other brain function.

The kind and quantity of consumed fat has either positive or negative impact on brain health. Vegetable shortening contain a very high proportion of saturated with respect to unsaturated fat, thus called highly saturated fat High saturated fat cause many health problems and affect brain in both human and animal models [3], such effect is due to the increase of oxidative stress after consuming H.F.D [4,5].

It was demonstrated that feeding H.F.D even for short duration [6] caused negative impairment in both learning and behavioural functions. It was proved that the high intake of saturated fats decrease Apo lipoprotein E which lead to losing amyloid Beta protein and plaques formation that interfere with neuron function as occurring in Alzheimer's patients. Consuming lipopoly saccharide systemically cause euro inflammation which in turn impair cognitive functions [7]. Mild cognitive impairment (MCI) affect 10- 20% of people aged more than 65 years old, 10% of this cases progress to Alzheimer within 1 year and injury in neurons & damage in connections [8, 9].

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Oxidative stress was showed to play an important role in neurodegenerative diseases.Thus, reactive oxygen species (ROS) disturb blood brain barrier (BBB) [10]. Paroxonose I (PONI) an engine carried by high-density lipoprotein (HDL). It has antioxidant as well as anti- inflammatory effect. A reduction in PON1 activity was detected in stroke and Alzheimer's patients [11]. Nitric oxide (NO) regulates brain blood flow and protein functions.

During brain injury and aging a transformation of NO to harmful form occurred through reacting with superoxide anion accompanied by peroxy nitrite gas production which causes damage to lipid, nucleic acid and protein [12].

Many oils such as chai, sesame and flaxseed oils showed positive effect on brain function, memory and learning ability.

These oils also protect brain from damages caused by consuming imbalance (especially high fat) diets and by polluted agents as $ALCl_3$. Studies mentioned that chia rich in omega 3 positively impact cognitive and memory functions [13, 14].

In several studies sesame oil showed a great effect in decreasing inflammation in nervous system and help amelioration memory and learning function [15,16].

It also has high antioxidant properties [17,5] and also showed an effect on decreasing anxiety and depression specially when mixing with fish oil [18].

Sesame oil also has brain protective effect from damages caused by $AlCl_3$ [19]. Sesame oil plays an important role in increasing memory abilities in older adults [20].

Flaxseed oil is rich in omega 3 fatty acids in a balance ratio with omega 6. Flaxseed oil contain also phenolic compounds and tocopherol. It is considered an important source of healthy fatty acids which help protecting the body from cardiovascular diseases, cancer, and osteoporosis also help protecting and improving brain injury [21]. Many studies noted that flaxseed oil control damage occurred in brain caused by lipopolysaccharide [17].

The aim of this study is to investigate the damage occurred by the high intake of fat as well as to assess the effect of fat source (vegetable shortening and corn oil) on the brain, oxidative stress and histology of brain cortex. We also aimed to assess the protective effect of sesame, flaxseed and chia oils on brain injury.

2. Experimental design and study plan

2.1. Animals

This study was conducted on 56 adult male Sprague – Dawley rats of a local strain purchased from National Research Centre, Dokki, Egypt. Weight ranged between180 and 200g. Rats were maintained in a well-ventilated room. Hygienic conditions were provided, room temperature was24ºC and relative humidity was 50%. Standard diet pellets and water were provided ad Libitum. Recommendations of the National regulations on animal welfare and Institutional Animal Ethical committee (I.A.E.C) were taken into consideration.

Sesame seed oil, corn oil and flaxseed oil were obtained from the local market. Chia seed oil was extracted, by petroleum ether, 50g chia seed powder at 50ºC for 8 hours. Solvent was evaporated in a rotary evaporator; pure chia seed oil was obtained.

2.2. Experimental design and diet planning:

Two kinds of diets were used: basal diel (12% protein, 10%fat ,4%salt mixture and 1% 10%fat,4%salt mixture and 1% vitamin mixture) and high fat diet (12% protein, 20%fat ,4%salt mixture and 1%10%fat ,4%salt mixture and 1% vitamin mixture and 1% choline chloride).

Basal diet and high fat diet were designed according to AOAC 2001. Rats were divided into 8 groups (7 rats each).

2.3. Basal diet fed Groups:

Groups from1 to 4 were fed basal diet (10% oil) and was distributed as follow: First group served as control and was provided basal diet source of fat (10%) was corn oil.. While in groups (2), (3), (4) corn oil was substituted by chia, sesame and flaxseed oils (10%) respectively.

High fat diet fed Groups:

From 5 to 8 were fed high fat diet (13% oil + 7% vegetable shortening).

Group 5 was control (fat source was 13 % corn oil and 7 % vegetable shortening) in groups 6-7-8 chia, sesame and flaxseed oils served as oil source (13%) instead of corn oil in respective order vegetable shortening 7% was also added.

2.4. Brain Homogenate:

At the end of experiment (after 6 weeks), brain was removed quickly and inserted in iced normal saline, to remove blood cells, and frozen at - 80 °C. The frozen tissue was then homogenized in phosphate buffer (pH was adjusted to7.4) and centrifuged at 4000 rpm for 10 min using cooling centrifuge (Laborzentrifugen, 2K15, Sigma, Germany). The supernatant was removed and used in estimation of neurotransmitters [22].

2.5. Determination of brain neurotransmitters:

Determination of brain neurotransmitters [noradrenaline (NA), dopamine (DA), and serotonin (5-HT)] was carried out using high performance liquid chromatography (HPLC) system, Agilent technologies 1100 series, that equipped with a quaternary pump (G131A model). Separation was accomplished on a reversed phase (RP) column (C18X 25 X 0.46 cm). The mobile phase consists of potassium phosphate buffer and methanol in a ratio of 97/3 (v/v), the flow

rate was 1 ml/min. using UV detector that was adjusted at 270 nm. The concentrations of serotonin and both catecholamine were determined by external calibration curve for each standard [23, 24].

2.6. Histology

Brain samples were prepared for histological examinations by light microscopy according to the methods described previously [25].

2.7. Biochemical Analyses

Nitric oxide (NO) was determined by colorimetric method as described previously. Assay for PON-1activity was also carried out. The aryl esterase activity of PON-1 was determined by a colorimetric method using phenyl acetate as a substrate. In this assay, PON1 catalyses the cleavage of phenyl acetate resulting in phenol formation. The rate of formation of phenol was measured by monitoring the increase in absorbance at 270 nm at 25°C. The working mix consisted of 20 mMTris/HCl buffer, pH8.0, containing 1 mM $CaCl_2$ and 4 mM phenyl acetate as the substrate. Samples diluted 1:3 in the buffer were added to the above mix and the changes in absorbance were recorded following a 20 s lag time. One unit of aryl esterase activity is equal to 1 μmol of phenol formed per min. The PON1 activity is expressed in kU/L, based on the extinction coefficient of phenol of 1310 M–1cm–1. Blank samples containing water were used to correct for the spontaneous hydrolysis of phenyl acetate [26].

2.8. Preparation of salad

Ingredients that affect positively brain function (lettuce, parsley, tomatoes, broccoli, mint, red cabbage, Almond and avocado) were purchased, washed and cut then mixed together. (5) dressings (that differ only in the source of oil) were prepared from lemon, vinegar, spices (salt and pepper) and either 5 or 10 g oil (corn oil in control salad while flaxseed or sesame oils in the (4) other salads). Cake preparation two kinds of cake were prepared. Source of fat were corn oil (control cake) in the first and sesame oil (as sesame oil highly tolerate temperature) in the second.

Cake ingredients:

Whole egg (50g), milk (50g), orange juice (50g), oil (25g), sugar (100g), wheat flour (150g), table spoon baking powder, vanilla.

Chemical analysis

The moisture, protein, fat and ash were determined while total carbohydrates were calculated

Sensory evaluation:

The samples were sensory evaluated for color, flavor, texture and overall acceptability based on 10 points for each.

The mean value of these sensory properties was evaluated by a 10 taste panelist.

2.9. Statistical analysis

The information obtained from the present study was statistically analysed [27].

Results and discussion

Oxidative stress plays a central role in the pathogenesis of metabolic diseases like diabetes mellitus, atherosclerosis, hyperlipidaemia, and their complications (like peripheral neuropathy) due to its great oxygen consumption, high lipid and poor antioxidants defence. Oxygen free radicals attack objects on the polyunsaturated components of membranes and may cause a serious organization dysfunction within cells and tissues [28].

Our study appeared a significant increase in NA, DA and SE levels in HFD control group, those increase reached 30%, 49.3% and 77.4% from values found in BDC group. This result was in agreement with a previous study [29] who indicated that administration of endotoxin stimulated the secretion of proinflammatory cytokines which induced hypothalamus (HPA) activation leading to elevation of noradrenaline (NE) and serotonin (5-HT) above normal levels released in thebrain. In addition, [30] confirmed this study and indicated that increased brain oxidative stress has been linked to the development of neurodegenerative diseases.

Contrarily, adding treatment oils (chia, flaxseed and sesame oils) instead of corn oil, to HFD rats (as found in the treated groups) regulated the disturbances in neurotransmitters level (table1).

Table (1): Neurotransmitters levels in different studied groups

Parameters / Groups	Noradrenaline (ug/g tissue)	Dopamine (ug/g tissue)	Serotonin (ug/g tissue)
BDC	**2.23**	**3.08**	**2.61**
BD +flaxseed oil	**1.59**	**3.04**	**2.99**
BD +sesame oil	**2.69**	**3.05**	**2.50**
BD + chia	**2.14**	**3.00**	**2.06**
HFDC	**2.91**	**4.60**	**4.63**
HFD + flaxseed oil	**2.61**	**3.30**	**2.89**
HFD+sesame oil	**2.53**	**2.39**	**3.16**
HFD +chia	**2.06**	**3.72**	**2.48**

BDC= Basal diet controlBD= Basal diet
HFDC=high fat diet controlHFD=high fat diet

It is worthy to mention that using experimental oils instead of corn oil led to a great amelioration in NA, DA and 5-HT values till reaching nearly that of normal diet. It has been suggested that the use of chia and flaxseed oils rich in omega-3 polyunsaturated fatty acids, (PUFAs) may have ameliorating effect of such damage by two possible ways; first, omega-3 PUFA may increase the level of catalase within the peroxisome and in the cytoplasm resulting in enhanced defence against free oxygen radicals; second, omega-

3 PUFAs, which have been supplemented, may be replaced with PUFA components of the membranes that had been attacked by oxygen free radicals [31].

Sesame oil in HFD group showed greatest effect in decreasing DA and 5-HT values. In many studies sesame oil was found to have various pharmacological properties, e.g. antioxidant activity

32], anti- proliferative activity [33] and responsible for enhancing antioxidant activity of vitamin E in lipid peroxidation systems,[34] lowering cholesterol levels, [35] increasing hepatic fatty acid oxidation enzymes [36]. All these properties help in protecting against brain dysfunction and neurotransmitters disturbances as found in the current study. Histopathological results of brain were showed in figures from 1 to 9.

Sections from rats supplemented with basic diet indicated the highly active neurons that having huge nuclei with relatively pale-stained, the nuclear chromatin and prominent nuclei disappeared, the surrounding support cells, glial cells, having small nuclei with densely stained, condensed chromatin with no visible nucleoli and background substance (neuropil) are shown in the cortex **(**Fig. 1). In case of rats that supplemented with basic diet and Flax, photomicrographs of brain cortex showed the neurons and glial cells having small darkly stained nuclei and surrounded with empty space. Few neurons exhibited normal structure **(**Fig. 2).

Photomicrographs of brain cortex from rats supplemented with basic diet and Sesame shows indicated the highly active neurons, glial cells, (red arrow) and neuropil appeared nearly to normal structure. The normal structure blood vessels was noted (Fig. 3). A photomicrograph of brain cortex from rat supplemented with basic diet and chia shows the highly active neurons), glial cells, (red arrow) and neuropil appeared nearly to normal structure (Fig. 4).

Examination of brain cortex from rat supplemented with high fat diet showed the degenerative changes in brain tissue in the form of congestion of cortex blood vessels. Note many pyramidal cells (arrow) having small darkly stained nuclei and surrounded with empty space (Fig. 5). On the other hand, the area between nerve cells presented foam structures (Fig. 6). supplemented with high fat diet and flaxseed showed no improvement as manifested by many pyramidal cells having small darkly stained nuclei that surrounded with empty spaces (Fig. 7). In rats supplemented with high fat diet and Sesame, photomicrographs of brain cortex showed marked improvement in the structure of cortex as compared with the high fat diet group (Fig. 8). On the other hand, rats supplemented with high fat diet and Chi showed moderate improvement in the cortex structure as compared with the high fat diet group. Some neurons appeared in shrunken form and surrounded with empty **spaces (Fig. (9).**

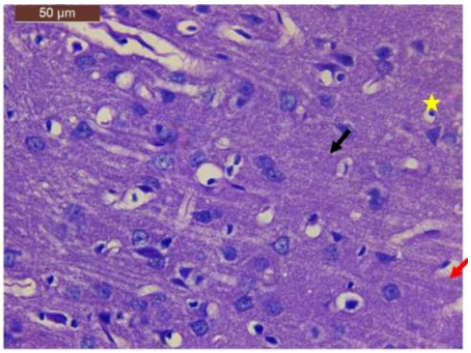

Figure (1): A photomicrograph of brain cortex from rat supplemented with basic diet shows the highly active neurons (arrow) that having huge nuclei with relatively pale-stained, the nuclear chromatin and prominent nuclei disappeared, the surrounding support cells, glial cells, (red arrow) having small nuclei with densely stained, condensed chromatin with no visible nucleoli and background substance (neuropil) are shown in the cortex, **(H & E stain, Scale bar: 50 µm).**

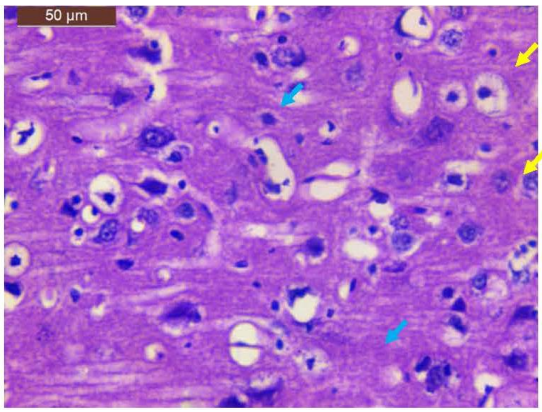

Figure (2): A photomicrograph of brain cortex from rat supplemented with basic diet and flaxseed shows the neurons (arrows) and glial cells (blue arrows) having small darkly stained nuclei and surrounded with empty space. Few neurons exhibited normal structure **(H & E stain, Scale bar: 50 µm).**

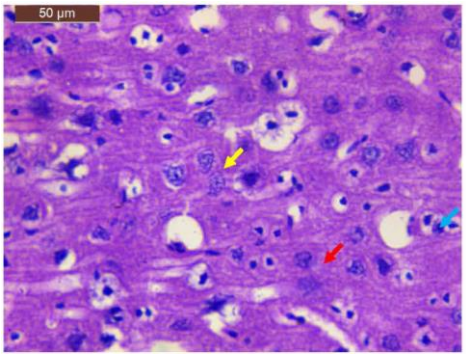

Figure (3): A photomicrograph of brain cortex from rat supplemented with basic diet and Sesame shows

the highly active neurons (yellow arrow), glial cells, (red arrow) and neuropil appeared nearly to normal structure. Note the normal structure blood vessels (blue arrow) **(H & E stain, Scale bar: 50 µm).**

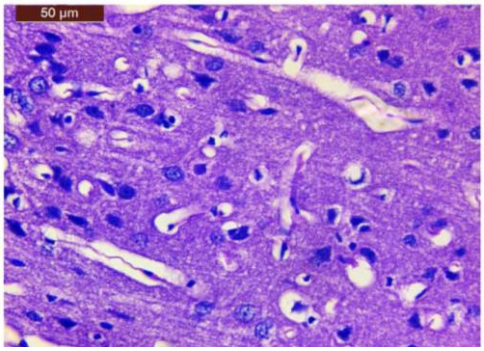

Figure (4): A photomicrograph of brain cortex from rat supplemented with basic diet and Chia shows the highly active neurons, glial cells, andneuropil appeared nearly to normal structure **(H & E stain, Scale bar: 50 µm).**

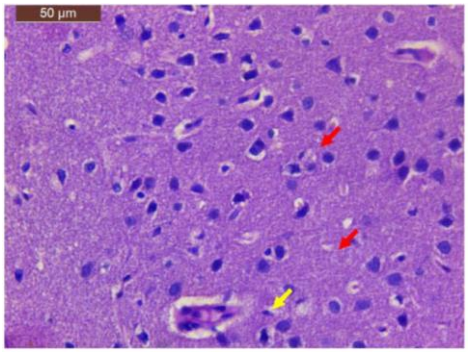

Figure (5): A photomicrograph of brain cortex from rat supplemented with high fat diet shows the degenerative changes in brain tissue in the form of congestion of cortex blood vessels. Note many pyramidal cells (arrow) having small darkly stained nuclei and surrounded with empty spaces. Notice the congested blood vessel (yellow arrow) **(H & E stain, Scale bar: 50 µm).**

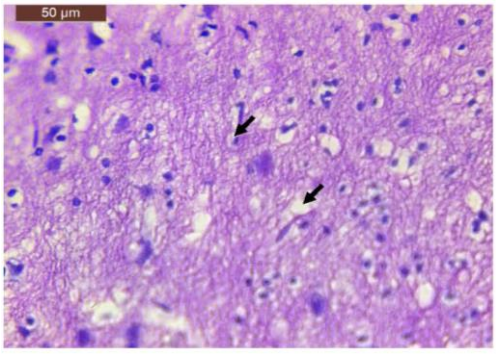

Figure (6): A photomicrograph of brain cortex from rat supplemented with high fat diet shows in the area between nerve cells presented foam structures (arrow) **(H & E stain, Scale bar: 50 µm).**

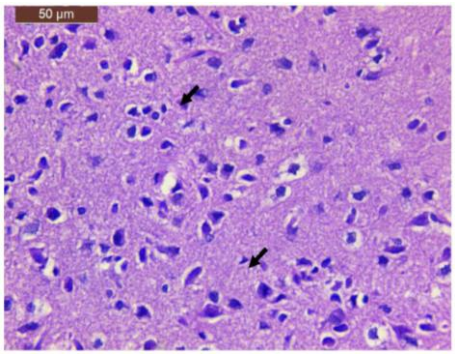

Figure (7): A photomicrograph of brain cortex from rat supplemented with high fat diet and flaxseed showing no improvement as manifested by many pyramidal cells (arrow) having small darkly stained nuclei and surrounded with empty spaces **(H & E stain, Scale bar: 50 µm).**

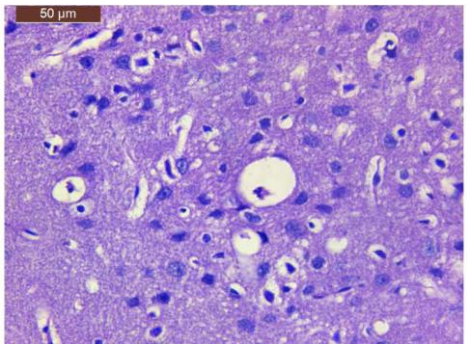

Figure (8): A photomicrograph of brain cortex from rat supplemented with high fat diet and Sesame. Marked improvement in the structure of cortex is observed as compared with the high fat diet group **(H & E stain, Scale bar: 50 µm).**

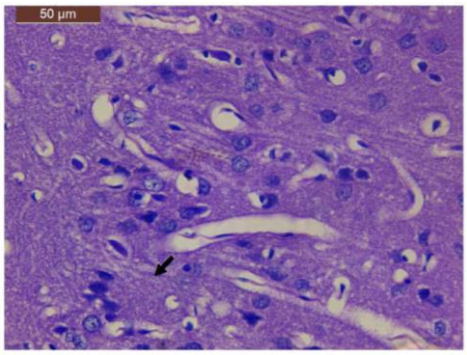

Figure (9): Aphotomicrograph of brain cortex from rat supplemented with high fat diet and Chia showing moderate improvement in the cortex structure as compared with the high fat diet group. Some neurons (arrow) appear shrunken and surrounded with empty spaces **(H & E stain, Scale bar: 50 µm).**

Paraoxinase 1 is synthesized in liver then transported in blood, it plays an important role in protection against harmful substances like organic phosphate found in insecticide, it also prevents the oxidation of low density lipoprotein.

Nitric Oxide (NO) is produced by the body and plays many important functions such as vasodilation thus increasing blood circulation. Data concerning oxidative stress are summarized in tables (2), (3), (4) and (5).

From table (2) it could be noticed that average paraoxinase 1 in basal diet control group was 13.765 (Ku/L). Higher values were showed in groups fed basal diet in which corn oil was substituted by flaxseed, sesame and chia oils (14.45, 14.62 and 14.52 Ku/L) respectively.

Table (2) Paraoxinase (KU/L) and LSD in control and treatment oils groups fed basal diet:

Groups / Fed basal diet	PON1	LSD with control	LSD between groups		
			Flax oil	Sesame oil	Chia Oil
BDC	**13.765**				
	± 0.549				
Flaxseed Oil	**14.448**	**0.130**		**0.668**	
	±0.528				
Sesame oil	**14.625**	**0.058**			**0.790**
	± 0.707				
Chia oil	**14.52**	**0.097**	**0.870**		
	± 0.883				

BDC=basal diet controlLSD=least significant difference

Table (3) Paraoxinase (KU/L) and LSD in control and treatment oils groups fed high fat diet:

Groups / Fed HFD	PON1	LSD with control	LSD between groups		
			Flax oil	Sesame oil	Chia Oil
HFDC	**9.56**	**0.000**			
	± 0.732				
Flaxseed Oil	**12.415**	**0.000**		**0.72**	**0.06**
	0.885				
Sesame oil	**11.533**	**0.000**			**0.252**
	0.696				
Chia oil	**10.986**	**0.000**			
	0.586				

HFDC=high fat diet controlHFD= high fat dietLSD=least significant difference

Tables (4) showed average nitric oxide (NO) values in both control and experimental groups fed basal diet which fluctuated between 23.37 μmol/g. tissue in (chia group) and 24.495 μmol/gtissue (in flaxseed group) compared with 23.27μmol/g tissue in basal control group. Our results illustrated that high fat diet control group showed marked decrease in PON1(30%)and remarkable increase in NO (71.5%)when compared with basal diet control as shown in tables (3) and (5). Such results indicate that HFD caused a change in oxidative stress that may cause brain damage. Treatment oils used in this study showed marked change in oxidative stress when compared with high fat diet control. The highest value of PON1was showed in flaxseed oil group with average PON1 12.41 and NO 29.04 followed by sesame then camechia

Table (4) Nitric oxide (μmol/g tissue) and LSD in control and treatment oils groups fed basal diet:

Groups / fed basal diet	NO	LSD with control	LSD between groups		
			Flax oil	Sesame oil	Chia Oil
BDC	**23.27**				
	± 0.914				
Flaxseed oil	**24.495**	**0.016**		**0.23**	**0.65**
	± 0.525				
Sesame oil	**23.93**	**0.884**			**0.611**
	± 0.935				
Chia oil	**23.37**	**0.514**			
	± 1.343				

BDC=basal diet control LSD=least significant difference

Tables (4) showed average nitric oxide (NO) values in both control and experimental groups fed basal diet which fluctuated between 23.37 μmol/g. tissue in (chia group) and 24.495 μmol/gtissue (in flaxseed group) compared with 23.27μmol/g tissue in basal control group. Our results illustrated that high fat diet control group showed marked decrease in PON1(30%)and remarkable increase in NO (71.5%)when compared with basal diet control as shown in tables (3) and (5). Such results indicate that HFD caused a change in oxidative stress that may cause brain damage. Treatment oils used in this study showed marked change in oxidative stress when compared with high fat diet control. The highest value of PON1was showed in flaxseed oil group with average PON1 12.41 and NO 29.04 followed by sesame then camechia

Table (5) Mean nitric oxide NO (μmol/g tissue) and LSD in control and treatment oils groups fed high fat diet:

Groups / Fed HFD	NO	LSD with control	LSD between groups		
			Flax oil	Sesame Oil	Chia Oil
HFDC	**39.905**				
	± 1.087				
Flaxseed oil	**29.04**	**0.00**		**0.00**	**0.00**
	± 1.110				
Sesame oil	**31.85**	**0.00**			**0.008**
	± 0.812				
Chia oil	**33.585**	**0.00**			
	± 0.847				

HFDC=high fat diet control HFD= high fat diet LSD=least significant difference

Table (6) Chemical analysis of cake(100 g)on fresh weight:

Moisture (g)	Protein (g)	Fat (g)	Fiber (g)	Ash (g)	Carbohydrate by difference(g)	Sodium (mg)	Potassium (mg)
67.2	3	5.3	14.3	1	9.2	20.6	361.5

Table (7) Chemical analysis of salad (100 g) on fresh weight:

Moisture (g)	Protein (g)	Fat (g)	Fiber (g)	Ash (g)	Carbohydrate by difference (g)	Sodium (mg)	Potassium (mg)
28.5	12.2	13	2	0.5	42.8	4.8	317

Statistical analysis in (Tables 2,3,4 and 5) revealed that no significant difference was found between basal diet groups concerning PON1 and NO while marked significant difference in NO was showed in flaxseed, Sesame and chia oils groups compared with high fat diet control significant increase in high fat diet fed experimental groups fed oils was also noted in PON1, compared with high fat diet control group.

From our results it could be noticed that high fat diet had negative effect on brain histopathology and oxidative stress as well as neurotransmitters. This effect was due to changing behaviour of nitric oxide to harmful form by reacting with superoxide anion

and forming peroxy nitrite gas as mentioned before [12]and proved by foam formation found in histopathological stain (Fig 6) such bad effect was also noticed by congestion of cortex blood vessels in brain (fig 5). Furthermore, damage was also shown through disturbance in neurotransmitters values causing imbalance in brain thus affecting memory and cognitive functions as well as increasing risk factor for brain diseases such as Alzheimer disease. Our results are in parallel with that found by [5] who declared the negative effect of high fat diet which affects oxidative stress. Same results were found by [6] who noted that high fat diet even for short duration affect potentially brain function. Sesame oil acts as magic ingredient that prevents brain damage. From our results it could be noted that when added sesame oil in basal diet rather than corn oil it caused high activity of neuron glial cells and neuropil thus increasing integrative systems, improving movement, complex behaviour as well as high protection and maintenance of brain as mentioned before [37].

It is worthy to declare that adding sesame oil to high fat diet ameliorate histopathological damages causes by high fat diet rich with corn oil, and also control its negative effect on oxidative stress and neurotransmitters levels in brain tissue. Such ameliorating effect of sesame oil are in agreement with that found by several studies [38,18] who noted that sesame oil has protective effect on brain. They also detected that sesame oil has a great antidepressant effect. The mechanism of such protective effect was proposed to be through activation of P38 MAPK that produce pro inflammatory cytokine [39].

Histopathological protective effect of sesame oil from neuron damage caused by $AlCl_3$ was noted by other study [40].

Many other studies showed effective suppressing effect that had sesame oil cake extract on nerve inflammation and apoptosis that lead to memory damage caused by B- amyloid deposition [41,42].

Positive histopathological effect was also shown in group fed chia oil with almost normal structure. Chia oil fed group showed marked improvement in PON1, NO and also neurotransmitters. Feeding rats on flaxseed oil with either normal or high fat diet affect positively oxidative stress as well as neurotransmitters while histological showed no marked change when added to high fat diet. Positive effect of chia on the prevention of neuronal diseases and on increasing mental health [13].

This effect is probably due to its high content of omega 3which is found in chia and flaxseed oils and confirmed by other study [14] through decreasing lipid peroxidation thus improving brain functions. In another study, flaxseed oil was proved to have anti-oxidative effect and also to promote neurotrophic [43]. Histopathological parameters were noted in another study [44].

salads and cake were prepared from sesame and flaxseed oils. (most abundant in local market).

Sesame oil was used in cake preparation as the source of fat as it tolerates high temperature.

While salads were produced from either flaxseed or sesame oils.

Based on our previous findings, Baked cake was produced and evaluated from sesame oil (5 g sesame oil/ 30 g one serving) and fortified with orange peel as a functional food for brain injury. Chemical analysis of cake was showed in table (6) from this table it could be noticed that carbohydrate content was 42.8% while protein was 12.2% and fat 13%.

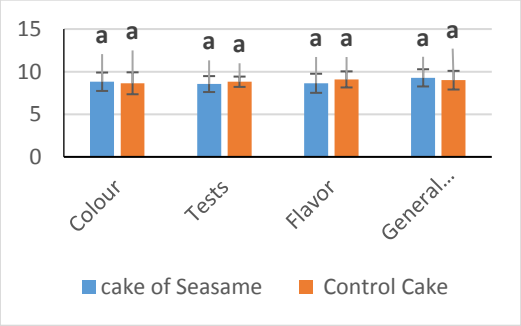

Fig (10) statistical analysis of sensory evaluation. parameters of control and sesame cakessensory evaluation of sesame oil cake compared with control are showed in fig (10) from this figure it could be mentioned that no significant difference was found in sensory evaluation parameters between both sesame and control cake. From table (7) it could be noticed that carbohydrate content in 100salad was 9.2g while protein content was 3g, fibre14.3g and fat 5.3g.

Sensory evaluationresults and statistical analysis of salads (control, with sesame oil and with flaxseed oil) were illustrated in figures (11) and (12).

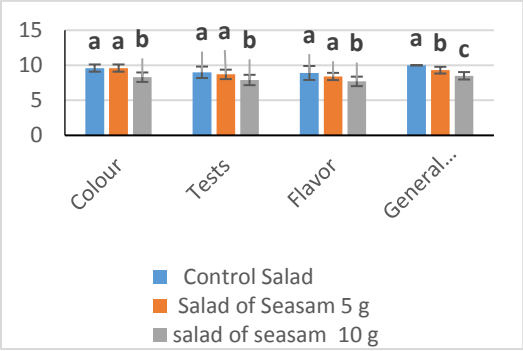

Fig (11) statistical analysis of sensory evaluation parameters of control and sesame (5g and 10 g) salads

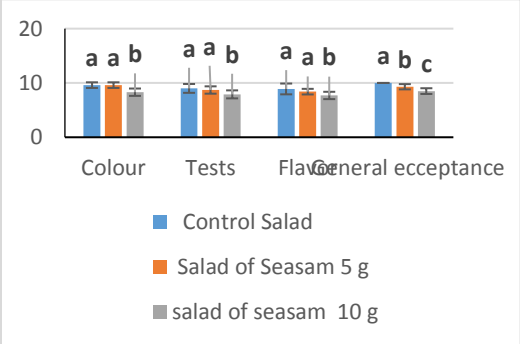

Fig (12) statistical analysis of sensory evaluation parameters of control and flaxseed oil (5g and 10 g) salads

From this results it could be noted that no significant different was noted in salad with both oils (flaxseed or sesame oils) compared with control salad (corn oil was used in dressing), high acceptance was showed in sample with 5 g while increasing amount of oil to 10g affected negatively sensory parameters.

From sensory evaluation results, it can be declared that administration of experimental oils in many type of food is achievable and highly acceptable.

3. Conclusion:

The present study highlights the importance of healthy source of fat for maintaining brain functions and health. From our results we can deduce that high intake of sesame, flaxseed and chia oils, rich in Omega 3 and antioxidant has

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