

# Impact of Peppermint and Thyme in Ameliorating Cardiac and Hepatic Disorders Induced by Feeding Rats Repeatedly Heated Fried Oil

Osman N. N.<sup>1,2</sup>, Balamash K.S.A<sup>1</sup>, Aljedaani M.S.<sup>1\*</sup>

<sup>1</sup> Biochemistry Department, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia. <sup>2</sup> Food Irradiation Research Dep. National Center for Radiation Research and Technology, Atomic Energy Authority, Cairo, Egypt.

## ABSTRACT

Deep frying is one of the most popular cooking methods using oil. Many people prefer fried food and make it a lifestyle for them. Numerous studies have demonstrated that consumption of heated oils from fast food can lead to undesirable health consequences. An investigation was carried out to study potential protective of thyme or peppermint alone or their combination against cardiac and hepatic disorders in rats fed a commercial diet fortified with heated frying oil (HFO) (15% w/w) for 45 days. Fifty Male Wistar rats divided to 5 equal groups: G I control, GII: animals fed basal diet fortified with 15% (w/w) HFO (positive control), GIII-V: animals fed as in GII and treated with thyme extract (500mg/kg), peppermint extract (290 mg/ kg), and the combination of both extracts through oral gavage, for 45 days. The results showed that rats in GII exhibited a significant increase in glucose, lactate dehydrogenase (LDH), Creatine Kinase (CK-MB), liver enzymes and lipid profile in comparison to control. Moreover, a significant rise in lipid peroxidation (MDA), nitric oxide (NO) and protein carbonyl contents (PCC), accompanied by a decline in antioxidants activity in cardiac and hepatic homogenates was also observed. These biochemical alterations were ameliorated when thyme, peppermint, and their combination was administered to rats fed diet supplemented with HFO compared to the GII. These data suggest the use of these herbs might protect against cardiac and hepatic injuries induced by feeding HFO.

Key Words: Oxidized oil, Peppermint, Thymus Vulgaris, Heated fried oil, Hepatic disorders.

## eIJPPR 2019; 9(6):10-20

**HOW TO CITE THIS ARTICLE:** Osman N. N., Balamash K.S.A, Aljedaani M.S. (2019). "Impact of Peppermint and Thyme in Ameliorating Cardiac and Hepatic Disorders Induced by Feeding Rats Repeatedly Heated Fried Oil", International Journal of Pharmaceutical and Phytopharmacological Research, 9(6), pp.10-20.

## **INTRODUCTION**

One of the most popular methods in cooking is deep frying, where its popularity return to short and easy preparation and palatability to consumers [1]. Fried foods have uniquearoma amount that cannot be provided by other cooking methods[2].Since the frying method involves presence oxygen and high temperature, thermal and oxidative effects will lead to the degrading quality of HFO [3]. Oil properties such astype, temperature, and duration have a large effect on thequality of final products [4]. The safety of heated fried oil (HFO), which is ingested with fried food, is a concern. Major properties such as toxic chemicals generated as polycyclic aromatic hydrocarbons, acrylamide and free radicals for that the HFO can be regarded as a xenobiotic [5-8]. Subsequently, consumption of fried foods is highly associated with the risk of coronary heart disease (CHD)[9], coronary artery disease [10], type 2 diabetes[11], heart failure[12] and obesity[13]. Previous investigations reported the presence of natural antioxidants from aromatic and medicinal plants is related to decreasing chronic diseases like damage of DNA [14] carcinogenesis [15], diabetes [16], and cardiovascular disease [17].

Peppermint (*Mentha piperita L.*) and Thyme (*Thymus vulgaris L.*) are a genus of an aromatic perennial and have medicinal substances of Lamiaceae family, peppermint is grown during increase the temperature in many countries [18]. The major chemical compounds of peppermint are menthol, menthone, and menthofuran, it also contains

Corresponding author: Myadah Shaher Aljedaani

Address: Biochemistry Department, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia.

E-mail: 🖂 myadah1991 @ gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. Received: 22 June 2019; Revised: 03 ovember 2019; Accepted: 05 November 2019

menthylacetate, eucalyptol, iso menthone and neomenthol [19]. Peppermint has antibacterial activity [20], antioxidant activity [21, 22], hepatoprotective effect [23], neuroprotective effect [24] hypocholesterolemic effect [25] and anti-diabetic effect [26].

Thyme is most prevalent in the Mediterranean regions [27]. Thyme contains high concentrations of phenols, including thymol, carvacrol, 1,8-cineole, q-cymene, linalool, borneol, a-pinene, and camphor [28]. Thyme is one of the most important species and is used as anti-inflammatory [29], antibacterial [30], antifungal [31], hepatoprotective [32], antioxidant [33, 34] and antitumor [35]. Therefore, this study aimed to investigate the impact of heated fried oil on the liver and heart functions in the rats. Furthermore, the role of natural antioxidant (Peppermint and Thyme) effect alone or in a mixture in ameliorating cardiac and hepatic disorders

## **MATERIALS AND METHOD**

### **Raw materials**

Fresh Palm oil and the leaves of *Mentha piperita* and *Thymus vulgaris* were obtained from the local supermarket in Jeddah, Saudi Arabia

### **Experimental animals**

Fifty adult male Wister rats, weighing 150 to 200 g were used as experimental animals obtained from the Central Animal House of King Fahd Medical Research Center. Jeddah, Saudi Arabia. The rats were kept at normal temperature and stander light cycle for one week before the start of experiments to adapt with adequate food and water. Animal procedures were performed under the Ethics committee of King Fahd Medical Research Center and the recommendations for proper care and use of laboratory animals. (Reference number:581-17)

### Preparation of water extracts of Mentha piperita

*Mentha piperita*leaves are washed, weighed (100 g/L) and triturated with water in the blender for 7 minutes. then the juice is filtered and frozen in the amber flask. Each flask was melted daily at ambient temperature two hours before administration [36].

### Preparation of water extracts of Thymus vulgaris

30g of dried paper of thymus was infused in 60 ml of distilled water for a day then, the sample was filtered using filter paper after that the aqueous filtered stored at \_20 \_C for 3 days [37].

### Preparation of heated fried oil (HFO) Diets

Palm oil is used as heated oil ten times, the heating process involved use 2.5L of the oil to fry 1K of potatoes and the temperature of the heating oil reach about 180°C for 10 min. To reheat the oil twice, the hot oil is cool for 5 hours, and then the entire frying process is repeated with a fresh batch of potatoes without adding fresh palm oil to compensate for oil losses. The test diets were formulated by mixing 15% (w:w) of each oil with commercial rat feed according to [38].

#### **The Experimental Design**

Fifty animals were used and divided into five groups each group contained 10 rats as follow: Group I (control): rats were fed a basal diet and given only distilled water. Group II: rats were fed a basal diet fortified with 15% (w / w) palm oil heated for 10 times. Group III: rats were fed as in group 2 and received 500mg/kg of Thymus vulgaris water extract by oral gavage for 45 days [37]. Group IV: rats were fed as in group 2 and received 290 mg/ kg body weight of Mentha piperita water extract by oral gavage for 45 days [36]. Group V: rats were fed as in group 2 and were received a mixture of the two herbs as in group 3 and 4 by oral gavage for 45 days.

During the experimental period, body weight was recorded once a week. At the end of the experimental period (45 days), rats fasted overnight before scarification. Blood samples were withdrawn by a heparinized capillary tube from the retro-orbital plexus of each rat under anesthesia with diethyl ether, then centrifuged at 3000 rpm for 10 min to separate serum, which stored at -20° C until biochemical analysis. Immediately after blood sampling, animals sacrificed and the heart and liver of each animal dissected and homogenized (1g/10ml ice-cold potassium chloride, 150 mM). The homogenate was then used for determination of oxidative stress by estimation of the level of the levels of malondialdehyde (MDA) as a lipid peroxidation marker, nitric oxide, and Protein Carbonyl Contents, glutathione reductase, and the activities of superoxide dismutase (SOD), and catalase (CAT) by colorimetric method using commercial KIT. Serum was used for estimated LDH, Creatine kinase-MB (CK-MB), blood glucose, and lipid profile: total cholesterol, LDL-C, HDL-C, and triglycerides levels. AST, ALT, and ALP were also estimated to study the liver function, by the colorimetric method using commercial KIT from sigma Aldrich.

### **Statistical Analysis**

The data of each group were analyzed using a one-way analysis of variance (ANOVA) with Microsoft excel program (2010) Mega Stat (10.0) Add-in. Results were expressed as mean  $\pm$  standard deviation (SD). Values of P more than or equal to 0.05 were considered to be a non-significant difference. While values less than 0.05 were counted as a significant difference.

#### RESULTS

# Effect of thyme and /or peppermint on serum enzyme activities

The effect of administration of aqueous extracts of *Thymus* vulgaris and /or peppermint *Mentha piperita L*. for 6 weeks on serum level of AST, ALT, ALP, LDH, and CK-MB in rats fed HFO were summarized in Table (1).As shown in the table, there were highly significant increases

(P=0.000) in the serum level of AST, ALT, ALP, LDH, and CK-MB in rats fed a diet fortified with HFO (GII) as compared with normal control rats (GI). Treatment rats fed HFO with thyme and /or peppermint significantly reduced the activity of all tested enzymes when compared to the untreated HFO group (GII).As compared to the individual treatment, the mixture of the aqueous extracts of thyme and peppermint had a more significant effect in restoring AST, ALT, ALP, LDH, and CK-MB levels.

Table 1. Effect of Thymus vulgaris and for Mentha piperna E. on serum enzyme activities of rais red fir o							
Groups	AST	ALT	ALP	LDH	CK-MB		
Oloups	(U/L)	(U/L)	(U/L)	(U/L)	(U/L)		
Control	26.3±4.52	31.6±5.08	85.4±7.71	426.03±10.21	130.99±4.29		
	72.9±9.92	93.6±6.96	$142 \pm 9.43$	914.08±9.60	264.56±5.29		
HFO	***	***	***	***	***		
	^^^	~~~	~~~	~~~	~~~		
HFO + thyme	42.4±4.25 *** ### ^^^	49.6±3.20 *** ### ^^^	105.8±9.02 *** ### ^^^	446.01±5.56 *** ### ^^	149.36±8.74 *** ### ^^^		
HFO + peppermint	39.3±4.37 *** ###	41±4.55 *** ###	101.3±4.37 *** #### ^	443.69±8.79 *** ### ^	147.85±6.29 *** ### ^^^		
HFO + thyme +	33.3±5.66	37.9±4.07	94.1±9.05	435.72±5.80	137.11±2.73		
HFO + thyme + peppermint	**	**	*	*	*		
	###	###	###	###	###		

The values are the mean  $\pm$  S.D. of parameters measured

 $P < 0.001 \ ***$  , 0.01  $\ **, 0.05*$  significantly different with control group.

P < 0.001 ### significantly different with HFO group.

P < 0.001 ^^^ ,0.01^^ ,0.05^ significantly different with HFO treated withthyme + peppermintgroup

# Effect of thyme and /or peppermint on serum lipid profile and glucose in rats fed with HFO

Table (2) showed the effect of thyme, peppermint or their mixture on serum lipid profile and glucose in rats fed on diet fortified with HFO. In the HFO group, there was a highly significant (p=0.000) elevation in TC, TG, LDL-C accompanied by a highly significant (p=0.000) reduction in HDL-C level as compared with the normal group. Moreover, an increase in glucose levels was significant in HFO to control. On the other hand, rats fed a diet fortified with HFO and treated with either thyme and peppermint or their mixture for 6 weeks and decreasing in TC, TG, LDL-C, glucose with increasing in HDL-C levels when compared to HFO group (Group II) .Moreover, the combined treatment of thyme and peppermint was more effective in preventing the alteration in the above parameters.

# Effect of Thyme and /or peppermint on tissue antioxidant activities of rats fed with HFO

The effect of administration of aqueous extracts of thyme and /or peppermint for 6 weeks on hepatic and cardiac antioxidants in rats consumed HFO diets is summarized in Table (3), it is obvious that a highly significant decrease (P=0.000) in SOD, CAT and GR activities in hepatic and cardiac tissues in HFO group (GII) when compared to their corresponding values in the control group. Supplementation with the aqueous extracts of thyme and /or peppermint has significantly (p=0.000) ameliorated the antioxidant status of the HFO group. Furthermore, the best-pronounced results were in the group treated with the mixture of both herbs when the results were closed to the control group.

International Journal of Pharmaceutical and Phytopharmacological Research (eIJPPR) | December 2019| Volume 9| Issue 6| Page 10-20 Osman N. N., Impact of Peppermint and Thyme in Ameliorating Cardiac and Hepatic Disorders Induced by Feeding Rats Repeatedly Heated Fried Oil

	• •		<u> </u>	0	
Groups	Total cholesterol	Triglyceride	HDL-C	LDL-C	Glucose
Groups	(mmol/L)	(mmol/L)	iglyceride         HDL-C         LDL-C           mmol/L)         (mmol/L)         (mmol/L)           .41±0.40         1.22±0.094         0.37±0.06           .46±0.47         0.58±0.08         2.55±0.38           ***         ***         ***           ^^^         ^^^         ^^^           .28±0.36         1.06±0.057         1.26±0.10           ***         ###         ####           ###         ####         ####           .45±0.37         1.10±0.057         1.22±0.08           ***         ***         ***           ###         ###         ###	(mmol/L)	
Control	2.26±0.36	1.41±0.40	1.22±0.094	0.37±0.06	4.92±0.44
	7.57±1.30	4.46±0.47	0.58±0.08	2.55±0.38	9.43±0.57
HFO	***	***	***	***	***
	~~~	~~~	eride         HDL-C         LDL $1/L$ )         (mmol/L)         (mmol/L) $0.40$ $1.22\pm0.094$ $0.37\pm0.037\pm0.037\pm0.037\pm0.037\pm0.036$ $2.55\pm0.08$ $***$ $***$ $***$ $***$ $\wedge$ $\wedge \wedge \wedge$ $\wedge \wedge \wedge$ $0.36$ $1.06\pm0.057$ $1.26\pm0.036\pm0.037$ $***$ $#**$ $***$ $\#$ $\#\#\#$ $\#\#$ $0.36$ $1.06\pm0.057$ $1.22\pm0.037$ $0.37$ $1.10\pm0.057$ $1.22\pm0.058$ $0.34$ $1.15\pm0.058$ $0.58\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm0.058\pm$	^^^	^^^
HFO +thyme	3.91±0.38 *** ###	2.28±0.36 *** ###	1.06±0.057 *** ###	1.26±0.10 *** ###	7.13±0.43 *** ###
HFO + peppermint	3.45±0.48 *** ###	2.45±0.37 *** ### ^^	1.10±0.057 *** ### ^^^	1.22±0.08 *** ### ^^^	6.02±0.55 *** ###
HFO +thyme +peppermint	2.97±0.38 * ###	1.93±0.34 ** ###	1.15±0.058 * ####	0.58±0.14 ** ###	5.64±0.75 ** ###

# Table 2: Effect of thyme and /or peppermint on serum lipid profile and glucose levels in rats fed HFO

The values are the mean  $\pm$  S.D. of parameters measured

P < 0.001 \*\*\*, 0.01 \*\*, 0.05\* significantly different with control group.

P < 0.001 ### significantly different with HFO group.

P < 0.001 ^^^ ,0.01^^ ,0.05^ significantly different with HFO treated with thyme + peppermintgroup.

Table 3:Effect of Thymus vulgaris and /or Mentha piperita L. on antioxidant activities in hepatic and cardiac
tissues in rats fed HFO

Groups	CAT (U/mg protein)		SOD (U/mg protein)		GR (U/g protein)	
	Liver	Heart	Liver	Heart	Liver	Heart
Control	73.65±5.01	35.01±1.46	6.94±0.58	3.58±0.27	0.89±0.06	0.42±0.03
HFO	32.88±2.79 *** ^^^	14.24±1,23 *** ^^^	3.04±0.27 ***	1.73±0.22 ***	0.22±0.04 *** ^^^	0.17±0.02 *** ^^^
HFO + Thyme	49.04±4.10 *** ### ^^^	22.84±1.39 *** ### ^^^	4.41±0.41 *** ### ^^^	2.81±0.16 *** ### ^^^	0.73±0.05 *** ### ^^	0.34±0.03 *** ### ^^
HFO + Peppermint	57.50±6.50 *** ### ^^^	25.57±1.00 *** ### ^^^	4.10±0.38 *** ### ^^^	3.03±0.13 *** ### ^^	0.66±0.06 *** ### ^^^	0.29±0.03 *** ### ^^^
HFO + Thyme+ Peppermint	68.14±3.45 *** ###	30.41±1.53 *** ###	6.18±0.38 ** ###	3.27±0.17 *** ###	0.81±0.04 ** ###	0.38±0.03 * ###

The values are the mean  $\pm$  S.D. of parameters measured

P < 0.001 \*\*\* ,0.01 \*\*, 0.05\* significantly different with control group.

P < 0.001 ### significantly different with HFO group.

P < 0.001 ^^^ ,0.01^^ ,0.05^ significantly different with HFO treated with thyme+ peppermintgroup.

# The effect of the aqueous extract of Thyme and /or peppermint on the oxidative stress of rats fed HFO

The effect of administration of water extracts of thyme and /or peppermint for 6 weeks on oxidative stress marker in hepatic and cardiac tissues is presented in Table (4). The current results showed that the levels of oxidative stress marker (MDA and, NO) and the content of PC in hepatic and cardiac tissues were significantly increased (p=0.000) in rats received HFO (G2) compared to control group. While supplementation of thyme and /or peppermint in the HFO group displayed significantly decreased in the above parameters compared to the untreated HFO group Furthermore, the best results were in the group treated with the mixture of both herbs when compared with each herb group.

Groups	MDA (µ mol/g prot)		NO (µ mol/g prot)		PC (nmol/mg prot)	
	Liver	Heart	Liver	Heart	Liver	Heart
Control	18.75±0.98	14.70±1.40	4.16±0.28	2.61±0.34	2.91±0.16	1.81±0.12
HFO	35.91±1.49	26.54±1.78	9.27±0.48	4.72±0.29	8.36±0.25	4.82±0.22
	***	***	***	***	***	***
	^^^	^^^	^^^	~~~	^^^	^^^
	24.75±2.24	22.15±1.20	5.85±1.82	3.16±0.17	4.22±0.29	2.85±0.49
HFO+ thyme	***	***	**	***	***	***
	###	###	###	###	###	###
	^^^	^^^	^	^	^^^	^^^
HFO +peppermint	27.32±2.47	19.38±1.00	6.32±0.79	2.95±0.33	3.85±0.36	2.45±0.35
	***	***	***	**	***	***
	###	###	###	###	###	###
	^^^	^^^	^^^	^^	~~~	^^
HFO+ thyme+ peppermint	22.22±1.44	17.25±1.48	4.95±0.31	2.84±0.28	3.30±0.40	2.10±0.06
	***	***	*	*	**	*
	###	###	###	###	###	###

Table 4:Effect of Thyme and /or peppermint on oxidative stress marker in hepatic and cardiac tissues of rats fed HFO

The values are the mean  $\pm$  S.D. of parameters measured

 $P < 0.001 \ ***$  , 0.01 \*\*, 0.05\* significantly different with control group.

P < 0.001 ### significantly different with HFO group.

P < 0.001 ^^^ ,0.01^^ ,0.05^ significantly different with HFO treated with thyme + peppermintgroup.

### DISCUSSION

The practice of using repeatedly heated cooking oil is common way to decrease cost, vegetable oil benefits could deteriorate throughout repeated heating which produced lipid oxidation and formation of trans-fat [39, 40], and the consumption of HFO increase the oxidative stress which might increase the risk of atherosclerosis [41] cancers [42], and cardiovascular disease [43].

The liver is the main organ of detoxification and metabolism for most chemicals, while water-soluble material could be easier excreted through kidneys, lipophilic converts into liver tissue before excreting [44]. The liver has big effects on lipid metabolism where it was synthesis many products such as cholesterol, lipogenesis, triglycerides, and lipoproteins [45]. Liver enzyme including AST and ALT have been regarded as markers of liver injury [46]. ALT is mainly in the liver tissues, but AST can also be found in the heart and skeletal muscles. Elevate AST and ALT may indicate negative effects on the liver though hepatitis, a physical trauma, ischemia, or cause injury as a result of drugs or toxins substances [47]. ALP is present in many organs such liver. Both ALP and GGT mainly are elevated in biliary tract diseases [48].

In the present study, rats fed on diet fortified with HFO had a significant increase in AST, ALT, and ALP. Dysfunction arising in the liver was coming from consumption HFO. Elevated serum aminotransferases might be related to destructive effects for toxic substances in HFO. However, several studies have examined the relationship between chronic consumption of HFO diets and the effect on raising serum liver enzymes in the rat [49-51]. Furthermore, in our study, rats fed on diet fortified with HFO had a significant increase in CK-MB and LDH when compared to the normal rats. These increased indicate the damage or destruction of myocardial cells return to the reduction of oxygen supplementation or glucose, cardiac membrane be permeable or rupture entirely, which leadsto the deficiency of many enzymes. Serum CK-MB is an important early causing not onlyby myocardial infarction but also any kind of myocardial injury because founding in myocardial tissue abundantly and the virtual absence of other tissues and also more sensitivity [52]. Elevation in the lactate dehydrogenase (LDH) activity indicates the disturbance in the normal cardiac functions[53]. Similar results were reported by [54, 55]. The study by Rahman et al [56] observed that the fried rapeseed oils (both mustard and rai) were more toxic for the rat with raised cardiohepatic changes.

In the present investigation, treated rats fed a basal diet containing 15% HFO with aqueous extracts of thyme and/or peppermint was significantly decreased the serum AST, ALT, ALP, LDH, and CK-MB. This indicates the ability of these extracts to enhance liver and heart function. The improvements in liver and heart enzymes in the HFO group after treatment could be beneficial in preventing cardiac and hepatic disorders. Many studies showed the positive effect of peppermint on liver function parameter [57-61].

Regard to the hepatoprotective effect of thyme [32, 62-64] reported that *Thymus vulgaris* used as a hepatic treatment by causes a significant positive change in oxidative stress and inflammatory markers, restoring normal liver

functions and preventing histopathological changes. However,(Mohamed Fizur *et al*; Nagoor Meeran *et al*) [65, 66] observed that the feeding of rats with thymol, was able to lower the elevated activity of serum CK-MB, suggested thymol might be keeping cardiac mitochondrial either structure or function.

In the present study, rats in the groupreceived HFO had a significant increase in TC, TG, and LDL-C in parallel to a highly significant decrease in HDL-C as compared to the control group. Many studies reported the effects of HFO consumption on the lipid profiles of rats [67, 68].

The increase in TC and TG levels in the current study coincided with the findings of [69, 70]. This increase in the level cholesterol in of the blood implicated (Hypercholesterolemia) has been in cardiovascular diseases. Hence, HFO diets may increase the risk of cardiovascular diseases. The increase in serum LDL-C and the decrease in serum LDL-C in HFO diets is in agreement with the work of [71]. However, examination relationship between HDL-C and cardiovascular risk was pervious studied where most of them illustrated a strong, inverse, independent relationship between HDL-C and CVD [72-74] Regard effect for feeding HFO on glucose levels, the current results showed significantly increasing in glucose level (HFO groups) comparing to control groups. Results are in agreement with [75-78].

(Chiang *et al*) [79] concluded that rodents fed a diet containing 20% HFO had glucose intolerance and insulin deficiency, due to oxidative stress-associated  $\beta$ -cell dysfunction.

Enhanced HMG-COA reductase activity in the liver may be liable for increased concentration of plasma cholesterol [80, 81]. The increase in HDL-C might be a result of the low admission of linoleic acid content of HFO or might be an assurance system against the oxidative stress brought about by the eating regimen containing HFO and a mechanism to avoid oxidative changes in other lipoprotein such as LDL [82] In the present investigation, treated rats fed diet fortified with HFO with aqueous extracts of thyme and/or peppermint was reduced serum TC, TG, and LDL-C, glucose and increased HDL-C compared to their untreated HFO rats indicating that the addition of thyme and peppermint could repair lipid metabolism dysfunction induced by HFO.

The hypolipidemic and hypoglycemic effects of peppermint and thyme were studied by many researchers [83-86]. These effects maybe related to the presence of substances such as menthol, thymol and flavonoid have important radical scavenging activity [87]. Moreover, flavonoids that present in mentha may act in several ways on blood components like lipids [88].

Toghyani et al [89] attributed the reduction of triglycerides and cholesterol to the lowering effect of thymol or carvacrol on HMG- Co-A reductase, the rate-limiting enzyme of cholesterol synthesis.

The present study showed an increase in levels of MDA, NO and the content of PC accompanied with a significant decrease in CAT, SOD, and GR activities in hepatic and cardiac tissues in the HFO group compared to the control group. The current results agree with several studies conducted on rats fed with [90, 91]. Recently, Ayari *et al* [92] showed an elevation in the level of MDA and reduced in the activities of CAT and GR in rats fed thermo-oxidized virgin olive oil compared to the control group.

Lipid peroxidation ranged fromintermediates and end productsincluding lipid hydroperoxides, aldehydes, and malondialdehyde (MDA) [93]. MDA is the most popular indicator of oxidative damage to cells and tissues. The increase in MDA levels in rats HFO may be elicited by free radicals of lipid peroxidation. The most general and accepted way to evaluate protein damage is by measuring protein carbonyls. The presence of increased protein carbonyl groups is an indicator of protein oxidation and thus, oxidative damage [94]. Protein carbonyls are unable to catabolize to rectify amino acids and therefore, block proteolysis and oxidized protein accretion [95] which reduces amino acid recycling and cell integrity. It could be suggested that protein carbonyl concentration should also be measured in addition to MDA because protein damage is most affected by ROS in comparison to lipid and DNA damage mechanisms [96]. Endogenous antioxidants including superoxide dismutase (SOD), catalase (CAT), and glutathione reductase (GR) protect the body from damage caused by ROS and free radicals. The significant decrease in the antioxidant activity in the current study agrees with [97, 98].

SOD is a free radical scavenging enzyme that protects cells from oxidative stress as a defense mechanism of the cell against the endogenous and exogenous release of superoxide [98]. Also, it is effected by the CAT in a precise manner to scavenge ROS. Catalase is an antioxidant enzyme that converts the H2 O2 into water and oxygen; thus, preventing the lipid peroxidation of the cell membrane [99]. However, glutathione reductase is the enzyme which, convert of oxidized glutathione back to its reduced form.

In the present investigation, treated rats feda dietcontaining HFO with aqueous extracts of thyme and/or peppermint was significantly decreased the level of MDA, NO and PC accompanied with a significant increase in CAT, SOD, and GR in liver and heart tissues.

Oxidative stress-induced by HFO resulted in a modification of antioxidant enzymes activities in the liver and heart but treated by thyme and peppermint rise level of antioxidant this can repair the damage that may occur in tissues by HFO. Thyme has a high level of flavonoid, thymol and carvacrol act a scavenge for free radicals.

Many studies have investigated the effect of thyme and peppermint in liver and heart tissue. El-Newary *et al* [63] observed that the administration of T. Vulgaris in rats fed alcohol ameliorate the increase in the level of MDA and significantly increased the antioxidants enzyme activities (GR, CAT, and SOD) in the liver.

Many experimental and clinical studies showed the beneficial effect of peppermint in improving the antioxidant parameter [62, 100]. Peppermint most of its pharmacological actions were related to antioxidant activity and theability to scavenge free radicals and/or inhibit lipid peroxidation [101-103].

# CONCLUSION

According to the results obtained it could be concluded that the two herbs showing stronger amelioration and may block many complications of cardiovascular and hepatic disease by controlling hyperglycemia, hyperlipidemia, oxidative stress and thus protects liver and heart from damage.

# REFERENCES

- K. N. van Koerten, M. A. I. Schutyser, D. Somsen, and R. M. Boom, "Crust morphology and crispness development during deep-fat frying of potato," Food Res. Int., vol. 78, pp. 336–342, 2015.
- [2] J. H. Song, M. J. Kim, Y. J. Kim, and J. H. Lee, "Monitoring changes in acid value, total polar material, and antioxidant capacity of oils used for frying chicken," Food Chem., vol. 220, pp. 306– 312, 2017.
- [3] I. Ben Hammouda, G. Márquez-Ruiz, F. Holgado, F. Freitas, M. D. R. G. Da Silva, and M. Bouaziz, "Comparative study of polymers and total polar compounds as indicators of refined oil degradation during frying," Eur. Food Res. Technol., vol. 245, no. 5, pp. 967–976, May 2019.
- [4] A. Arias-Mendez, A. Warning, A. K. Datta, and E. Balsa-Canto, "Quality and safety driven optimal operation of deep-fat frying of potato chips," J. Food Eng., vol. 119, no. 1, pp. 125–134, 2013.
- [5] C. F. Huang et al., "Oxidized frying oil and its polar fraction fed to pregnant mice are teratogenic and alter mRNA expressions of vitamin a metabolism genes in the liver of dams and their fetuses," J. Nutr. Biochem., vol. 25, no. 5, pp. 549–556, 2014.
- [6] L. Yu, J. Li, S. Ding, F. Hang, and L. Fan, "Effect of guar gum with glycerol coating on the properties and oil absorption of fried potato chips," Food Hydrocoll., vol. 54, pp. 211–219, 2016.
- [7] J. Cheng, S. Zhang, S. Wang, P. Wang, X. O. Su, and J. Xie, "Rapid and sensitive detection of

acrylamide in fried food using dispersive solidphase extraction combined with surface-enhanced Raman spectroscopy," Food Chem., vol. 276, pp. 157–163, Mar. 2019.

- [8] L. Zhao et al., "Heating methods generate different amounts of persistent free radicals from unsaturated fatty acids," Sci. Total Environ., vol. 672, pp. 16– 22, Jul. 2019.
- [9] S. Kakde, R. S. Bhopal, S. Bhardwaj, and A. Misra, "Urbanized South Asians' susceptibility to coronary heart disease: The high-heat food preparation hypothesis," Nutrition, vol. 33, pp. 216–224, Jan. 2017.
- [10] J. P. Honerlaw et al., "Fried food consumption and risk of coronary artery disease: The Million Veteran Program," Clin. Nutr., 2019.
- [11] L. E. Cahill et al., "Fried-food consumption and risk of type 2 diabetes and coronary artery disease: A prospective study in 2 cohorts of US women and men," Am. J. Clin. Nutr., vol. 100, no. 2, pp. 667– 675, 2014.
- [12] L. Djoussé, A. B. Petrone, and J. Michael Gaziano, "Consumption of fried foods and risk of heart failure in the physicians' health study," J. Am. Heart Assoc., vol. 4, no. 4, 2015.
- [13] P. Guallar-Castillón et al., "Intake of fried foods is associated with obesity in the cohort of Spanish adults from the European Prospective Investigation into Cancer and Nutrition," Am. J. Clin. Nutr., vol. 86, no. 1, pp. 198–205, Jul. 2007.
- [14] İ. Kurt-Celep et al., "Hypericum olympicum L. recovers DNA damage and prevents MMP–9 activation induced by UVB in human dermal fibroblasts," J. Ethnopharmacol., vol. 246, p. 112202, Jan. 2020.
- [15] K. Nagai et al., "Enhanced anti-cancer activity by menthol in HepG2 cells exposed to paclitaxel and vincristine: Possible involvement of CYP3A4 downregulation," Drug Metab. Pers. Ther., vol. 34, no. 1, 2019.
- [16] R. A. Najdi, M. M. Hagras, F. O. Kamel, and R. M. Magadmi, "A randomized controlled clinical trial evaluating the effect of Trigonella foenum-graecum (fenugreek) versus glibenclamide in patients with diabetes," Afr. Health Sci., vol. 19, no. 1, pp. 1594– 1601, Mar. 2019.
- [17] H. A. Collin, "Herbs, spices and cardiovascular disease," in Handbook of Herbs and Spices, vol. 3, Elsevier Ltd, 2006, pp. 126–137.
- [18] V. Rajkumar, C. Gunasekaran, I. K. Christy, J. Dharmaraj, P. Chinnaraj, and C. A. Paul, "Toxicity, antifeedant and biochemical efficacy of Mentha piperita L. essential oil and their major constituents

against stored grain pest," Pestic. Biochem. Physiol., vol. 156, pp. 138–144, May 2019.

- [19] K. Skalicka-Woźniak and M. Walasek, "Preparative separation of menthol and pulegone from peppermint oil (Mentha piperita L.) by highperformance counter-current chromatography," Phytochem. Lett., vol. 10, pp. xciv–xcviii, Dec. 2014.
- [20] R. Singh, M. A. M. Shushni, and A. Belkheir, "Antibacterial and antioxidant activities of Mentha piperita L.," Arab. J. Chem., vol. 8, no. 3, pp. 322– 328, May 2015.
- [21] E. Schmidt et al., "Chemical composition, olfactory evaluation and antioxidant effects of essential oil from Mentha x piperita.," Nat. Prod. Commun., vol. 4, no. 8, pp. 1107–12, Aug. 2009.
- [22] Z. Wu et al., "Chemical Composition and Antioxidant Properties of Essential Oils from Peppermint, Native Spearmint and Scotch Spearmint," Molecules, vol. 24, no. 15, 2019.
- [23] T. Gadiraju, Y. Patel, J. M. Gaziano, and L. Djousse, "Protective effect of peppermint and parsley leaves oils against hepatotoxicity on experimental rats," J. Am. Coll. Cardiol., vol. 67, no. 13, Supplement, p. 1913, 2016.
- [24] Z. Rabiei, E. Heidarian, and M. Rafieian-Kopaei, "The neuroprotective effect of pretreatment with Lavandula officinalis ethanolic extract on brain edema in rat stroke model," J. Zanjan Univ. Med. Sci. Heal. Serv., vol. 23, no. 98, pp. 1151–1163, 2015.
- [25] N. Z. Johari, I. S. Ismail, M. R. Sulaiman, F. Abas, and K. Shaari, International Journal of Applied Research in Natural Products, vol. 8, no. 1. Healthy Synergies Publications, 2015.
- [26] J. Angel, K. S. Sailesh, and J. Mukkadan, "Original Article A study on Anti - diabetic effect of peppermint in alloxan induced diabetic model of wistar rats," vol. 3, no. 4, 2013.
- [27] H. Mohammadi, F. Amirikia, M. Ghorbanpour, F. Fatehi, and H. Hashempour, "Salicylic acid induced changes in physiological traits and essential oil constituents in different ecotypes of Thymus kotschyanus and Thymus vulgaris under wellwatered and water stress conditions," Ind. Crops Prod., vol. 129, pp. 561–574, Mar. 2019.
- [28] A. Komaki, F. Hoseini, S. Shahidi, and N. Baharlouei, "Study of the effect of extract of Thymus vulgaris on anxiety in male rats," J. Tradit. Complement. Med., vol. 6, no. 3, pp. 257–261, Jul. 2016.
- [29] F. C. Fachini-Queiroz et al., "Effects of Thymol and Carvacrol, Constituents of Thymus vulgaris L. Essential Oil, on the Inflammatory Response,"

Evidence-Based Complement. Altern. Med., vol. 2012, pp. 1–10, 2012.

- [30] S. Karaman, M. Digrak, U. Ravid, and A. Ilcim, "Antibacterial and antifungal activity of the essential oils of Thymus re 6 olutus Celak from Turkey," vol. 76, pp. 183–186, 2001.
- [31] M. Šegvić Klarić, I. Kosalec, J. Mastelić, E. Piecková, and S. Pepeljnak, "Antifungal activity of thyme (Thymus vulgaris L.) essential oil and thymol against moulds from damp dwellings," Lett. Appl. Microbiol., vol. 44, no. 1, pp. 36–42, Jan. 2007.
- [32] R. Grespan et al., "Hepatoprotective Effect of Pretreatment with Thymus vulgaris Essential Oil in Experimental Model of Acetaminophen-Induced Injury.," Evid. Based. Complement. Alternat. Med., vol. 2014, p. 954136, Feb. 2014.
- [33] Z. E. Bistgani, M. Hashemi, M. DaCosta, L. Craker, F. Maggi, and M. R. Morshedloo, "Effect of salinity stress on the physiological characteristics, phenolic compounds and antioxidant activity of Thymus vulgaris L. and Thymus daenensis Celak," Ind. Crops Prod., vol. 135, pp. 311–320, Sep. 2019.
- [34] A. Cerda et al., "The enhancement of antioxidant compounds extracted from Thymus vulgaris using enzymes and the effect of extracting solvent," Food Chem., vol. 139, no. 1–4, pp. 138–143, 2013.
- [35] M. Nikolić et al., "Chemical composition, antimicrobial, antioxidant and antitumor activity of Thymus serpyllum L., Thymus algeriensis Boiss. and Reut and Thymus vulgaris L. essential oils," Ind. Crops Prod., vol. 52, pp. 183–190, Jan. 2014.
- [36] S. M. Barbalho et al., "Metabolic Profile of Offspring from Diabetic Wistar Rats Treated with Mentha piperita (Peppermint).," Evid. Based. Complement. Alternat. Med., vol. 2011, p. 430237, 2011.
- [37] A. A. Shati and F. G. Elsaid, "Effects of water extracts of thyme (Thymus vulgaris) and ginger (Zingiber officinale Roscoe) on alcohol abuse," Food Chem. Toxicol., vol. 47, no. 8, pp. 1945– 1949, 2009.
- [38] K. Jaarin, X.-F. Leong, M. Nadzri, M. Najib, S. Das, and M. R. Mustafa, "Heated Palm Oil on Blood Pressure and Vascular Reactivity Intake of Repeatedly Heated Palm Oil Causes Elevation in Blood Pressure with Impaired Vasorelaxation in Rats," Tohoku J. Exp. Med. Tohoku J. Exp. Med, vol. 219, no. 2191, pp. 71–78, 2009.
- [39] C. A. Martin, M. C. Milinsk, J. V. Visentainer, M. Matsushita, and N. E. De-Souza, "Trans fatty acidforming processes in foods: A review," An. Acad. Bras. Cienc., vol. 79, no. 2, pp. 343–350, 2007.

- [40] R. Perumalla Venkata and R. Subramanyam, "Evaluation of the deleterious health effects of consumption of repeatedly heated vegetable oil," Toxicol. Reports, vol. 3, pp. 636–643, Jan. 2016.
- [41] R. Gupta, S. K. Vind, S. P. Singh, S. Kumar, and M. Kumar, "The Effect Of Different Deep Fried Vegetable Oil On Cardiovascular System In Rats Model," World J. Pharm. Res., vol. 3, no. 7, pp. 1130–1139, 2014.
- [42] B. K. Smith, L. E. Robinson, R. Nam, and D. W. L. Ma, "Trans-fatty acids and cancer: a mini-review," 2017.
- [43] D. Mozaffarian, M. B. Katan, A. Ascherio, M. J. Stampfer, and W. C. Willett, "Trans Fatty Acids and Cardiovascular Disease," N. Engl. J. Med., vol. 354, no. 15, pp. 1601–1613, Apr. 2006.
- [44] J. Y. L. Chiang, "Bile acid metabolism and signaling," Compr. Physiol., vol. 3, no. 3, pp. 1191– 1212, 2013.
- [45] R. Stinkens, G. H. Goossens, J. W. E. Jocken, and E. E. Blaak, "Targeting fatty acid metabolism to improve glucose metabolism," Obes. Rev., vol. 16, no. 9, pp. 715–757, Sep. 2015.
- [46] D. S. Pratt and M. M. Kaplan, "Evaluation of Abnormal Liver-Enzyme Results in Asymptomatic Patients," N. Engl. J. Med., vol. 342, no. 17, pp. 1266–1271, Apr. 2000.
- [47] E. G. Giannini, R. Testa, and V. Savarino, "Liver enzyme alteration: a guide for clinicians," Can. Med. Assoc. J., vol. 172, no. 3, pp. 367–379, Feb. 2005.
- [48] S. M. Barbalho et al., "Metabolic profile of offspring from diabetic Wistar rats treated with Mentha piperita (peppermint)," Evidence-based Complement. Altern. Med., vol. 2011, 2011.
- [49] D. U. Owu, E. E. Osim, and P. E. Ebong, "Serum liver enzymes profile of Wistar rats following chronic consumption of fresh or oxidized palm oil diets," Acta Trop., vol. 69, no. 1, pp. 65–73, Mar. 1998.
- [50] N. Totani and Y. Ojiri, "Mild Ingestion of Used Frying Oil Damages Hepatic and Renal Cells in Wistar Rats," J. Oleo Sci., vol. 56, no. 5, pp. 261– 267, 2007.
- [51] M. N. Jane, O. G. Appolos, and O. O. Debora, "Effects of Vegetable Oil Reused for Frying on the Liver of Albino Rats," vol. 7, no. 1, pp. 11–14, 2019.
- [52] D. H. Priscilla and P. S. M. Prince, "Cardioprotective effect of gallic acid on cardiac troponin-T, cardiac marker enzymes, lipid peroxidation products and antioxidants in experimentally induced myocardial infarction in

Wistar rats," Chem. Biol. Interact., vol. 179, no. 2– 3, pp. 118–124, May 2009.

- [53] M. Risenfors et al., "Effect of early intravenous rt-PA on infarct size estimated from serum enzyme activity: Results from the TEAHAT Study," J. Intern. Med. Suppl., vol. 229, no. 734, pp. 11–18, 1991.
- [54] M. A. Hamsi et al., "Effect of consumption of fresh and heated virgin coconut oil on the blood pressure and inflammatory biomarkers: An experimental study in Sprague Dawley rats," Alexandria J. Med., vol. 51, no. 1, pp. 53–63, Mar. 2015.
- [55] K. Sukalingam, K. Jaarin, Q. H. M. Saad, S. Mohamed, and F. Othman, "Effect of rutacea plant extract (ADD-X) on inflammatory biomarkers, cardiac LDL, troponin T and histological changes in ovariectomized rats fed with heated palm oil," Int. J. Toxicol. Pharmacol. Res., vol. 8, no. 4, pp. 223–231, 2016.
- [56] M. H. Rahman, S. S. Rahman, D. Mandal, and M. N. Rahman, "International Journal of Nutrition and Metabolism Evaluation of effects of various rapeseed oils on serum lipids and cardio-hepatic enzymes in experimental rats," vol. 10, no. 1, pp. 1–5, 2018.
- [57] A. Sharma, M. K. Sharma, and M. Kumar, "Protective Effect of Mentha piperita against Arsenic-Induced Toxicity in Liver of Swiss Albino Mice," Basic Clin. Pharmacol. Toxicol., vol. 100, no. 4, pp. 249–257, Apr. 2007.
- [58] A. F. Khalil, H. O. Elkatry, and H. F. El Mehairy, "Protective effect of peppermint and parsley leaves oils against hepatotoxicity on experimental rats," Ann. Agric. Sci., vol. 60, no. 2, pp. 353–359, Dec. 2015.
- [59] P. R. Frank, V. Suresh, G. Arunachalam, S. K. Kanthlal, and V. M. Ziaudheen, "Evaluation of hepatoprotective effect of adiantum incisum forsk leaf extract against CCL4 induced hepatotoxicity in rats," Int. Res. J. Pharm., vol. 3, no. 3, pp. 230–234, 2012.
- [60] M. Khodadust, F. Samadi, F. Ganji, Y. Jafari Ahangari, and G. Asadi, "Effects of Peppermint (Mentha piperita L.) Alcoholic Extract on Carbon Tetrachloride-induced Hepatotoxicity in Broiler Chickens Under Heat Stress Condition," Gorgan Univ. Agric. Sci. Nat. Resour., vol. 3, no. 1, pp. 1– 16, Jun. 2015.
- [61] M. M. Zangeneh, S. Salmani, A. Zangeneh, E. Bahrami, and M. Almasi, "Antiulcer activity of aqueous extract of leaves of Mentha piperita in Wistar rats," Comp. Clin. Path., vol. 28, no. 2, pp. 411–418, Apr. 2019.

- [62] A. R. Abu-Raghif, A. S. Sahib, and S. A. Hasan, "Hepatoprotective effects of thyme extract in Cisplatin-induced liver toxicity in rabbits." 2016.
- [63] S. A. El-Newary, N. M. Shaffie, and E. A. Omer, "The protection of Thymus vulgaris leaves alcoholic extract against hepatotoxicity of alcohol in rats," Asian Pac. J. Trop. Med., vol. 10, no. 4, pp. 361–371, Apr. 2017.
- [64] F. Geyikoglu et al., "Hepatoprotective Role of Thymol in Drug-Induced Gastric Ulcer Model," Ann. Hepatol., vol. 17, no. 6, pp. 980–991, Jan. 2019.
- [65] M. F. Nagoor Meeran and P. Stanely Mainzen Prince, "Protective effects of thymol on altered plasma lipid peroxidation and nonenzymic antioxidants in isoproterenol-induced myocardial infarcted rats," J. Biochem. Mol. Toxicol., vol. 26, no. 9, pp. 368–373, Sep. 2012.
- [66] M. F. Nagoor Meeran, G. Jagadeesh, and P. Selvaraj, "Thymol, a dietary monoterpene phenol abrogates mitochondrial dysfunction in β-adrenergic agonist induced myocardial infarcted rats by inhibiting oxidative stress," Chem. Biol. Interact., vol. 244, pp. 159–168, Jan. 2016.
- [67] M. Dhibi et al., "Consumption of Oxidized and Partially Hydrogenated Oils Differentially Induces Trans-Fatty Acids Incorporation in Rats' Heart and Dyslipidemia," J. Am. Coll. Nutr., vol. 35, no. 2, pp. 125–135, Feb. 2016.
- [68] P. Chaturvedi, K. B. Mazunga, and P. Moseki, Jahresbericht über die Erzeugungswirtschaft der Molkerei Böhm.-Mähr. Verb. f. Milch u. Fette, Prag; Für d. Jahr ... = Výroční zpráva o výrobním hospodářstvi mlékárny. Böhm.-Mähr. Verb. f. Milch u. Fette, 2016.
- [69] C. F. Rueda-Clausen et al., "Olive, soybean and palm oils intake have a similar acute detrimental effect over the endothelial function in healthy young subjects," Nutr. Metab. Cardiovasc. Dis., vol. 17, no. 1, pp. 50–57, Jan. 2007.
- [70] H. Gumaih, "Effect of reused palm oil on biochemical and hematological parameters of mice," Egypt. Acad. J. Biol. Sci. B. Zool., vol. 7, no. 1, pp. 13–21, Jun. 2015.
- [71] A. O. Falade, G. Oboh, A. O. Ademiluyi, and O. V. Odubanjo, "Consumption of thermally oxidized palm oil diets alters biochemical indices in rats," Beni-Suef Univ. J. Basic Appl. Sci., vol. 4, no. 2, pp. 150–156, Jun. 2015.
- [72] J. P. Després, I. Lemieux, G. R. Dagenais, B. Cantin, and B. Lamarche, "HDL-cholesterol as a marker of coronary heart disease risk: the Québec cardiovascular study.," Atherosclerosis, vol. 153, no. 2, pp. 263–72, Dec. 2000.

- [73] A. R. Sharrett et al., "Coronary heart disease prediction from lipoprotein cholesterol levels, triglycerides, lipoprotein(a), apolipoproteins A-I and B, and HDL density subfractions: The Atherosclerosis Risk in Communities (ARIC) Study.," Circulation, vol. 104, no. 10, pp. 1108–13, Sep. 2001.
- [74] C. E. Koro, S. J. Bowlin, T. E. Stump, D. L. Sprecher, and W. M. Tierney, "The independent correlation between high-density lipoprotein cholesterol and subsequent major adverse coronary events," Am. Heart J., vol. 151, no. 3, p. 755.e1-755.e6, Mar. 2006.
- [75] C.-H. Liao, H.-M. Shaw, and P.-M. Chao, "Impairment of glucose metabolism in mice induced by dietary oxidized frying oil is different from that induced by conjugated linoleic acid," Nutrition, vol. 24, no. 7–8, pp. 744–752, Jul. 2008.
- [76] O. Middleton, N. & Dingels, and M. Penumetcha, "Effects of heated versus unheated soybean oil in C57BL/6J mice," FASEB J., vol. 27, 2013.
- [77] P.-M. Chao, H.-L. Huang, C.-H. Liao, S.-T. Huang, and C. Huang, "A high oxidised frying oil content diet is less adipogenic, but induces glucose intolerance in rodents," Br. J. Nutr., vol. 98, no. 01, p. 63, Jul. 2007.
- [78] A. Zeb and A. A. Khan, "Improvement of Serum Biochemical Parameters and Hematological Indices Through α-Tocopherol Administration in Dietary Oxidized Olive Oil Induced Toxicity in Rats.," Front. Nutr., vol. 5, p. 137, 2018.
- [79] Y.-F. Chiang, H.-M. Shaw, M.-F. Yang, C.-Y. Huang, C.-H. Hsieh, and P.-M. Chao, "Dietary oxidised frying oil causes oxidative damage of pancreatic islets and impairment of insulin secretion, effects associated with vitamin E deficiency.," Br. J. Nutr., vol. 105, no. 9, pp. 1311– 9, May 2011.
- [80] E. Hochgraf, S. Mokady, and U. Cogan, "Dietary Oxidized Linoleic Acid Modifies Lipid Composition of Rat Liver Microsomes and Increases Their Fluidity," J. Nutr., vol. 127, no. 5, pp. 681–686, May 1997.
- [81] F. J. Sánchez-Muniz, S. López-Varela, M. C. Garrido-Polonio, and C. Cuesta, "Dietary effects on growth, liver peroxides, and serum and lipoprotein lipids in rats fed a thermoxidised and polymerised sunflower oil," J. Sci. Food Agric., vol. 76, no. 3, pp. 364–372, Mar. 1998.
- [82] C. Garrido-Polonio et al., "Thermally oxidised sunflower-seed oil increases liver and serum peroxidation and modifies lipoprotein composition in rats," Br. J. Nutr., vol. 92, no. 2, pp. 257–265, Aug. 2004.

- [83] R. Mani Badal, D. Badal, P. Badal, A. Khare, J. Shrivastava, and V. Kumar, "Pharmacological Action of Mentha piperita on Lipid Profile in Fructose-Fed Rats.," Iran. J. Pharm. Res. IJPR, vol. 10, no. 4, pp. 843–8, 2011.
- [84] S. M. Barbalho et al., "Mentha piperita effects on wistar rats plasma lipids," Brazilian Arch. Biol. Technol., vol. 52, no. 5, pp. 1137–1143, Oct. 2009.
- [85] S. N. Ekoh, E. I. Akubugwo, V. C. Ude, and N. Edwin, International journal of biosciences., vol. 4, no. 2. International Network for Natural Sciences (INNSPUB), 2014.
- [86] M. Ramchoun et al., "Hypolipidemic and antioxidant effect of polyphenol-rich extracts from Moroccan thyme varieties," ESPEN. J., vol. 7, no. 3, pp. e119–e124, Jun. 2012.
- [87] R. M. Samarth, M. Panwar, and A. Kumar, "Modulatory effects ofMentha piperita on lung tumor incidence, genotoxicity, and oxidative stress in benzo[a]pyrene-treated Swiss albino mice[retracted article]," Environ. Mol. Mutagen., vol. 47, no. 3, pp. 192–198, Apr. 2006.
- [88] J. T. Doyama, H. G. Rodrigues, E. L. B. Novelli, E. Cereda, and W. Vilegas, "Chemical investigation and effects of the tea of Passiflora alata on biochemical parameters in rats," J. Ethnopharmacol., vol. 96, no. 3, pp. 371–374, Jan. 2005.
- [89] M. Toghyani, M. Tohidi, A. Gheisari, and S. Tabeidian, African journal of biotechnology., vol. 9, no. 40. Academic Journals, 2010.
- [90] M. Dhibi et al., "The intake of high fat diet with different trans fatty acid levels differentially induces oxidative stress and non alcoholic fatty liver disease (NAFLD) in rats," Nutr. Metab. (Lond)., vol. 8, no. 1, p. 65, Sep. 2011.
- [91] Y.-Y. Chen, J.-F. Liu, C.-M. Chen, P.-Y. Chao, and T.-J. Chang, "A study of the antioxidative and antimutagenic effects of Houttuynia cordata Thunb. using an oxidized frying oil-fed model.," J. Nutr. Sci. Vitaminol. (Tokyo)., vol. 49, no. 5, pp. 327– 33, Oct. 2003.
- [92] D. Ayari, F. Boukazoula, B. Soumati, and L. Souiki, "Evaluation of oxidative stress biomarkers of rabbits' liver exposed to thermooxidized virgin olive oil obtained from blanquette olive cultivars," Biomarkers, vol. 24, no. 4, pp. 407–413, May 2019.
- [93] N. A. Strobel, R. G. Fassett, S. A. Marsh, and J. S. Coombes, "Oxidative stress biomarkers as predictors of cardiovascular disease," Int. J. Cardiol., vol. 147, no. 2, pp. 191–201, Mar. 2011.

- [94] M. F. Beal, "Oxidatively modified proteins in aging and disease," Free Radic. Biol. Med., vol. 32, no. 9, pp. 797–803, May 2002.
- [95] W. Dröge, "Free Radicals in the Physiological Control of Cell Function," Physiol. Rev., vol. 82, no. 1, pp. 47–95, Jan. 2002.
- [96] I. Dalle-Donne, R. Rossi, D. Giustarini, A. Milzani, and R. Colombo, "Protein carbonyl groups as biomarkers of oxidative stress," Clinica Chimica Acta, vol. 329, no. 1–2. Elsevier, pp. 23–38, 2003.
- [97] S. Srivastava, M. Singh, J. George, K. Bhui, and Y. Shukla, "Genotoxic and Carcinogenic Risks Associated with the Consumption of Repeatedly Boiled Sunflower Oil," J. Agric. Food Chem., vol. 58, no. 20, pp. 11179–11186, Oct. 2010.
- [98] V. R. Vásquez-Garzón, J. Arellanes-Robledo, R. García-Román, D. I. Aparicio-Rautista, and S. Villa-Treviño, "Inhibition of reactive oxygen species and pre-neoplastic lesions by quercetin through an antioxidant defense mechanism," Free Radic. Res., vol. 43, no. 2, pp. 128–137, Jan. 2009.
- [99] K. Niska, K. Pyszka, C. Tukaj, M. Wozniak, M. W. Radomski, and I. Inkielewicz-Stepniak, "Titanium dioxide nanoparticles enhance production of superoxide anion and alter the antioxidant system in human osteoblast cells.," Int. J. Nanomedicine, vol. 10, pp. 1095–107, 2015.
- [100] Z. Rabiei, S. Mokhtari, S. Asgharzade, M. Gholami, S. Rahnama, and M. Rafieian-kopaei, "Inhibitory effect of Thymus vulgaris extract on memory impairment induced by scopolamine in rat," Asian Pac. J. Trop. Biomed., vol. 5, no. 10, pp. 845–851, Oct. 2015.
- [101] K. Bellassoued et al., "Protective effects of Mentha piperita L. leaf essential oil against CCl4 induced hepatic oxidative damage and renal failure in rats," Lipids Health Dis., vol. 17, no. 1, p. 9, Dec. 2018.
- [102] Z. Sun, H. Wang, J. Wang, L. Zhou, and P. Yang, "Chemical Composition and Anti-Inflammatory, Cytotoxic and Antioxidant Activities of Essential Oil from Leaves of Mentha piperita Grown in China," PLoS One, vol. 9, no. 12, p. e114767, Dec. 2014.
- [103] S. M. Prabu, S. Thangapandiyan, N. C. Sumedha, and S. Miltonprabu, "Mentha piperita protects against Cadmium induced oxidative renal damage by restoring antioxidant enzyme activities and suppressing inflammation in rats," Artic. Int. J. Pharmacol. Toxicol. Sci., vol. 1, no. 2, pp. 17–28, 2013.