Biochemical effect of olive leaves on experimentally induced cardiac stress in rats

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Aim
The present study aimed to evaluate the protective effect and treatment of olive leaves administration on cardiac necrosis markers, some electrolytes, and cardiac tissue antioxidants in myocardial necrosis induced experimentally in rats by subcutaneous injection of isoproterenol (ISO).
Results
ISO-induced myocardial infarction in male rats resulted in a significant increase in creatine kinase, creatine kinase MB, lactate dehydrogenase, aspartate aminotransferase, glucose, potassium, and phosphorus in serum, in addition to a significant increase in glucose-6-phosphate dehydrogenase in red blood cells. In addition, it resulted in a significant decrease in serum calcium and sodium in serum. Furthermore, this study demonstrated that there was a significant decrease in heart tissue superoxide dismutase and a significant decrease in catalase activity, as well as a significant increase in heart l-malondialdehyde levels, in ISO-injected rats.
Conclusion
This study shows that that olive leaves administration is effective against myocardial infarction and oxidative damage in heart tissue induced by ISO in rats.

Keywords:
cardiac necrosis markers, isoproterenol, olive leaves

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Introduction

Acute myocardial infarction (AMI) is the most common cause of death in the world. WHO estimated the incidence of AMI with about 1.5 million occurring per year, and 12.6% of death of AMIs worldwide and incidence of AMI increase with age and tend to be of male predominance; premenopausal women appear to be protected up to ~70 years, when the sexes converge to equal incidence. Elderly people tend to have higher rates of morbidity and mortality from their infarcts [1].

Myocardial infarction (MI) increases the generation of reactive oxygen species in ischemic tissue, bringing about oxidative damage of membrane lipids, proteins, carbohydrates, and DNA and changes in the mechanical, electrical, structural, and biochemical properties of the heart [2]; thus, a great deal of research is focused on the role of antioxidants in the prevention of many human diseases, particularly atherosclerosis, congestive heart failure, and myocardial ischemia–reperfusion injury restoration of the flow of blood to a previously ischemic tissue or organ [3,4].

Isoproterenol (ISO) is a synthetic adrenergic agonist that causes severe stress in the myocardium, resulting in infarct such as necrosis of the heart muscle [5]. Isoproterenol, L-B-(3,4 dihydroxy) phenyl-isopropylamino ethanol hydrochloride, an adrenergic agonist, has been reported to exhibit many metabolic and morphological aberrations in heart tissue of experimental animals [6]. Experimental and clinical studies on heart failure have shown that there is increased generation of reactive oxygen species such as superoxide anion ($O_2^{\bullet-}$) and hydroxyl radical ($OH^{\bullet}$), which are involved in the formation of lipid peroxide, cell membrane damage, and destruction of antioxidative defense system [7].

In rats, the administration of purified oleuropein from olive leaves is able to reduce the oxidative damage caused by ethanol in the liver, and it suppresses oxidative stress as monitored by the elevation activity of the main antiperoxidative enzyme, catalase (CAT), and decreases lipid peroxidation products in the rat liver [8]. In addition, polyphenols present in olive oil, such as oleuropein, hydroxytyrosol, tyrosol, and caffeic acid, have an important antioxidant and anti-inflammatory effect [9].

Olive leaves also improved insulin resistance, increased the release of triglycerides (TG) from the liver, and decreased the flux of free fatty acids (FFAs) from

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peripheral adipose tissue back to the liver [10]. Therefore, we aimed in this work to evaluate the protective effect of olive leaves administration on cardiac necrosis markers, some electrolytes, and cardiac tissue antioxidants in myocardial necrosis induced experimentally in rats by subcutaneous injection of ISO.

Materials and methods

A total of 120 male albino rats aged 12–16 weeks, weighing 180–220 g, were used in the experimental investigation of this study. Induction of myocardial necrosis was done by ISO solution injected subcutaneously at a dose of 20 mg/kg body weight in 1 ml of saline subcutaneously twice for 2 consecutive days at an interval of 24 h to induce acute myocardial necrosis and at a dose of 5 mg/kg body weight weekly for induction of chronic myocardial necrosis [11]. This study was approved by local ethical committee on experimental animals.

Medicinal plant

Olive leaves powder was prepared as follows: after gathering the olive leaves from some regions of Borg El-Arab (Egypt), the leaves were washed with distilled water and dried. The leaves were then powdered and passed through a mesh to increase their contact with powdered ration.

Experimental design

Rats were allocated into four groups as follows:

First group (group I), control group (negative control): This group consists of 30 rats that were fed the tabulated ordinary rat ration through the whole time of the experiment.

Second group (group II), isoproterenol group (ISO) (chronic heart necrotic group): This group comprised 30 rats that were fed the tabulated ordinary rat ration and injected subcutaneously with isoproterenol at a dose of 5 mg/kg body weight in 1 ml of saline, S.C., weekly for 8 weeks.

Third group (group III), treated group: This group comprised 30 rats that were kept on powdered olive leaves through the whole time of the experiment and injected subcutaneously with ISO at a dose of 5 mg/kg body weight in 1 ml of saline, subcutaneously, weekly for 8 weeks.

Fourth group (group IV), olive leaves group (positive control): This group comprised 30 rats reared on powdered olive leaves through the whole time of the experiment.

Samples

Blood samples were collected after overnight fasting from the retro-orbital venous plexus located at the medial canthus of the eye using capillary tubes three times at the third, sixth, and ninth week after the eighth injection and 10 rats were killed from each group at the time of blood sampling.

Blood samples were divided into two parts

(1) Serum samples were separated by centrifugation at 3000 rpm for 15 min. The clear serum was received in dry sterile tubes and used directly for determination of the following biochemical parameters:
   (a) Creatine kinase (CK) [12], creatine kinase MB (CK-MB) [13], lactate dehydrogenase (LDH) [14], aspartate aminotransferase (AST) [15], total protein [16], albumin (Alb) [17], glucose [18], calcium (Ca) [19], sodium (Na) [20], potassium (K) [21], and phosphorus (P) [22].
(2) Heparinized tubes for whole blood were collected for the determination of glucose-6-phosphate dehydrogenase (G-6-PD) [23].

Tissue samples

Ten rats from all groups at the third, sixth, and ninth week after the eighth injection were killed and heart samples were collected from all groups for determination of antioxidant enzymes such as CAT [24], superoxide dismutase (SOD) [25], and l-malondialdehyde (l-MDA) [26].

Preparation of heart tissue

Heart samples were collected with blood samples. Immediately after killing the animals by decapitation, the heart was removed by dissection.

(1) Heart tissue was washed with a PBS solution, pH 7.4, containing 0.016 mg/ml heparin to remove any red blood cells and clots.
(2) About 0.05 g of heart was homogenized in 5 ml of 10% (w/v) cold PBS (i.e. 50 mmol/l potassium phosphate, pH 7.5, 0.1 mmol/l EDTA) per gram tissue, using a tissue homogenizer.
(3) The mixture was centrifuged at 4000 rpm for 20 min at 4°C, and the resulting supernatant was assayed for the following:
   (a) CAT activity.
   (b) SOD activity.
   (c) l-MDA concentration at liver, kidney, and brain.

Statistical analysis

The statistical analysis was carried out using analysis of variance with two factors under significance level of 0.05 for the whole results using SPSS (version 19) (International Business Machines Corp., New York, USA). Data were treated as complete randomized design according to procedures of statistics [27].

Results

The presented data revealed that MI caused by ISO is accompanied by a significant ($P<0.05$) increase in serum CK at the third and sixth week; AST at all periods; and in serum CK-MB, K, and Ph at the sixth and ninth week of injection in the ISO group. Serum LDH showed a significant ($P<0.05$) increase at all periods, but CK showed a significant increase at the ninth week only in the ISO group. However, a significant increase ($P<0.05$) was seen in serum glucose and glucose-6-phosphate at all periods. However, serum CK-MB, K, and Ph showed a significant increase ($P<0.05$) at the third week only, whereas serum Ca showed a significant decrease ($P<0.05$) at all periods in the ISO group and Na showed a significant decrease at the third, sixth, and ninth week in the ISO group. Serum total protein and albumin instead showed a significant decrease at the ninth week only in the ISO group.

Heart tissue SOD showed a significant decrease ($P<0.05$) at all periods in the ISO group, whereas cardiac muscle CAT showed a significant decrease ($P<0.05$) at all periods in the ISO group. Cardiac muscle MDA instead showed a significant increase ($P<0.05$) at all periods in the ISO group.

There was a significant increase ($P<0.05$) in the treated group serum AST at the third week and treated group serum CK at the sixth week, whereas there was a significant increase in the treated group serum CK at the third and ninth week, serum CK-MB treated group at the third and sixth week, and treated group serum LDH at the third and sixth week. The treated group serum glucose showed a significant increase ($P<0.05$) at the sixth and ninth week in comparison with the control group but lower than the ISO group.

The serum total protein showed a significant increase ($P<0.05$) at the ninth week in the olive leaves (+ control group). In addition, serum albumin showed a significant increase ($P<0.05$) at all periods in the olive leaves (+ control group).

Discussion

AMI, commonly known as heart attack, is a disease that occurs when the blood supply to a part of the heart is interrupted, causing death of the heart tissue. It means necrosis of a region of myocardium, caused by an interruption in the supply of blood to the heart usually as a result of occlusion of a coronary artery [27].

The medicinal use of olive leaves, fruit, and oil dates back to ancient times. In recent years, olive leaf has become extremely popular for its wide array of health benefits. Scientific studies have shown that olive leaf extract is valuable for maintaining cardiovascular health, joint health, fighting infections, boosting antioxidant status, and supporting general well-being [5].

ISO [1-(3, 4-dihydroxyphenyl)-2-isopropylamino ethanolhydro-chloride] is a synthetic catecholamine and β-adrenergic agonist that induces severe stress in the cardiac muscle leading to development of MI [28]. The MI is produced because of its action on the cardiac β1 receptors [29].

Data obtained in Table 1 showed a significant decrease in serum CK, CK-MB, and LDH in treated or olive leaves group after olive leaves administration to rat. This increase is much less than the ISO group. The obtained results are in agreement with previous results or studies [9].

This decrease compared with the ISO group suggests that olive leaves may likely have cardioprotective compounds; hence, cardiac markers showed lower levels than the ISO group, which strongly indicates cardiac protection of olive leaves and prevention against damage to cardiac muscle [30].

The data presented in Table 1 also recorded a significant increase in the activity of serum AST activity in ISO and at the third week of the treated groups with olive leaves administration, indicating that ISO has a toxic effect on the liver [31].

Data represented in Table 1 revealed a significant increase in the activity of serum cardiac biomarkers (CK, CK-MB, LDH, and AST) in ISO-injected rats when compared with normal control group. This may be because of the generation of free radicals by ISO that initiate lipid peroxidation of the membrane polyunsaturated fatty acids, leading to impairment of the membrane structural and functional integrity. As the myocardium contains an abundant concentration of many enzymes, once it is metabolically damaged it releases its content into extracellular fluid [32].

Data represented in Table 2 showed a significant decrease in serum glucose after olive leaves administration to ISO administrated rat, and this may be because of the hypoglycemic effect of olive leaves [33].

The hypoglycemic effect of olive leaves may be because of stimulating glycogenesis or enhancing glucose utilization by inhibition of glucose absorption from the intestine [34].

Table 1 The mean values of serum CK (U/l), CK-MB (U/l), LDH (U/l) and AST (U/l) in ISO and OL administrated group (treated) compared with control groups

Test	Group	Periods		
		3rd week	6th week	9th week
CK	Control (–)	149.30±10.40	160.81±11.79	169.31±11.18
	ISO	611.70±18.83*	792.83±20.15*	1128.78±22.15*
	Treated	482.81±23.81*	509.75±20.11*	458.01±17.31*
	Olive leaves control (+)	145.83±16.51	152.85±8.01	160.15±10.31
CK-MB	Control (–)	216.60±7.10	223.70±8.99	232.81±9.15
	ISO	489.81±14.12*	677.83±20.83*	808.79±23.58*
	Treated	431.38±12.11*	410.58±16.03*	321.83±11.83
	Olive leaves control (+)	218.15±6.66	229.83±10.51	231.75±8.87
LDH	Control (–)	498.81±16.15	483±15.39	519.83±11.75
	ISO	1381.89±52.31*	1587.83±38.88*	2243.39±51.32*
	Treated	821.70±11.53*	772.83±19.77*	683.15±18.75
	Olive leaves control (+)	501.83±8.31	500.70±8.83	511.81±10.51
AST	Control (–)	107.83±6.67	115.11±8.11	109.82±7.30
	ISO	291.81±7.51*	315.11±9.70*	378.81±10.57
	Treated	242.56±8.31*	151.36±8.89	131.75±7.77
	Olive leaves control (+)	109.81±4.62	117.7±3.70	125.81±5.33

AST, aspartate aminotransferase; CK, creatine kinase; CK-MB, creatine kinase MB; ISO, isoproterenol; LDH, lactate dehydrogenase; OL, olive leaves. *Significant at $P<0.05$.

Table 2 The mean values of serum glucose level (mg/dl), erythrocytes (G-6-PD) (U/1012RBCs), serum calcium level (mg/dl) and serum sodium (mEq/l) in ISO and OL administrated group (treated) compared with control groups

Test	Group	Periods		
		3rd week	6th week	9th week
Glucose	Control (–)	82.31±2.51	89.51±2.31	83.81±2.30
	ISO	129.81±3.61*	159.87±5.11*	178.75±5.82*
	Treated	91.77±2.38	119.81±3.75*	131.83±4.91*
	Olive leaves control (+)	83.81±2.01	95.18±3.11	89.81±5.30
Erythrocytes (G-6-PD)	Control (–)	7.01±0.39	6.56±0.44	6.89±0.38
	ISO	10.12±1.51*	11.99±0.75*	14.75±1.01*
	Treated	8.15±0.38	8.11±0.62	8.75±0.54
	Olive leaves control (+)	7.25±0.73	6.99±0.87	6.98±0.89
Calcium	Control (–)	8.71±0.38	8.68±0.42	8.79±0.51
	ISO	7.05±0.61*	6.71±0.62*	6.15±1.02*
	Treated	8.01±0.36	8.01±0.45	8.90±0.62
	Olive leaves control (+)	8.26±0.39	8.75±1.20	8.51±1.13
Sodium	Control (–)	151.53±3.11	159.81±3.70	161.82±4.11
	ISO	101.35±4.75*	91.18±5.70*	109.81±6.82*
	Treated	139.82±3.75	124.81±4.17	128.11±3.35
	Olive leaves control (+)	147.1±5.90	159.75±4.75	151.81±5.11

G-6-PD, glucose-6-phosphate dehydrogenase; ISO, isoproterenol; OL, olive leaves. *Significant at $P<0.05$.

In addition, the data represented in Table 2 showed no significant increase in G-6-PD in the treated group when compared with the control group after olive leaves administration to normal rat, and this might be because olive leaves depressed the activities of lipogenic and cholesterogenic enzymes such as malic enzyme, fatty acid synthase, G-6-PD, and 3-hydroxy-3-methyl-glutryl coenzyme A reductase [35,36].

However, the data obtained in Table 2 showed a significant increase in G-6-PD in ISO groups when compared with the control group, and this may be because of the development and progression of heart failure [36] as the increased activity of G-6-PD may increase the rate of synthesis of NADP, thereby increasing lipid, cholesterol biosynthesis, and lipid peroxidation [37].

Data represented in Tables 2 and 3 showed a significant increase in serum K and P and a significant decrease in serum Ca and Na in the ISO group, whereas in the treated group no significant increase in serum K and P and no significant decrease in serum Ca and Na was found.

The results are similar to those of Poudyal *et al.* [38], who stated that the absorbed dietary calcium is usually

Table 3 The mean value of serum potassium level (mEq/l), serum phosphorus level (mg/dl), heart tissue SOD (U/g tissues) and cardiac, muscle CAT (mmol/g tissue) in ISO and OL administrated group (treated) compared with control groups

Test	Group	Periods		
		3rd week	6th week	9th week
Potassium	Control (–)	2.94±0.11	2.98±0.21	3.01±0.30
	ISO	5.01±0.25*	5.93±0.51*	6.59±0.78*
	Treated	3.15±0.70	4.01±0.53	3.87±0.51
	Olive leaves control (+)	2.85±0.42	2.88±0.78	2.97±0.91
Phosphorus	Control (–)	4.11±0.21	4.22±0.17	4.29±0.33
	ISO	6.98±0.87*	8.79±1.11*	8.88±1.21*
	Treated	4.81±0.39	4.91±0.81	4.85±0.91
	Olive leaves control (+)	4.15±0.41	3.99±1.01	4.18±1.12
Heat tissue SOD	Control (–)	54.31±2.35	50.75±3.11	58.75±1.97
	ISO	30.75±2.22*	26.15±3.01*	20.10±1.98*
	Treated	45.61±3.15	41.31±2.77	40.11±3.03
	Olive leaves control (+)	52.63±2.54	53.71±2.23	51.91±2.01
Cardiac muscle CAT	Control (–)	61.75±4.44	65.31±3.51	59.88±3.16
	ISO	28.81±2.11*	23.81±3.51*	18.75±2.11*
	Treated	48.11±3.45	54.27±3.75	39.21±2.75
	Olive leaves control (+)	60.15±3.33	62.81±2.75	57.26±3.01

CAT, catalase; ISO, isoproterenol; OL, olive leaves; SOD, superoxide dismutase. *Significant at $P<0.05$.

filtered in the kidney (98–99%) and reabsorbed from renal tubules into the blood; it appears that its decrease in serum probably resulted from either poor intestinal absorption or decreased renal reabsorption. Another possible mechanism for this observation could be a humeral effect of olive leaves on the calcium metabolic hormones such as parathormone, 1, 25-dihydroxy cholecalciferol, and calcitonin. These remain a subject for further investigation.

Mineral bioavailability could be influenced by several factors in the diet such as inhibitors and promoters in meal and diet composition [39].

These results are in agreement with those of Tuck *et al.* [40], who stated that olive leaves significantly reduced serum sodium and that it probably resulted from a decrease in renal reabsorption of sodium with consequent excretion of sodium in urine. Increased excretion of sodium is usually associated with excess water loss as uremia. Physiologically, this is usually compensated for by excess secretion of aldosterone with resultant increase in sodium reabsorption particularly at the distal convoluted tubule and the collecting duct, leading to water retention to compensate the effects of excess water loss following loss of sodium.

Furthermore, a marked decrease in serum sodium concentration was observed by Scheffler *et al.* [41], who attributed it to a change in glomerular filtration rate and/or renal blood flow or interference with aldosterone secretion and/or action on the distal tubules or interference with adrenergic sodium handling. The ISO might have caused renal disease. These results are in agreement with those of Smith *et al.* [42], who suggested that the rise in the concentration of potassium might be because of renal disease that largely affected the renal medulla.

Furthermore, the nonsignificant slightly increased K level in the treated group, which is lower than the ISO group, suggested mild hypokalemic effects, and this may be because of an improvement in renal function by increasing potassium reabsorption. In addition, the reason for olive leaves to increase serum levels of potassium and phosphorus nonsignificantly in comparison with the control group may be because olive leaves increase mineral absorption [43].

In addition, the data represented in Table 3 showed an increase in tissue SOD and CAT activities in the treated group after olive leaves administration to rats when compared with the ISO group, which showed a significant decrease in SOD and a significant decrease in CAT when compared with the control group, and this may be because of the antioxidant activity of olive oil and leaves to scavenge reactive oxygen species and to enhance the cellular antioxidant enzymes SOD and CAT in cells [44].

The obtained data in Table 3 recorded a significant decrease in tissue SOD and CAT in the ISO group when compared with control rats, and this may be because ISO produce quinones that react with oxygen to generate superoxide anions ($O_{2^-}^{\bullet}$ and H_2O_2), which have damaging effects in cells [45].

Superoxide radicals generated at the site of damage in MI modulates SOD and CAT, resulting in the lowered activities of these enzymes and accumulation of superoxide anion, which also damages the myocardium [11].

Data represented in Table 4 showed a decrease in tissue MDA (one of the end products of lipid peroxidation processes) after olive leaves administration in the treated group in comparison with the ISO group. The results agreed with those of Visioli *et al.* [46], who reported that olive oil and leaves have antioxidant properties, which could have inhibited lipoxygenase enzymes and could have increased the antioxidant capacity.

Lipid peroxides decreased significantly in tissue after olive leaves treatment. Treatment of rats with the antioxidant olive oil and leaves controlled lipid peroxidation [47].

In addition, data represented in Table 4 showed a significant increase in tissue MDA in the ISO group when compared with the control group; this may be because of excessive formation of free radicals by auto-oxidation of ISO and activation of the lipid peroxidative process, resulting in an irreversible damage to the heart in animals subjected to ISO stress [48].

In this study, data represented in Table 4 showed decreased levels of serum total proteins in ISO-induced rats with a significant decrease at the ninth week. A decrease in serum total proteins could be because of increased free-radical production by the administration of ISO [49].

Data represented in Table 4 showed a significant decrease of serum albumin in the ISO group at the ninth week. Low albumin and total protein concentrations may result from a number of oxidative processes, such as changes in vascular permeability, secondary to vascular injuries, or may be a marker of increased oxidation of lipoproteins [50].

Olive oil and leaves are potent antioxidants that protect against oxidative modifications. A decrease in the levels of total proteins and A/G ratio could be because of increased free-radical production by ISO [51]. Olive leaves increase the levels of total proteins and albumin in serum.

The serum total protein fraction and A/G ratio was found to be significantly reduced in isoproterenol myocardial infracted rats when compared with control rats. The electrophoresis technique for separation of serum total protein levels was reported in isoproterenol-induced myocardial infracted rats, a decrease in albumin or sometimes γ-globulin [52].

Data represented in Table 4 showed a significant increase in serum total protein at the ninth week in the olive leaves group, and also the data represented in Table 4 showed a significant increase in olive leaves group at all periods of serum albumin.

Olive leaves supplementation increased the total serum proteins and this was characterized by a relative increase in albumin level. This increase in total proteins with relative increase in albumin levels alludes to the hepatoprotective effect of olive oil and leaves as reported earlier [53]. In their studies, lead treatment with a sativum significantly reduced the activities of amino ALT, AST, and ALP. They showed that hepatoprotective activity of olive oil and leaves lies in the ability to decrease the production of ALT, AST, and ALP, thus giving evidence of no leak

Table 4 The mean value of cardiac muscles l-MDA (mmol/g tissues), serum total protein (g/dl) and serum albumin (g/dl) in ISO and OL administrated group (treated) compared with control groups

Test	Group	Periods		
		3rd week	6th week	9th week
Cardiac muscle MDA	Control (–)	0.77±0.03	0.83±0.11	0.89±0.12
	ISO	2.85±0.13*	3.11±0.25*	4.54±0.39*
	Treated	0.88±0.05	0.79±0.03	0.91±0.12
	Olive leaves control (+)	0.78±0.36	0.85±0.31	0.97±0.35
Serum total protein	Control (–)	6.86±0.43	6.95±0.79	7.11±0.58
	ISO	5.98±0.75	5.72±0.79	5.28±0.67*
	Treated	6.87±0.70	6.90±1.01	6.93±0.93
	Olive leaves control (+)	6.99±0.88	7.58±0.93	8.49±0.97*
Serum albumin	Control (–)	4.23±0.52	4.42±0.66	4.51±0.51
	ISO	4.29±0.79	4.51±0.82	3.85±0.78*
	Treated	4.19±0.31	4.33±0.49	4.44±0.81
	Olive leaves control (+)	5.11±0.72*	5.63±0.86*	5.09±0.92*

ISO, isoproterenol; l-MDA, l-malondialdehyde; OL, olive leaves. *Significant at $P<0.05$.

of these biomarkers into the blood. Supplementation of sodium nitrite ($NaNO_2$) in toxicated rats with olive oil and leaves ameliorated the nitrite adverse effects, as evidenced by a significant increase in serum total protein content [54].

Decreased levels of serum total proteins and A/G ratio were observed in ISO-induced rats. A decrease in serum total proteins and A/G could be because of increased free-radical production by the administration of ISO. Pretreatment with olive leaves significantly increased the levels of serum total proteins and A/G ratio. This could be because of the ability of olive oil and leaves to scavenge free radicals and inhibit lipid peroxidation [55].

A significant increase in serum total proteins and albumin was observed in rats administered olive leaves, which indicates its ability to stimulate the regeneration of hepatic tissue and increases protein synthesis in damaged liver and improves the functional status of the liver cells. It has antioxidant effects; it can reduce toxicity associated with free radical damage and play a role in improving host immunity and normalizing the oxygen utilization in cells. In addition, it has been found to inhibit lipid peroxidation, which is considered one of the main features of aging in liver cells [56,57].

The findings of the present study demonstrated that olive leaves administration is effective against MI and oxidative damage in heart tissue induced by ISO in rats, as olive leaves were able to ameliorate serum biochemical parameters and enzymatic antioxidant defense system, and to prevent lipid peroxidation in heart tissue. These results may contribute to a better understanding of the heart treatment and protective roles of olive leaves, emphasizing its influence for preventing cardiovascular complications.

Conclusion

The findings of the present study demonstrated that olive leaves administration is effective against MI and oxidative damage in heart tissue induced by ISO in rats, as olive leaves were able to ameliorate serum biochemical parameters and enzymatic antioxidant defense system and to prevent lipid peroxidation in heart tissue. These results may contribute to a better understanding of the heart treatment and protective roles of olive leaves, emphasizing its influence for preventing cardiovascular complications.

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Conflicts of interest
There are no conflicts of interest.

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