

## Original Research Article

# Antioxidant activity of *Ipomoea biloba* in Isoproterenol Induced Myocardial Infarction male albino Rats

The goal of this study was to see if ethanolic leaf extract of *Ipomoea Biloba* could protect Albino rats from Isoproterenol-induced cardiotoxicity by measuring enzymatic and non-enzymatic antioxidant activity. The rats were split into five groups, each with six rodents. Group I rats were Served as a normal control; Group II rats were given isoproterenol alone; Group III and IV rats were given ethanolic extract and ISO; and Group V rats were given ethanolic extract alone. After the completion of experimental period, the levels of superoxide radical, Catalase (CAT), Glutathione Peroxidase (GPx), Glutathione-S-transferase (GST), Reduced Glutathione (GSH), Calcium dependent Adenosine Triphosphatase ( $\text{Ca}^{2+}$ -ATPase), Magnesium dependent ATPase ( $\text{Mg}^{2+}$ -ATPase), Vitamin C and Vitamin E. In comparison with isoproterenol control rats in MI treated rats, *Ipomoea biloba* increases the activities of SOD (45%), GPX (70%) CAT (30%) and pretreatment with *Ipomoea biloba* boosted the activity of  $\text{Na}^+/\text{K}^+$  ATPase while decreasing the activities of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ATPase. Finally, the innovative findings of this study demonstrated that an ethanolic extract of *Ipomoea biloba* leaves provided significant cardiac protection against ISO-induced myocardial infarction in experimental mice. In both plasma and cardiac tissue, the ethanol extract treatment significantly inhibited enzymatic and non-enzymatic antioxidation activity.

**Key words:** Antioxidant, Isoproterenol, Myocardial infarction, *Ipomoea biloba*

## Introduction

Antioxidants are substances that prevent oxidation, a chemical reaction that can produce free radicals and chain reactions that can damage an entity's cells. Antioxidants like thiols and ascorbic acid can stop these processes from happening. Plants and mammals maintain sophisticated systems of releasing antioxidants, such as glutathione, to balance oxidative stress. (Dabelstein *et al.*, 2007).

Many foods, particularly fruits and vegetables, are high in antioxidants, which help to counteract the detrimental effects of oxidation on cells throughout the body (Tracey Roizman

2018). Antioxidant substances reduce reactive oxygen species (ROS), which causes free radicals to decay. When the ROS benefit is questioned, there is a greater vulnerability to atopic or disease consequences due to disruption to the Thymus-1 immune response chain's attack-kill-present-respond activity. Free radicals are unbalanced molecules that form as consequences of the conversion of food into energy in your body. They also release when you are exposed to pollutants in the environment. By altering the structure of biological DNA, free radicals can cause harm. They can also harm cellular membranes, altering their appearance and threatening cell survival. Free radical damage could speed up the ageing process and raise the risk of heart disease, cancer, and other disorders. Antioxidants help free radicals by altering their chemical structure and converting them to harmless molecules (Kandhan *et al.*2017,). Excessive antioxidant consumption may consequently result in antioxidative stress, in which antioxidants may reduce or stop adaptive stress responses, resulting in severe health conditions and injury (Poljsak, & Milisav 2012).

Antioxidative stress occurs when the immune system's ability to balance pathogenic threats is hampered by an overabundance of bioactive antioxidant molecules. The primary contrast is oxidative stress, which can result in diseases like acute myocardial infarction or cancer (Valko,*et al.*2006,). Among other disorders, oxidative stress is a major active factor in the onset and progression of cancer, diabetes mellitus, cardiovascular diseases, neurodegenerative diseases, and inflammatory diseases (Arika *et al*, 2019). Hence this present investigation was aimed to investigate the Antioxidant activity against ethanolic leaf extract of *Ipomoea biloba* leaves against the ISO induced myocardial infarction in rats.

## **MATERIALS AND METHODS**

### **Chemicals and reagents**

Isoproterenol was acquired from the Sigma Aldrich (USA). All other additional chemicals and reagents were used in the analytical grade and the same was purchased from the Himedia chemicals, USA.

### **Collection of plant**

The fresh and matured leaves of *Ipomoea biloba* were collected from Kolli Hills, Namakkal district, Tamil Nadu coastal area. Then the collected leaves were washed completely with distilled water and the same was processed and dehydrated under the shady cabin.

### **Preparation of plant material**

The shade dried plant leaves were powdered with an electrical blender and then the 10gm of *Ipomoea biloba* leaf powder was mixed with 100 ml of ethanol. Then it was heat macerated at the 85°C for 30 minutes and then the suspension was filtered by using the Whatman filter paper. Then the resulted plant extract was powdered by vacuum evaporation process and finally the powder was used for the further investigations.

### **Experimental animals**

The adult male Wistar albino rats were used for the study and the same was collected from the Institutional animal house. All the experimental animals were maintained under the standard laboratory conditions. All experimental animals were acclimatized for 7 days in prior to the starting of experiments and during that period animals were fed with standard pelleted rat chow and water ad libitum.

### **Experimental design**

The rats were divided into five groups of six animals each.

**Group I:** Served as a normal control.

**Group II:** Rats were administered isoproterenol (20mg/kg) by the subcutaneous injection to induce the myocardial infarction.

**Group III and IV:** Rats were pretreated with the ethanolic extract of *Ipomoea biloba* leaf extract (100 and 200mg/kg, respectively) for a period of 28 days subsequently to the subcutaneous injection of isoproterenol (20mg/kg, b.w) for 2 consecutive days.

**Group V:** Rats were received the ethanolic extract of *Ipomoea biloba* (200mg/kg b.w) alone for 28 days without any experimental treatments.

After the experimental period, blood and heart tissue samples were collected and serum was separated and used for estimation of Superoxide Dismutase (SOD), Catalase (CAT),

Glutathione Peroxidase (GPx), Glutathione-S-transferase (GST), Reduced Glutathione (GSH), Calcium dependent Adenosine Triphosphatase (Ca<sup>2+</sup>-ATPase), Magnesium dependent ATPase (Mg<sup>2+</sup>-ATPase), Vitamin C and Vitamin E.

### **Preparation of heart tissue homogenate**

After the completion of experiments, all the experimental animals were anesthetized by chloroform administration and sacrificed by cervical decapitation. After the animal scarification, the heart tissues were excised washed thoroughly in ice-cold phosphate buffered saline to remove the excess blood. Ten percent of homogenate was prepared in 0.1M Tris HCl buffer (pH-7.4). Then the homogenate was centrifuged at 6000 rpm for 20 min at 4°C and the supernatant was used for the further biochemical assays.

### **Determination of Antioxidant activities**

The level of antioxidant activities of plasma and heart tissue were estimated by following methods superoxide dismutase enzyme Das et al., 2000, catalase enzyme by the method of Sinha, (1972), glutathione level in the heart cell lysate was assayed Glutathione peroxidase activity was estimated by the method of Ellman, 1959, Glutathione-s-transferase activity was estimated by method of Habig *et al.*, 1973, Reduced Glutathione (GSH) was estimated by the method of Beutler, 1984, activity of cytochrome C-oxidase was assayed by the method of Pearl *et al.*, (1963). ascorbic acid were estimated by the method of Omaye *et al.*, (1979) and vitamin E were estimated by the methods of Varley et al., 1981.

### **Statistical analysis**

Statistical analysis all conclusions happen to be demonstrated as Mean  $\pm$  SD. in each group for six animals. All the compiled data were statistically examined utilizing SPSS10 software. Theory Hypothesis test approaches included one-way variance analysis (ANOVA) followed by the least significant difference (LSD) test. The significance level at alpha=0.05 was considered to statistical significance.

### **Results**

Levels of enzymatic antioxidants in the plasma of control and experimental animals are shown in Table 1. SOD, catalase, Glutathione Peroxidase (GPx), Glutathione-S-transferase

(GST), Reduced Glutathione (GSH) activities were significantly lowered due to the myocardial infarction in Group II rats. *Ipomoea biloba* administration successfully prevented the decrease in the activities of these enzymes in Group III & IV animals.

ISO-induced myocardial necrosis produced a significant depletion in activities of antioxidant enzyme such as SOD, GPx and GR compared to normal animals. *Ipomoea biloba* 200mg/kg treatment to myocardial necrotic rats significantly restored the activities of CAT, GPx and GR. *Ipomoea biloba* 100mg/kg, however, could only restore the ISO depilated activities of CAT and GPx significantly.

*Ipomoea biloba* 100mg/kg and *Ipomoea biloba* 200mg/kg treatments to ISO intoxication rats augmented the SOD levels decreased by ISO but not to a significant extent.

**Table 1 Levels of enzymatic antioxidants in ISO induced rats against *Ipomoea biloba* leaf extract**

<b>GROUPS</b>	<b>Group I – Control</b>	<b>Group II - ISO induced</b>	<b>Group III - ISO + EEIB (100 mg/kg b.wt)</b>	<b>Group IV - ISO + EEIB (200 mg/kg b.wt)</b>	<b>Group V - EEIB (200 mg/kg b.wt)</b>
<b>SOD</b>	115.13±8.95	63.58±5.21	102.67±7.17	110.84±8.18	112.55±7.08
<b>CAT</b>	7.83±1.68	2.33±0.93	6.95±0.32	7.12±1.97	7.76±1.64
<b>GPx</b>	42.31±3.69	22.57±3.04	32.55±4.12	39.44±3.97	40.12±4.01
<b>GST</b>	12.27±0.08	8.43±0.17	10.79±1.03	10.42±0.04	12.18±1.02

*ISO- Isoproterenol, EEIB- Ipomoea biloba leaf extract*

SOD: Superoxide dismutase (*Inhibition of 50% nitrite formation/min/mg protein*), CAT: Catalase (*micromoles of H<sub>2</sub>O<sub>2</sub> decomposed/min/mg protein*), GPx: Glutathione peroxidase (*micromoles of glutathione consumed/min/mg protein*), GST: Glutathione-S-Transferase (*1 μM of CDNB conjugate formed/min/mg protein*)

**Figure 1. Levels of enzymatic antioxidants in ISO induced rats against *Ipomoea biloba* leaf extract**

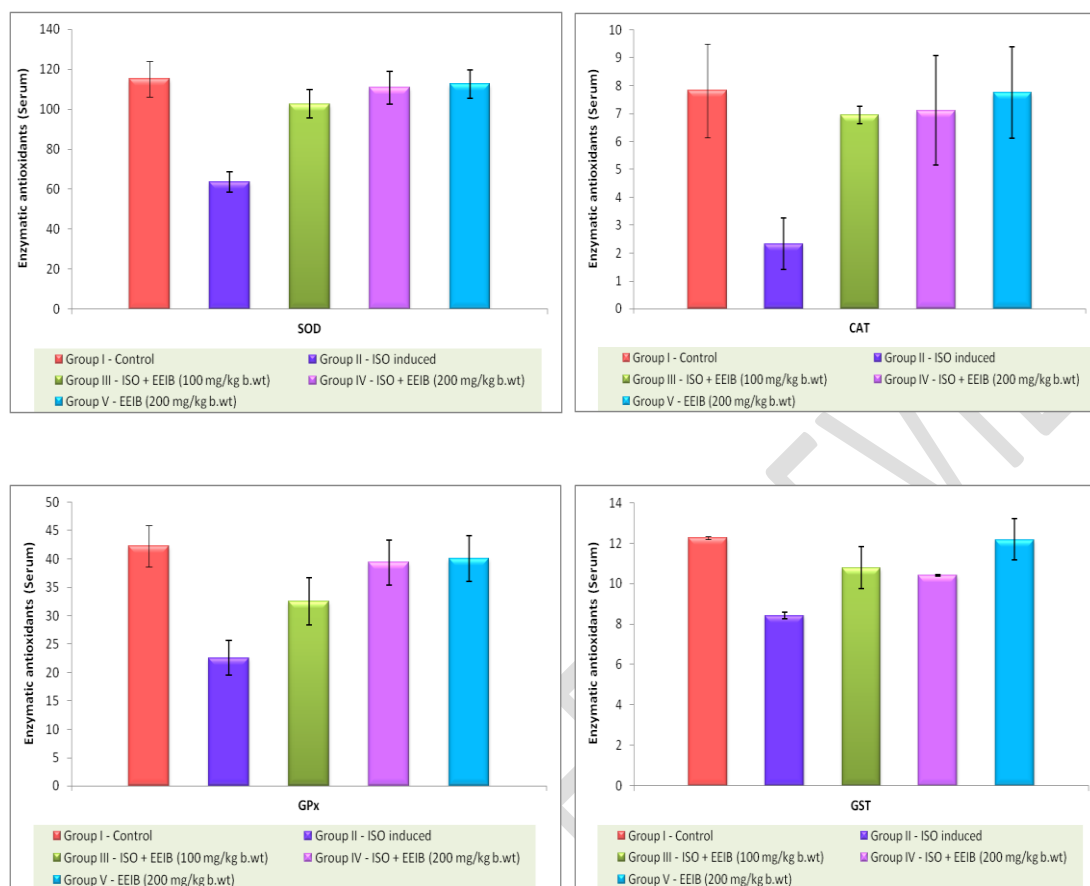


Table 2 show that significant decline in myocardial GSH was observed in ISO control group as compared to the normal group. *Ipomoea biloba* 100mg/kg significantly prevent the ISO – induced decline. *Ipomoea biloba* 100mg/kg also insignificantly elevated the decreased GSH levels.

Isoproterenol administered rats (Group II) showed a significant decrease in reduced glutathione,  $\alpha$ -tocopherol and ascorbic acid levels when compared with control rats (Group I). In *Ipomoea biloba* pretreated and isoproterenol administered animals (Group III & IV), these levels were significantly increased when compared to Group II animals. Group III animals had significantly elevated reduced glutathione,  $\alpha$ -tocopherol and ascorbic acid when compared with Group II animals. Group IV animals had significantly elevated reduced glutathione,  $\alpha$ -tocopherol and ascorbic acid when compared with Group II animals.

Oral feeding of *Ipomoea biloba* 100mg/kg as well as 200mg/kg to rats did not adversely affect the basal levels of GSH, CAT, GPx and GR, nor were they significantly elevated in comparison to the normal rats. However, *Ipomoea biloba per se* feeding to rats at both doses elevated GSH level higher than normal.

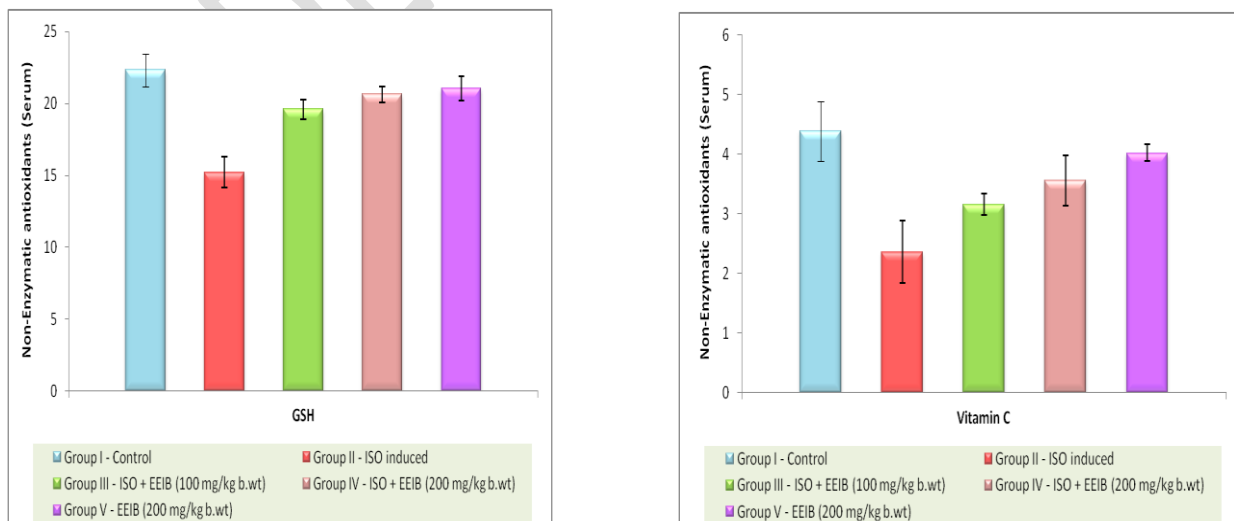
**Table 2 Levels of non-enzymatic antioxidants in ISO induced rats against *Ipomoea biloba* leaf extract**

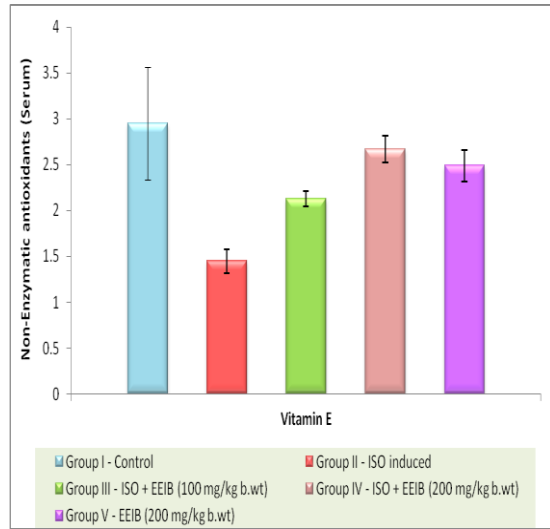
GROUPS	GSH		Vitamin C		Vitamin E	
	Serum	Tissue	Serum	Tissue	Serum	Tissue
Group I – Control	22.32±1.12	10.74±2.38	4.39±0.5	2.05±0.31	2.95±0.61	1.33±0.23
Group II - ISO induced	15.21±1.06	3.66±1.29	2.36±0.52	0.93±0.19	1.45±0.13	0.67±0.19
Group III - ISO + <i>EEIB</i> (100 mg/kg b.wt)	19.57±0.69	9.21±0.08	3.16±0.18	1.44±0.23	2.13±0.08	0.83±0.21
Group IV - ISO + <i>EEIB</i> (200 mg/kg b.wt)	20.63±0.57	9.72±1.95	3.56±0.42	1.81±0.25	2.67±0.15	0.98±0.25
Group V - <i>EEIB</i> (200 mg/kg b.wt)	21.06±0.86	10.23±0.31	4.02±0.14	1.92±0.33	2.49±0.17	1.06±0.18

ISO- Isoproterenol, *EEIB*- *Ipomoea biloba* leaf extract

GSH – The Reduced Form of Glutathione

**Figure 2. Levels of non-enzymatic antioxidants in ISO induced rats against *Ipomoea biloba* leaf extract**





**Table 3** The activity of membrane bound ATPases such as  $\text{Na}^+\text{K}^+\text{ATPase}$ ,  $\text{Mg}^{2+}\text{ATPase}$ ,  $\text{Ca}^{2+}\text{ATPase}$  were assayed in the heart homogenate of control and experimental animals

GROUPS	$\text{Na}^+\text{K}^+\text{ATPase}$	$\text{Ca}^{2+}\text{ATPase}$	$\text{Mg}^{2+}\text{ATPase}$
<b>Group I - Control</b>	0.58±0.07	0.73±0.08	0.53±0.04
<b>Group II - ISO induced</b>	0.23±0.05	1.93±0.06	0.98±0.11
<b>Group III - ISO + EEIB (100 mg/kg b.wt)</b>	0.38±0.06	1.74±0.09	0.73±0.14
<b>Group IV - ISO + EEIB (200 mg/kg b.wt)</b>	0.45±0.05	1.56±0.19	0.67±0.08
<b>Group V - EEIB (200 mg/kg b.wt)</b>	0.51±0.07	0.71±0.11	0.59±0.10

Values are expressed as mean ± SD of six animals.

ISO- Isoproterenol, EEIB- Ipomoea biloba leaf extract

$\text{Na}^+\text{K}^+\text{ATPase}$ : Sodium potassium-dependent ATPase;  $\text{Ca}^{2+}\text{ATPase}$ : Calcium-dependent ATPase;  $\text{Mg}^{2+}\text{ATPase}$ : Magnesium-dependent ATPase

Units :  $\mu\text{moles of Pi liberated/min./mg protein}$

**Figure-3** The activity of membrane bound ATPases such as  $\text{Na}^+\text{K}^+\text{ATPase}$ ,  $\text{Mg}^{2+}\text{ATPase}$ ,  $\text{Ca}^{2+}\text{ATPase}$  were assayed in the heart homogenate of control and experimental animals

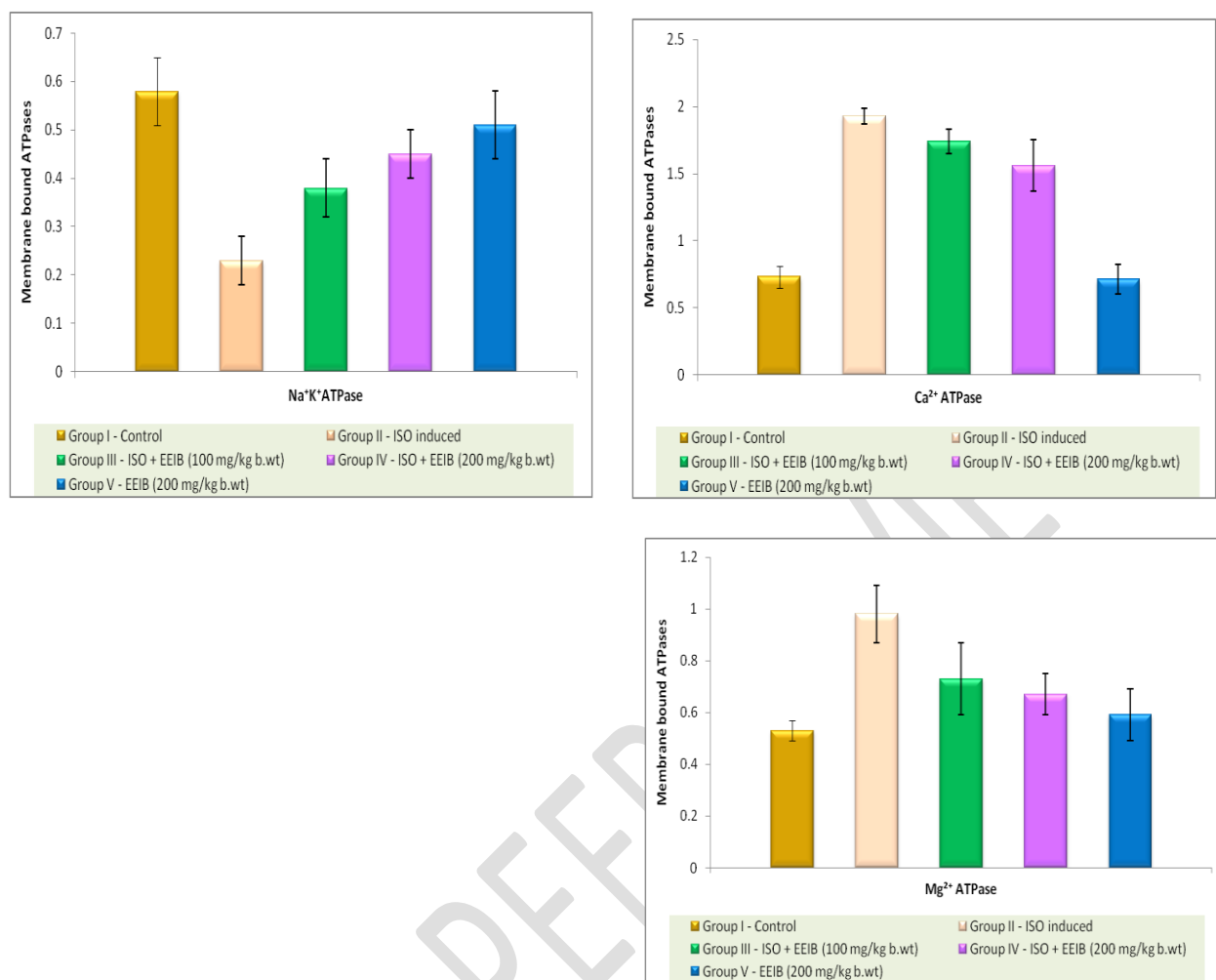


Figure 3 shows the activities of membrane bound enzymes (Na<sup>+</sup>/K<sup>+</sup> - ATPase, Ca<sup>2+</sup> and Mg<sup>2+</sup> -ATPases) in normal and ISO-induced rats. The activity of Na<sup>+</sup>/K<sup>+</sup> - ATPase was decreased significantly and the activities of Ca<sup>2+</sup> and Mg<sup>2+</sup> ATPase were increased significantly in the heart of ISO-induced rats when compared with normal control rats. Pretreatment with *Ipomoea biloba* to ISO-induced rats significantly decrease the activities of Ca<sup>2+</sup> and Mg<sup>2+</sup> ATPases in the heart when compared to ISO-alone induced control rats.

## Discussion

When animals are given high doses of ISO, a powerful synthetic catecholamine, the heart develops “infarct-like” lesions, similar to those found in acute myocardial infraction (AMI) and sudden death in humans (Anand *et al.*,2011).

Antioxidant enzymes (GPx & GST) activity is reduced by isoproterenol treatment (Table 1). Reduced availability of their substrate, GSH, which was depleted on isoproterenol, could explain the lower activity of GPx and GST in the isoproterenol intoxicated group. Treatment with *Ipomoea biloba* leaves raised GSH levels as well as GPx and GST activity in the heart. According to reports, higher GPx levels make the heart more resistant to myocardial infarction (Yoshida, 1996).

$\alpha$ -tocopherol is a chain-breaking antioxidant that sequesters free radicals. In the myocardial infarcted rats, a decrease in tissue-tocopherol should have resulted in increased lipid peroxidation, leading to heart injury. *Ipomoea biloba* leaves extract preserved  $\alpha$ -tocopherol levels in the rat heart and hence protected it from isoproterenol-induced injury (Table 2). Ascorbic acid is said to augment the antioxidant action of  $\alpha$ -tocopheryl radical to  $\alpha$ -tocopherol (Leung *et al.*, 1981). *Ipomoea biloba* leaves extract probably assisted the above process indirectly, since the flavonoids in it have an ascorbic acid-sparing property (Middleton, 1984).

Isoproterenol treatment resulted in a decrease in mitochondrial antioxidant levels (Table 2). GSH is a tripeptide that is essential for cell survival. GSH can protect cells from lipid peroxidation when used alone or in combination with other proteins (Tirmenstein and Reed, 1988). Mitochondrial GSH is important for sustaining cell viability because it regulates mitochondrial inner membrane permeability by keeping sulphhydryl groups in a decreased condition. GSH is drawn from the cytosolic pool and transported into the mitochondrial matrix (Fernandez – checa *et al.*, 1991). Glutathione biosynthesis enzymes are not found in mitochondria (Meister 1991). Mitochondria use a system that includes a high affinity transporter to transfer GSH from the cytoplasm (Martensson *et al.*, 1990).

Glutathione (GSH) and glutathione enzymes such as glutathione peroxidase, glutathione-S-transferase (GST), glutathione reductase, catalase, and superoxide dismutase (SOD) effectively scavenge harmful free radicals (Poliodoro *et al.*, 1984). The mitochondrial membrane is protected from peroxidative damage by GPx, an antioxidant enzyme. When GPx activity is reduced, mitochondria become more sensitive to isoproterenol-induced cardiac injury, resulting in a shift in mitochondrial function. GPx has been observed to be inactivated in the presence of severe oxidative stress (Litov *et al.*, 1981). The activity of GPx requires adequate quantities of glutathione and NADPH, and reduced glutathione availability, as seen in isoproterenol-

administered rats (Table 2), and NADPH resulted in decreased GPx activity (Condell and Tappel, 1983). Similarly, decreased glutathione availability causes GPx and GST activity to decrease. Our findings revealed that rats given isoproterenol had lower GPx activity (Table 2). The activity of GPx was sustained after pretreatment with *Ipomoea biloba* leaves extract.

Reduced glutathione is a non-enzymatic antioxidant biomolecule that is abundant in the body (Meister, 1984). It effectively scavenges free radical species such as H<sub>2</sub>O<sub>2</sub>, superoxide anions, and alkoxy radicals when combined with GPx, GR, and CAT-SOD couples.

It protects cellular constituents from the detrimental effects of ROS and peroxides generated during metabolism as a substrate for antioxidant enzymes GPx and glutathione transferase (GST). Reduced GSH levels in ISO-intoxicated rats could be owing to its increased usage for enhancing GPx and GST activities.

Glutathione levels depleted by ISO were significantly elevated by *Ipomoea biloba* 200mg/kg treatment. It may be understood that increased level of GSH could either be because of its enhanced synthesis or due to improved GR activity in presence of *Ipomoea biloba*.

SOD, CAT, and GPx create a mutually supporting enzyme system that serves as the first line of defense against oxidative injury, decomposing O<sub>2</sub> and H<sub>2</sub>O<sub>2</sub> before they interact to form more dangerous hydroxyl radicals (Vandana Panda & Suresh 2008).

SOD activity reduced considerably in the ISO group of rats in this study, possibly due to an increased production of superoxide anions. The elimination of superoxide anions can be harmed by a decrease in SOD activity, which can be damaging to the myocardium (Sharma et al., 2001). After ISO treatment, the activity of the H<sub>2</sub>O<sub>2</sub> scavenging enzymes CAT and GPx also fell dramatically. Excessive superoxide anions may inactivate SOD, resulting in inactivation of the H<sub>2</sub>O<sub>2</sub> scavenging enzymes, which could explain the fall in enzyme levels. The administration of *Ipomoea biloba* to ISO-challenged rats successfully avoided the decrease in SOD, CAT, and GPx activities, which could be attributed to *Ipomoea biloba's* ability to scavenge radicals and so protect these enzymes (Vandana Panda & Suresh 2008).

GR is an antioxidant enzyme that aids in the conversion of GSSG (a GPx end product) to GSH. There was a significant decrease in GPx activity in ISO-treated cells, which resulted in a decrease in substrate availability for GR and, as a result, a decrease in GR activity. *Ipomoea*

*biloba* administration to ISO myocardial infarction rats restored GR activity, speeding up the conversion of GSSG to GSH.

Reduced GSH levels caused membrane integrity loss, cardiac contractile failure, and myocyte toxicity in ISO-induced rats, eventually leading to myocardial necrosis (Marikannan and Darlin Quine, 2012). In the heart of ISO-induced rats, pretreatment with *Ipomoea biloba* dramatically boosted the activities of mitochondrial SOD, CAT, GPx, and GST, as well as the levels of mitochondrial GSH. This could be attributed to *Ipomoea biloba*'s direct effect on lipid peroxidation levels and indirect effect on lipid levels (Ganapathy & Rajadurai 2015).

### **Protection of membrane integrity by *Ipomoea biloba* leaves extract in isoproterenol-induced myocardial infarction**

The activity of ATPases was dramatically reduced in membrane tissues treated with isoproterenol (Table 2)  $\text{Na}^+$  and  $\text{K}^+$  ATPase is regarded to be a necessary component of animal cell plasma membranes, as it is involved in the active transport of  $\text{Na}^+$  and  $\text{K}^+$  ions.  $\text{Ca}^{2+}$  is a second messenger in the cell, and an increase in cytosolic  $\text{Ca}^{2+}$  ATPase pumps  $\text{Ca}^{2+}$  out of the cytosol at a rapid rate. Intracellular  $\text{Ca}^{2+}$  overload can arise as a result of changes in the membrane  $\text{Na}^+$ ,  $\text{K}^+$  ATPase, and  $\text{Ca}^{2+}$  pump activities, leading to cardiomyopathy.  $\text{Na}^+$   $\text{K}^+$  ATPase is known to be inhibited by high cholesterol levels. Malondialdehyde, a thiobarbituric acid reactive result of lipid peroxidation, is formed more frequently when  $\text{Ca}^{2+}$  ATPase is reduced in the membrane. Pretreatment with *Ipomoea biloba* leaves extract reduces ATPase activity and keeps it at a normal level (Jayalakshmi & Niranjali, 2005).

In this work, we found that ISO-induced rats had lower  $\text{Na}^+/\text{K}^+$  ATPase activity and higher  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ATPase activity. Since  $\text{Na}^+/\text{K}^+$  ATPase is a 'SH' group containing enzyme and lipid-dependent, inactivation could be attributed to increased lipid peroxidation by free radicals on ISO-induction (Paritha and Devi,1997). ISO activates adenylate cyclase, which results in increased  $\text{Ca}^{2+}$  ATPase in ISO-induced rats. During ischemia, calcium overload in cardiac cells activates the membrane's  $\text{Ca}^{2+}$ -dependent ATPase, depleting high energy phosphate reserves and indirectly blocking  $\text{Na}^+$  and  $\text{K}^+$  transport and inactivating the  $\text{Na}^+/\text{K}^+$  ATPase (Rajadurai & Stanely, 2007). In ISO-induced rats, pretreatment with *Ipomoea biloba* boosted the activity of  $\text{Na}^+/\text{K}^+$  ATPase while decreasing the activities of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ATPase. This may be related to *Ipomoea biloba*'s capacity to preserve the 'SH' groups from oxidative degradation

by inhibiting peroxidation of membrane lipids. This impact could be attributed to *Ipomoea biloba's* ability to stabilize membranes.

The activity of membrane-associated enzymes such as ATPases can be measured to see if there is a change in the membrane under pathological situations. The plasma membrane is intricately related with ATPases, which contribute in the energy-demanding translocation of sodium, potassium, calcium, and magnesium (Mourelle and Franco.1991). The  $\text{Na}^+$ - $\text{Ca}^{2+}$  exchange pathway in the myocardium can be activated by inhibiting  $\text{Na}^+/\text{K}^+$ ATPase. This  $\text{Na}^+$ - $\text{Ca}^{2+}$  exchange pathway could be involved in calcium regulation in cells (Rajadurai & Stanely, 2007). The active calcium transport protein  $\text{Ca}^{2+}$  ATPase is responsible for maintaining proper intercellular calcium levels in a range of cell types.

## CONCLUSIONS

In conclusion, the novel findings of this present investigation were proved that the ethanolic extract of *Ipomoea biloba* leaves were showed the appreciable cardio protection against the ISO-induced myocardial infarction in experimental rats. The ethanolic extract treatment noticeably reduced the enzymatic and non-enzymatic antioxidation activity in both plasma as well as heart tissue. These results were proved the cardioprotective action of the ethanolic extract of *Ipomoea biloba* leaves. Hence, it was concluded that the *Ipomoea biloba* leaves may play a significant role in the development of novel cardio-protective drugs in future. However, the additional researches were still needed in future to elucidate the exact curative mechanism of the *Ipomoea biloba* leaves against the myocardial infarction.

## COMPETING INTERESTS DISCLAIMER:

**Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.**

## References

1. Ambrosio G., Zweier J. L., Duilio C. et al., "Evidence that mitochondrial respiration is a source of potentially toxic oxygen free radicals in intact rabbit hearts subjected to ischemia and reflow," *The Journal of Biological Chemistry*, vol. 268, no. 25, pp. 18532–18541, 1993.
2. Anand A. Zanwar, Mahabaleshwar V. Hegde, and Subhash L. Bodhankar Cardioprotective activity of flax lignan concentrate extracted from seeds of *Linum usitatissimum* in isoprenaline induced myocardial necrosis in rats 2011; Vol. 4(2): 90–97.
3. Arika W, C. M. Kibiti, J. M. Njagi, and M. P. Ngugi, "In vitro antioxidant properties of dichloromethanolic leaf extract of *Gnidia glauca* (Fresen) as a promising antiobesity drug," *Journal of Evidence-Based Integrative Medicine*, vol. 24, 2019.
4. Baker, H., Handelman, G.J., Short, S., Machlin, L.J., Bhagavan, H.N., Dratz, E.A. and Frank, O., 1986. Comparison of plasma  $\alpha$  and  $\gamma$  tocopherol levels following chronic oral administration of either all-rac- $\alpha$ -tocopheryl acetate or RRR- $\alpha$ -tocopheryl acetate in normal adult male subjects. *The American journal of clinical nutrition*, 43(3), pp.382-387.
5. Condell RA and Tappel AL (1983) Evidence for suitability of glutathione peroxidase as a protective enzyme: studies of oxidative damage, renaturation, and proteolysis. *Arch Biochem Biophys*, 223: 407-416.
6. Dabelstein W, Reglitzky A, Schütze A, Reders K (2007). "Automotive Fuels". *Ullmann's Encyclopedia of Industrial Chemistry*.
7. Fernandez-checa JC, Garcia-Ruiz C, Ookhtens M and Kaplowitz N (1991) Impaired uptake of glutathione by hepatic mitochondria from chronic ethanol-fed rats. Tracer kinetic studies *invitro* and susceptibility to oxidant stress. *J Clin Invest*, 87: 397-405.
8. Fraga, C.G. and Tappel, A.L., 1988. Damage to DNA concurrent with lipid peroxidation in rat liver slices. *Biochemical Journal*, 252(3), pp.893-896.
9. Ganapathy P, Rajadurai M 2015. Cardioprotective effect of  $\beta$ -sitosterol on isoproterenol induced myocardial infarction in male albino wistar rats. Periyar University Thesis
10. Griendling.K.K and FitzGerald G A, "Oxidative Stress and cardiovascular injury part I: Basic mechanisms and in vivo monitoring of ROS," *Circulation*, vol. 108, no. 16, pp. 1912–1916, 2003.

11. Habig, W.H. and Jakoby, W.B., 1981. Assays for differentiation of glutathione S-Transferases. In *Methods in enzymology* (Vol. 77, pp. 398-405).
12. Jayalakshmi R and S Niranjali Devaraj 2004 Antioxidant effect of tincture of *Crataegus* on oxidative stress in isoprpterenol – induced myocardial infraction in rat, *Journal of Pharmacy and Pharmacology*, 56: 921-926.
13. Jayalakshmi R and S Niranjali Devaraj 2005 Cardioprotective effect of tincture of *Crataegus* (TCR) on experimentally induced myocardial infraction in rats University of madras Shodhganga@INFLIBNET: Cardioprotective effect of tincture of *crataegus* TCR on experimentally induced myocardial infarction in rat.
14. Kakkar, P., Das, B. and Viswanathan, P.N., 1984. A modified spectrophotometric assay of superoxide dismutase.
15. Kandhan Karthishwaran, Salem Obaid Saeed Obaid Al Shamisi, Shyam Sreedhara Kurup, Sabitha Sakkir & Abdul Jaleel CheruthFree-radical-scavenging and antioxidant capacities with special emphasis on enzyme activities and *in vitro* studies in *Caralluma flava* N. E. Br. Pharmaceutical Biotechnology Pages 156-162 2017.
16. Leung HW, Vang MJ and Mavis RD (1981) The co-operative interaction between Vit-E and Vit-C suppression of peroxidation of membrane phospholipids. *Biochem Biophys Acta*, 664: 266-272.
17. Litov RE, Mathew CL and Tappel AL (1981) Vitamin E protection against *in vivo* lipid peroxidation initiated in rats by methyl ethyl ketone peroxide as monitored by pentane. *Toxicol Appl Pharmacol*, 58: 96-106.
18. Marikannan M, Darlin Quine S. Ellagic acid protects mitochondria from  $\beta$ -adrenergic agonist induced myocardial damage in rats; evidence from *in vivo*, *in vitro* and ultra-structural study. *Food Res Int* 45; 1-8, 2012.
19. Martensson J, Lai JCK and Meister A (1990) High affinity transport of glutathione is part of a multi component system, essential for mitochondrial function. *Proc Natl Acad Sci USA*, 87: 7185-7189.
20. Meister A (1991) Glutathione deficiency produced by inhibition of its synthesis, and its reversal, applications in research and therapy. *Pharmacol Ther*, 51: 155-194.
21. Meister A. New aspect of glutathione biochemistry and transport selective alterations of glutathione metabolism *Nutr Rev* 1984; 42:397-400.

22. Middleton E Jr (1984) The flavonoids. *Trends pharmacol Sci*, 5: 335-338.
23. Mourelle M, Franco M T, 1991. Erythrocyte defects procedure the onset of CCl<sub>4</sub> induced liver cirrhosis protection by silymarin. *Life Sci*. 48, 1083-1090.
24. Omaye, S.T., Turnbull, J.D. and Sauberlich, H.E., 1979. [1] Selected methods for the determination of ascorbic acid in animal cells, tissues, and fluids. In *Methods in enzymology* (Vol. 62, pp. 3-11).
25. Paritha I A, Devi C S, 1997. Effect of  $\alpha$ - tocopherol on lipid peroxidation in isoproterenol induced myocardial infraction in rats. *Indian J. Biochem Biophys*, 41,369-376.
26. Polidoro G, De Ilio C, Aruduini A, La Rovere G and Federici G (1984) Superoxide dismutase reduced glutathione and TBA-reactive products in erythrocytes of patients with multiple sclerosis. *Int J Biochem*, 16: 505-509.
27. Poljsak, B.; Milisav, I. "The Neglected Significance of "Antioxidative Stress"". *Oxidative Medicine and Cellular Longevity*. **2012**: 480895.
28. Rajadurai.M, Stanely Mainzen Prince 2007. Preventive effect of naringin on isoproterenol – induced cardiotoxicity in Wistar rats: an *in vivo* and *in vitro* study *Toxicology* 232, 2007.
29. Rotruck, J.T., Pope, A.L., Ganther, H.E., Swanson, A.B., Hafeman, D.G. and Hoekstra, W., 1973. Selenium: biochemical role as a component of glutathione peroxidase. *Science*, 179(4073), pp.588-590.
30. Sharma M , Kishore K, Gupta SK, Joshi S, Arya DS. Cardioprotective potential of *Ocimum sanctum* in isoproterenol induced myocardial infraction in rats. *Mol Cell Biochem* 2001; 225:75-83.
31. Sinha, A.K., 1972. Colorimetric assay of catalase. *Analytical biochemistry*, 47(2), pp.389-394.
32. Tirmenstein MA and Reed DJ (1988) Characterization of glutathione-dependent inhibition of lipid peroxidation of isolated rat liver nuclei. *Arch Biochem Biophys*, 261: 1-11.
33. Tracey Roizman, D.C. What Are the Benefits of Eating Antioxidants? 2018
34. Valko, M.; Rhodes, C. J.; Moncol, J.; Izakovic, M.; Mazur, M. (2006-03-10). "Free radicals, metals and antioxidants in oxidative stress-induced cancer". *Chemico-Biological Interactions*. **160** (1):1–40.

35. Vandana S Panda, Suresh R Naik. Naik. Cardioprotective activity of *Ginkgo biloba* Phytosomes in isoproterenol-induced myocardial necrosis in rats: A biochemical and histoarchitectural evaluation *Experimental and Toxicologic Pathology* 60 (2008) 397-404.
36. Weisfeldt M. L, Zweier J., Ambrosio G, Becker L. C., and Flaherty J. T, "Evidence that free radicals result in reperfusion injury in heart muscle," *Basic Life Sciences*, vol. 49, pp. 911–919, 1988.
37. Yoshida T, Watanabe M, Engelman DT, Engelman RN, Schley JA, Maulik N, Ho YS, Oberley TD and Das DK (1996) Transgenic mice overexpressing glutathione peroxidase are resistant to myocardial ischemia reperfusion injury. *J Mol Cell Cardiol*, 28: 1759-1767.

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