Academic Sciences International Journal of Pharmacy and Pharmaceutical Sciences

ISSN- 0975-1491 Vol 4, Issue 4, 2012

Research Article

# EVALUATION OF HYPOLIPIDEMIC ACTIVITY OF VARIOUS EXTRACTS FROM WHOLE PLANT OF *IONIDIUM SUFFRUTICOSUM* (GING.) (FAMILY: VIOLACEAE) IN RAT FED WITH HIGH FAT DIET

**D.SATHEESH KUMAR AND A. KOTTAI MUTHU***

**Department of pharmacy, Annamalai University, Annamalai Nagar 608002, India. Email: arthik03@yahoo.com**

*Received: 19 Feb 2012, Revised and Accepted: 25 April 2012*

**ABSTRACT**

The present study was designed to investigate the hypolipidemic effect of different extracts from whole plant of *Ionidium suffruticosum* (Ging.) (Family: Violaceae) in rats fed with high fat diet. The acute toxicity study was found that all the extracts are safe up to 2000mg/kg, so one tenth of this dose was considered as evaluation dose. Various extracts (Petroleum ether, Ethyl acetate and Methanol) of *Ionidium suffruticosum* were administered in doses of 200mg/kg/day to rats fed with high fat diet to assess its possible lipid-lowering potential. There was a noticed increase in the body weight in HFD fed group ($p<0.001$), which was reduced by the administration of methanolic extract of *Ionidium suffruticosum* (200mg/kg). The elevated levels of total cholesterol, triglycerides, phospholipids, LDL-C and VLDL-C were observed in rats fed with high fat diet (group II). After treatment of methanolic extract of *Ionidium suffruticosum* (200mg/kg/day) showed a significant ($p<0.001$) decrement in body weight, plasma and tissue total cholesterol, triglycerides, phospholipids, plasma LDL-C and VLDL-C along with an increase in plasma HDL-C when compared to HFD rats (group II). The similar result was not found in other two extract treatment groups. The methanolic extract of *Ionidium suffruticosum* could protect against atherosclerosis and decrease the atherogenic index than that of other extract treatment groups. This finding provides some biochemical basis for the use of methanolic extract of whole plant of *Ionidium suffruticosum* as hypolipidemic agent having preventive and curative effect against hyperlipidemia.

**Keywords:** *Ionidium suffruticosum*, High fat diet, Rats, Hypolipidemia

## INTRODUCTION

Coronary Artery Disease (CAD) has been reported as the most common cause of death in developed as well as developing nations[1-3]. Hyperlipidemia is characterized by elevated serum total cholesterol, low-density (LDL) and very low density lipoprotein cholesterol (VLDL) with decreased high-density lipoprotein (HDL) levels. Hyperlipidemia-associated lipid disorders are considered to cause atherosclerotic cardiovascular disease[4].

*Ionidium suffruticosum* (Ging.) (Syn: *Hybanthus enneaspermus*) it belongs to the family Violaceae known as Lakshmisheshta, Padmavati, Padmacharini or Purusharathna in Sanskrit, is an important plant in the Indian system of medicine. It is a small suffrutescent perennial herb found in the regions of former Madras Presidency in India, Ceylon, tropical Asia, Africa, and Australia. It grows 15-30 cm in height with many diffuse or ascending branches and is pubescent in nature[5].Traditionally the plant is used as an aphrodisiac, demulcent, tonic, diuretic, in urinary infections, diarrhea, leucorrhoea, dysuria, and sterility[6]. Moreover, the plant is reported, in ancient ayurvedic literature, to cure conditions of "kapha" and "pitta", urinary calculi, strangury, painful dysentery, vomiting, burning sensation, wandering of the mind, urethral discharges, blood troubles, asthma, epilepsy, cough, and to give tone to the breasts[5]. Literature survey revealed that there is a no earlier scientific reports regarding hypolipidemic activity of this plant. Therefore, objective of the present investigation was to study the effect of various extracts of whole plant of *Ionidium suffruticosum* (Ging.) on hyperlipidemia elicited by high-fat diet in rats.

## MATERIALS AND METHODS

### Plant materials

The whole plant of *Ionidium suffruticosum* (Ging), were collected from Kilikulam, Tirunelveli District of Tamil Nadu, India. Taxonomic identification was made from Botanical Survey of Medicinal Plants Unit Siddha, Government of India. Palayamkottai. The whole plant of *Ionidium suffruticosum* (Ging), were dried under shade, segregated, pulverized by a mechanical grinder and passed through a 40 mesh sieve. All the three extract were stored in screw cap vial at $4^0$C until further use.

### Preparation of Extracts

The above powdered materials were successively extracted with Petroleum ether (40-60ºC) by hot continuous percolation method in Soxhlet apparatus for 24 hours. Then the marc was subjected to Ethyl acetate (76-78ºC) for 24 hrs and then marc was subjected to Methanol for 24 hours. The extracts were concentrated by using a rotary evaporator and subjected to freeze drying in a lyophilizer till dry powder was obtained.

### Animals

Thirty six adult male Wistar rats, weighing approximately 150-180g were obtained from Central Animal House, Rajah Muthiah Medical College, Annamalai University. The animals were kept in cages, 2 per cage, with relative humidity (55%) in a 12 hour light/dark cycle at 25º±2ºC. They were given access to water and a commercial diet *ad libitum*. The experiment were carried out as per the guidelines of Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), New Delhi, India, and approved by the Institutional Animal Ethics Committee (IAEC), Annamalai University (Approved number: 160/1999/CPCSEA/745).

**Animal diet:** The compositions of the two diets were used as follows7:

**Control diet:** Wheat flour 22.5%, roasted bengal gram powder 60%, skimmed milk powder 5%, casein 4%, refined oil 4%, salt mixture with starch 4% and vitamin & choline mixture 0.5%.

**High fat diet:** Wheat flour 20.5%, roasted bengal gram 52.6%, skimmed milk powder 5%, casein 4%, refined oil 4%, coconut oil 9%, salt mixture with starch 4% and vitamin & choline mixture 0.5%, cholesterol 0.4%.

### Acute toxicity studies

Oral acute toxicity studies were carried out with male Wistar rats weighing 150-180g as per (OECD) draft guidelines 423 adopted on 17th December 2001 received from Committee for the purpose of Control and Supervision of Experimental Animals (CPCSEA). The rats were fed with various extracts of *Ionidium suffruticosum* suspended in 1% gum acacia at the dose of 2000mg/kg body weight. The animals were observed individually every 30 minutes after dosing the first 24hrs and thereafter daily for a total of 14 days. The time at which signs of toxicity appear and disappear was observed systematically and recorded for each animal.

**Experimental Design**

A total number of 36 rats were divided into six groups of six rats each:

Group I: Standard chow diet (Control).

Group II: High Fat Diet (HFD).

Group III: HFD + Pet.ether extract of *Ionidium suffruticosum* (200mg/kg B.Wt)

Group IV: HFD + Ethyl acetate extract of *Ionidium suffruticosum* (200mg/kg B.Wt)

Group V: HFD + Methanolic extract of *Ionidium suffruticosum* (200mg/kg B.Wt)

Group VI: HFD + standard drug atorvastatin (1.2 mg/kg body weight)

All the three extracts and atorvastatin were suspended in 2% tween 80[8] separately and fed to the respective rats by oral intubation. In all the three extracts at the dose level of 200mg/kg were fixed as per the OECD guidelines. At the end of 9 weeks all the rats were sacrificed by cervical dislocation after overnight fasting. Just before sacrifice, blood was collected from the retro-orbital sinus plexus under mild ether anaesthesia and blood sample collected in heparinised tubes and plasma was separated. Liver, heart and aorta were cleared of adhering fat, weighed accurately and used for the preparation of homogenate. Animals were given enough care as per the Animal Ethical Committee's recommendations.

**Biochemical analysis**

Plasma samples were analyzed for total cholesterol, HDL-cholesterol and triglycerides using Boehringer Mannheim kits by Erba Smart Lab analyzer USA. LDL-cholesterol and VLDL-cholesterol were calculated by using Friedwald method[9].Ester cholesterol[10] and free cholesterol[10] were analyzed by using digitonin. Portions of liver, heart and aorta tissues were blotted, weighed and homogenized with methanol (3 volumes) and the lipid extracts were obtained by the method of Folch et al (1957)[11]. Extracts were used for the estimation of ester cholesterol and free cholesterol, triglycerides[12], and phospholipids[13]. Free fatty acids were estimated by using method of Falholt et al (1973)[14]. Plasma total cholesterol: HDL-cholesterol ratio and LDL-cholesterol: HDL-cholesterol ratio was also calculated to access the atherogenic risk.

**Statistical analysis**

Results were expressed as mean ± SE of 6 rats in each group. The statistical significance between the groups was analysed by using one way analysis of variance (ANOVA), followed by Dunnet's multiple comparison test. Significance level was fixed at 0.05.

**RESULTS**

From the acute toxicity it was found that all the extracts are safe upto 2000mg/kg so one tenth of this dose (200mg/kg) was considered as the evaluation dose. As shown in Table 1.The body weight of group II rats were increased significantly ($p<0.001$) in comparison with normal control group I rats. The increment in the weight was reduced significantly ($p<0.001$) by the administration of methanolic extract of *Ionidium suffruticosum* (200mg/kg) as well as atorvastatin 1.2mg/kg in comparison with the HFD fed rats (group II). The average food intake per rat per day was found to be 20.2±1.0g. Food intake was the same in all the HFD rats.

**Table 1: Average Body weight changes in control and experimental rats**

| Groups | Initial Weight (g) | Final Weight (g) | Average Body weight gain (g) |
|---|---|---|---|
| Group I | 145±1.82$^{bNS}$ | 166.66±2.47 $^{b*}$ | 22.00±3.39 $^{b*}$ |
| Group II | 150±2.88$^{aNS}$ | 220.00±2.58$^{a*}$ | 69.00±6.00$^{a*}$ |
| Group III | 145±1.29$^{aNS, bNS}$ | 205.83±3.51$^{aNS, b*}$ | 60.00±3.87 $^{aNS, b*}$ |
| Group IV | 150.83±2.01$^{aNS,bNS}$ | 200.00±3.16$^{aNS, b**}$ | 58.00±3.74 $^{aNS, b*}$ |
| Group V | 154.16±1.53$^{aNS,bNS}$ | 179.16±2.38$^{aNS, b*}$ | 26.00±4.30 $^{aNS, b*}$ |
| Group VI | 156.66±2.74$^{aNS,bNS}$ | 174.83±1.74$^{aNS,b*}$ | 19.80±3.39 $^{aNS, b*}$ |

Values are expressed as mean ± SE (n=6 rats)

*P* values: *<0.001, **<0.05

NS: Non significant

a →group I compared with groups II, III, IV, V, VI;

b →group II compared with groups III, IV, V, VI.

Group I: Standard chow diet. (Control)

Group II: High Fat Diet (HFD).

Group III: HFD + Pet.ether extract of *Ionidium suffruticosum* (200mg/kg b.wt)

Group IV: HFD + Ethyl acetate extract of *Ionidium suffruticosum* (200mg/kg b.wt)

Group V: HFD + Methanolic extract of *Ionidium suffruticosum* (200mg/kg b.wt)

Group VI: HFD + Standard drug atorvastatin (1.2 mg/kg b.wt)

As shown in Table 2. There was a significant increase ($p<0.001$) in the level of plasma total cholesterol, ester cholesterol, free cholesterol, free fatty acid, phospholipids and triglycerides in the group II rats fed with HFD in comparison with the normal untreated control rats (Group I). Treatment with methanolic extract of *Ionidium suffruticosum* at the dose 200mg/kg body weight was found significantly reduced ($p<0.001$) in the level of plasma total cholesterol, ester cholesterol, free cholesterol, free fatty acid phospholipids and triglycerides in comparison with HFD rats (group II). The similar result was not found in other two extract treated groups. However, group V (methanolic extract of *Ionidium suffruticosum* with HFD) showed that the plasma total cholesterol, ester cholesterol, free cholesterol, free fatty acid phospholipids and triglycerides level was restored to near normal as that of group VI (atorvastatin 1.2mg/kg with HFD).

As shown in Table 2. In the HFD group, there was a significant increase in the value of atherogenic index 4.57±0.03 ($p<0.001$), while the group receiving methanolic extract of *Ionidium suffruticosum* along with high fat diet, showed a significant decrease in atherogenic index 1.92±0.01 ($p<0.001$), comparable to the normal control group 2.05±0.03($p<0.001$).

As shown in Table 3. The reduction in the HDL produced by the group of animals fed with HFD was significant ($P<0.001$) in comparison with group I animals. However, the treatment with methanolic extract of *Ionidium suffruticosum* at the dose of 200 mg/kg significantly increased the HDL-cholesterol level when compared to HFD rats (Group II). The elevated levels of LDL and VLDL-cholesterol in rats fed with HFD (group II) was significant ($P<0.001$) in comparison with control rats (group I). Treatment with methanolic extract of *Ionidium suffruticosum* (Group V) markedly

reduced the level of plasma LDL-cholesterol and VLDL-cholesterol when compared to HFD rats (group II).In comparison of all the three extract group (Group III, IV & V) with HFD (group II) rats, the methanolic extract of *Ionidium suffruticosum* was showed significant reduction on both LDL-cholesterol and VLDL-cholesterol than that of other groups. The high fat diet rats caused significant (P<0.001) increase in the ratios of total cholesterol: HDL-cholesterol and LDL-cholesterol: HDL-cholesterol. A significant (p<0.001) increase in the ratios of total cholesterol: HDL-cholesterol and LDL- cholesterol: HDL-cholesterol in the rat fed with HFD (group II) in comparison with normal untreated rats (Group I) Administration of methanolic extract of *Ionidium suffruticosum* along with HFD was found significantly reduced the ratios of total cholesterol: HDL-cholesterol and LDL-cholesterol: HDL-cholesterol when compared to HFD group (II).

**Table 2: Effect of various extracts of *Ionidium suffruticosum* on plasma lipid profile in control and experimental rats**

| Groups | Total cholesterol (mg/dl) | Free cholesterol (mg/dl) | Ester cholesterol (mg/dl) | Free fatty acid (mg/dl) | Phospholipid (mg/dl) | Triglyceride (mg/dl) | Athrogenic index |
|---|---|---|---|---|---|---|---|
| Group I | 122.38± 0.83$^{b*}$ | 28.63± 0.18$^{b*}$ | 94.91± 1.51$^{b*}$ | 40.86± 0.27$^{b*}$ | 99.56± 0.12$^{b*}$ | 59.02± 0.90$^{b*}$ | 2.05± 0.03$^{b*}$ |
| Group II | 178.13± 2.59$^{a*}$ | 47.76± 0.18$^{a*}$ | 132.49± 0.92$^{a*}$ | 60.56± 0.13$^{a*}$ | 138.44± 0.26$^{a*}$ | 72.42± 0.69$^{a*}$ | 4.57± 0.03$^{a*}$ |
| Group III | 142.20± 1.88$^{a**, b**}$ | 40.62± 0.51$^{a*, b*}$ | 102.64± 1.21$^{a**, b*}$ | 52.35± 0.16$^{a*, b*}$ | 134.49± 0.11$^{a*, b**}$ | 69.53± 0.27$^{a*, b**}$ | 3.35± 0.05$^{a**, b**}$ |
| Group IV | 132.05± 0.85$^{a**, b*}$ | 36.05± 0.32$^{a*, b**}$ | 95.47± 0.61$^{a*, b*}$ | 48.19± 0.32$^{a**, b*}$ | 123.34± 0.21$^{a*, b*}$ | 60.14± 0.38$^{a*, b*}$ | 2.69± 0.01$^{a*, b*}$ |
| Group V | 111.29± 1.91$^{a*, b*}$ | 30.42±. 0.15$^{a*, b*}$ | 83.40± 0.71$^{a*, b*}$ | 42.18± 0.22$^{a*, b*}$ | 100.19± 0.27$^{a*, b**}$ | 53.63± 0.60$^{a*, b*}$ | 1.92± 0.01$^{a*, b*}$ |
| Group VI | 107.84± 2.61$^{a*, b*}$ | 29.00± 0.23$^{a*, b*}$ | 78.60± 1.75$^{a*, b*}$ | 39.84± 0.28$^{a*, b*}$ | 97.78± 0.31$^{a*, b*}$ | 51.74± 0.34$^{a*, b*}$ | 1.80± 0.02$^{a*, b*}$ |

Values are expressed as mean ± SE (n=6 rats), *P* values: $^{*}$ < 0.001, $^{**}$ < 0.05, NS: Non Significant

**Table 3: Effect of various extracts of *Ionidium suffruticosum* on plasma lipoprotein in control and experimental rats**

| Groups | HDL cholesterol (mg/dl) | LDL cholesterol (mg/dl) | VLDL cholesterol (mg/dl) | LDL- c/HDL-c ratio | HDL-c/ TC ratio |
|---|---|---|---|---|---|
| Group I | 59.03±0.35$^{b*}$ | 24.84±0.43$^{b*}$ | 11.94±0.13$^{b*}$ | 0.41±0.01$^{b*}$ | 0.47±0.02$^{b*}$ |
| Group II | 38.91±0.43$^{a*}$ | 42.68±0.23$^{a*}$ | 14.47±0.17$^{a*}$ | 1.08±0.09$^{a*}$ | 0.21±0.01$^{a*}$ |
| Group III | 42.50±0.31$^{a**, b*}$ | 34.03± 0.33$^{a*, b*}$ | 13.90±0.06$^{a*, b*}$ | 0.79±0.01$^{a**, b*}$ | 0.29±0.01$^{a*, b**}$ |
| Group IV | 48.68± 0.34$^{a*, b*}$ | 24.11± 0.11$^{a**, b*}$ | 12.09± 0.03$^{a*, b*}$ | 0.49±0.01$^{a*, b**}$ | 0.36±0.02$^{a*, b*}$ |
| Group V | 58.71±0.39$^{a*, b*}$ | 21.74± 0.22$^{a*, b*}$ | 10.78± 0.12$^{a*, b*}$ | 0.36±0.02$^{a*, b*}$ | 0.51±0.01$^{a*, b*}$ |
| Group VI | 59.72± 0.37$^{a*, b*}$ | 19.96± 0.36$^{a*, b*}$ | 10.35± 0.08$^{a*, b*}$ | 0.33±0.02$^{a*, b*}$ | 0.55±0.03$^{a*, b*}$ |

Values are expressed as mean ± SE (n=6 rats), *P* values: * < 0.001, ** < 0.05, NS: Non Significant

As shown in Tables 4&5. The significant (P<0.001) increase in levels of both free and ester cholesterol were also observed in tissue of rats fed with high fat diet (group II) when compared to control rats (group I). Both tissues free and ester cholesterol reduced remarkably on treating the HFD rats with methanolic extract of *Ionidium suffruticosum* than that of other extract treating groups.

**Table 4: Effect of various extracts of *Ionidium suffruticosum* on tissues ester cholesterol profile in control and experimental rats**

| Groups | Ester cholesterol (mg/g tissue) | | |
|---|---|---|---|
| | Liver | Heart | Aorta |
| Group I | 1.68 ± 0.02$^{b*}$ | 2.86± 0.01$^{b*}$ | 2.02±0.42$^{b*}$ |
| Group II | 3.55±0.02$^{a*}$ | 6.96±0.02$^{a*}$ | 6.81±0.23$^{a*}$ |
| Group III | 3.05±0.02$^{a**, b*}$ | 5.57±0.01$^{aNS, b**}$ | 6.34±0.15$^{a*,b**}$ |
| Group IV | 2.02±0.01$^{a*,b**}$ | 3.78±0.03$^{a**,b*}$ | 4.98±0.24$^{a*,b**}$ |
| Group V | 2.59±0.03$^{a*,b*}$ | 3.10±0.01$^{a*,b*}$ | 2.69±0.09$^{a*,b*}$ |
| Group VI | 1.84±0.01$^{a*,b*}$ | 2.98±0.01$^{a*,b*}$ | 2.83±0.11$^{a*,b*}$ |

Values are expressed as mean ± SE (n=6 rats) *P* values: $^{*}$ < 0.001, $^{**}$ < 0.05 NS : Non Significant

**Table 5: Effect of various extracts of *Ionidium suffruticosum* on tissues free cholesterol profile in control and experimental rats**

| Groups | Free cholesterol (mg/g tissue) | | |
|---|---|---|---|
| | Liver | Heart | Aorta |
| Group I | 0.79±0.01$^{b*}$ | 0.73± 0.01$^{b*}$ | 0.40±0.01$^{b*}$ |
| Group II | 1.28±0.01$^{a**}$ | 1.03±0.03$^{a*}$ | 2.30±0.02$^{a*}$ |
| Group III | 1.21±0.01$^{a**,b**}$ | 0.92±0.02$^{a*,b*}$ | 1.42±0.03$^{a*,b**}$ |
| Group IV | 1.04 ±0.01$^{a*,b**}$ | 0.82±0.01$^{a**,b*}$ | 1.11±0.01$^{a*,b*}$ |
| Group V | 0.82±0.01$^{a*,b*}$ | 0.62±0.01$^{a*,b*}$ | 0.74±0.01$^{a*,b*}$ |
| Group VI | 0.86±0.04$^{a*,b*}$ | 0.64±0.04$^{a*,b*}$ | 0.63±0.04$^{a*,b*}$ |

Values are expressed as mean ± SE (n=6 rats), *P* values: $^{*}$ < 0.001, $^{**}$ < 0.05, NS: Non Significant

As shown in Tables 6. The concentration of tissue triglyceride was elevated in rats fed with high fat diet (group II) as compared to control rats (group I). The tissue triglyceride levels were significantly reduced in rats treated with methanolic extracts of *Ionidium suffruticosum* at the dose of 200mg/kg and as well as standard drug atorvastatin along with HFD when compared with rats fed with high fat diet (group II). Administration of methanolic extract of *Ionidium suffruticosum* significantly reduced the triglyceride level when compared with other two extract treatment groups.

As shown in Tables 7. The concentration tissue phospholipids were significantly increased in rats fed HFD (group II) as compared to control animals (group I). Treatment with methanolic extract of *Ionidium suffruticosum* along with HFD was showed significantly reduced the phospholipids levels when compared to HFD fed rats (group II). Administration of methanolic extract of *Ionidium suffruticosum* significantly ($p<0.001$) reduced the phospholipids level when compared with other two extracts.

**Table 6: Effect of various extracts of *Ionidium suffruticosum* on tissues Triglyceride level in control and experimental rats**

| Groups | Triglyceride (mg/g tissue) | | |
|---|---|---|---|
| | Liver | Heart | Aorta |
| Group I | 8.25±0.01$^{b*}$ | 10.67±0.01$^{b*}$ | 10.02±0.03$^{b*}$ |
| Group II | 28.11±0.19$^{a*}$ | 48.16±0.16$^{a*}$ | 21.03±0.28$^{a*}$ |
| Group III | 25.08 ± 0.27 $^{a*,b**}$ | 40.03±0.13$^{a**, b**}$ | 18.68±0.09$^{a*, b**}$ |
| Group IV | 18.84±0.15$^{a*, b**}$ | 31.57± 0.20 $^{a**, b*}$ | 16.52±0.11$^{a*, b*}$ |
| Group V | 12.29±0.10$^{a*,b*}$ | 21.48 ± 0.12$^{a*,b*}$ | 13.22 ± 0.12 $^{a*, b*}$ |
| Group VI | 10.65±0.09$^{a*,b*}$ | 18.78±0.16$^{a*, b*}$ | 13.15 ± 0.09 $^{a*, b*}$ |

Values are expressed as mean ± SE (n=6 rats), *P* values: $^{*}$ < 0.001, $^{**}$ < 0.05, NS : Non Significant

**Table 7: Effect of various extracts of *Ionidium suffruticosum* on tissues Phospholipids level in control and experimental rats in each group**

| Groups | Phospholipids (mg/g tissue) | | |
|---|---|---|---|
| | Liver | Heart | Aorta |
| Group I | 19.40±0.15$^{b*}$ | 23.48 ±0.07$^{b*}$ | 9.32±0.05$^{b*}$ |
| Group II | 29.63±0.09$^{a*}$ | 37.41±0.12$^{a*}$ | 16.31± 0.09$^{a*}$ |
| Group III | 25.85± 0.05$^{a**,b*}$ | 34.19±0.15$^{a*,b*}$ | 15.24 ± 0.12$^{a*, b**}$ |
| Group IV | 23.63 ± 0.11$^{a*,b**}$ | 32.27±0.07 $^{a*,b*}$ | 12.51± 0.13$^{a**, b*}$ |
| Group V | 20.37±0.16$^{a*,b*}$ | 27.17±0.23$^{a*,b*}$ | 11.11±0.12$^{a*, b*}$ |
| Group VI | 18.72±0.17$^{a**,b*}$ | 25.39±0.18$^{a*,b*}$ | 10.67± 0.10$^{a*, b*}$ |

Values are expressed as mean ± SE (n=6 rats), *P* values: $^{*}$ < 0.001, $^{**}$ < 0.05, NS: Non Significant

**DISCUSSION**

The body weight of high fat diet rats were increased significantly, which was reduced significantly by the administration of methanolic extract of *Ionidium suffruticosum.* The weight reducing effect may be attributed to its potential to inhibit lipogenesis and enhanced thermogenesis, since obesity is associated with defective thermogenesis[15].

Plasma lipid profiles are elevated in the group receiving high fat diet; earlier studies reveal significant elevation of lipid parameters in plasma and tissue response to atherogenic diet or high fat diet[16-18]. The reduction in the HDL produced by the group of animals fed with HFD, this result is highly significant in that low HDL-cholesterol is now considered as the most significant risk factor for atherosclerosis[19, 20]. After administration of methanolic extract of *Ionidium suffruticosum* was showed significantly increased the HDL-C concentration. It is well known that increased HDL-cholesterol levels have a protective role in coronary artery disease[21]. HDL may be protective by reversing cholesterol transport, inhibiting the oxidation of LDL and by neutralizing the atherogenic effects of oxidized LDL[22].

The elevated levels of LDL and VLDL-cholesterol in rats fed with HFD, Clinical and epidemiological studies have proved that individuals with elevated LDL show an increased risk for cardiovascular diseases[23]. Supplementation of cholesterol in diet rapidly results in a marked increase in the production of cholesteryl rich-VLDL by the liver and intestine[24] and a reduced number as well as rate of cholesterol removal by the hepatic LDL receptors[25]. The level of LDL-C and HDL-C were significantly reduced by administration of methanolic extract of *Ionidium suffruticosum* than that of other two extracts treated groups. There is strong evidence from several studies that the extent of reduction in the incidence of CHD is directly related to the magnitude of reduction in LDLc and VLDLc levels[26].

The high fat diet rats significantly increased in the ratios of total cholesterol: HDL-cholesterol and LDL-cholesterol: HDL-cholesterol. A significant increased in the ratios of total cholesterol: HDL-cholesterol and LDL- cholesterol: HDL-cholesterol indicate increased risk of atherosclerosis and coronary heart disease[27]. Decline in the ratios of total cholesterol: HDL-cholesterol and LDL- cholesterol: HDL-cholesterol observed in the methanolic extract of *Ionidium suffruticosum* treated rats (group V) might be consequence of higher proportion of HDL-cholesterol which reduced risk by virtue of increased reverse cholesterol transport from peripheral organs to liver[28,29].

The ester and free cholesterol levels were significantly increased in HFD group (II) in comparison with control rats. This high cholesterol concentration in circulation may damage the endothelial cells lining the large arteries and aorta and this may be an initial event in the etiology of atherosclerosis[30]. Treatment with methanolic extract of *Ionidium suffruticosum* reduces the level of both ester and free cholesterol than that of other two extracts treating groups. This lipid lowering effect may be due to the inhibition of hepatic cholesterogenesis or due to the increase in excretion of fecal sterol[31].

The concentration of plasma and tissue triglyceride was elevated in rats fed with high fat diet. Recent studies also show that triglycerides are independly related to coronary heart disease[32,33] and most of the antihypercholesterolemic drugs do not decrease triglycerides levels, but methanolic extract of *Ionidium suffruticosum* lowered it significantly ($P<0.001$) and this effect might be related to increase the endothelium bound lipoprotein lipase which hydrolyses the triglycerides into fatty acids. The concentration of plasma and tissue phospholipids were significantly increased in rats fed with HFD, this may be due to decreased phospolipase activity[34,35]. The group receiving methanolic extract of *Ionidium suffruticosum* significantly reduced the phospholipids level when compared with other two extracts. The plant extract may have stimulation of lipoprotein lipase activities resulting in decrease of plasma triglyceride and might

increase the uptake of triglyceride from plasma by skeletal muscle and adipose tissues[33] (El-Hazmi and Warsy 2001)

Atherogenic index was decreased in rats fed with HFD; a decrease in the atherogenic index is inversely related with coronary heart disease and its elevation in considered as an antiatherosclerotic factor[36] (Mukherjee et al. 1995). Administration of methanolic extract of *Ionidium suffruticosum* significantly ($p<0.001$) reduced the phospholipids level when compared with other two extracts. The plant extract may have stimulation of lipoprotein lipase activities resulting in decrease of plasma triglyceride and might increase the uptake of triglyceride from plasma by skeletal muscle and adipose tissues[33] (El-Hazmi and Warsy 2001).

In conclusion, the result of present study revealed that the methanolic extract of whole plant of *Ionidium suffruticosum* significantly reduced the plasma lipid and lipoprotein profile, thus reduced the atherogenic index. It also the significantly reduced the tissues free cholesterol, ester cholesterol, triglycerides and phospholipids when compared to other extracts. This finding provides some biochemical basis for the use of methanolic extract of whole plant of *Ionidium suffruticosum* as antihyperlipidemic agent having preventive and curative effect against hyperlipidemia. Further, studies are required to again more insight in to the possible mechanism of action.

**ACKNOWLEDGEMENT**

The authors extend their sincere thanks to All India Council for Technical Education (AICTE), Govt. of India, New Delhi (1-51/RID/CA/5/2009-10.) for providing financial support and motivation for the present investigation.

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