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Journal of Advanced Scientific Research

Available online through http://www.sciensage.info

ISSN
0976-9595
Research Article

PHYTOPHARMACOLOGICAL EVALUATION OF HYDROALCOHOLIC EXTRACT OF BARK OF *PONGAMIA GLABRA* VENT. FOR ANTI-OBESITY ACTIVITY AND EFFECT ON LIPID PROFILE AND HEPATIC ENZYMES

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ABSTRACT

Pongamia glabra is a native Indian subcontinent as well as south-east Asia drug used widely in many herbal formulations. The bark extract is used in the present study to evaluate its anti-obesity activity and its effect on lipid profile and hepatic enzyme. *In-vivo* studies were done using high fat diet along with DPMA model. Anti-obesity Evaluations included in the study was analysis of serum biochemical parameters (Serum Lipid Profile), determination of atherogenic index and coronary risk, Determination of Adiposity Levels, Fat Depot and Liver weight/Body weight Ratio (%) and histopathological analysis of liver tissues and adipose tissues. The results of the present study suggested that in actute toxicity studies, animals did not show any mortality at the dose of 500 mg/kg;bw. The *Pongamia glabra* bark at the dose of 500 mg/kg body weight found to show strong reducing effect on serum TC, TG and LDL levels among the treatments. The atherogenic index and coronary risk index showed significant reduction when treated with hydroalcoholic extract of *Pongamia glabra* bark extract. A significant increase in Lee index was observed in rat fed with high fat dies. The study showed that Weight of different body fat depots i.e. epitdidymal, retroperitoneal, mesenteric fat depot and total fat were significantly increased in HFD group as compared to the normal control group of rat. The histopathological studies suggested that *Pongamia glabra* bark extracts suppress the enlargement of hepatocytes and the accumulation of vesicles in the hepatic tissues. The present study thus clearly indicates that *Pongamia glabra* stem bark has a significant anti-obesity effect which supports its traditional uses.

Keywords: Obesity, *Pongamia glabra,* High fat diet, DPMA, Lipid Profile, Adiposity Levels, Histopathological analysis.

1. INTRODUCTION

Obesity can be defined as the condition of an abnormal growth of adipose tissue that occurs because of enlargement of fat cell size termed as hypertrophic obesity or may be increase in number of fat cells termed as hyperplastic obesity. Sometimes the combination of both the conditions may be observed. The disease is considered to become world epidemic condition [1]. The data of World Health Organization also highlighted that around 1.9 billion adults of age 18 years were listed as an overweight and having an body mass index (BMI) of 25-29.9 kg/m^2 and also around 650 million were listed as obese with BMI >30 kg/m^2. The report also highlighted that greater than 340 million children of age between 5-19 years are overweight [2, 3].

The usage of various synthetic drug therapies are followed for the effective treatment of obesity including Orlisat, Sibutramine, Rimonant, Fenfluramine etc. and these drugs have modest clinical efficacy but it is also being observed that the usage of these medicaments is commonly associated with gastrointestinal (GIT), cardiovascular and also central nervous system (CNS) related side effects. Many plant based products including crude extracts along with isolated compounds from medicinal plants can contribute in the reduction of body weight and also to prevent diet induced obesity and they are commonly used in treating and managing obesity [4, 5]. Dietary phytochemicals might be employed as anti-obesity agents since they have the ability to suppress growth of adipose tissue, inhibit differentiation of preadipocytes along with stimulation of lipolysis, and apoptosis of existing adipocytes. All these mechanisms are thereby responsible for the reduction of adipose tissue mass. Common

phytochemicals includes polyphenols, terpenoids, organosulphurs and phytosterols that have proven potential as anti-obesity agents. *Pongamia glabra* is native to Indian subcontinent as well as south-east Asia and have many health benefits. It is an evergreen deciduous plant and the hight of the plant is around 8 m and can grow upto 15-25 m. *Pongamia glabra* have found to possess many prenylated flavonoids like furanoflavonols, furanoflavone, chromenoflavones, pyranochalcones etc. Pongaflavanol and tunicatachalcone are present in stem bark of *Pongamia glabra*. Many pharmacological actions of *Pongamia glabra* are explored including anti-hyperammonemic, anti-filarial, antiviral and anti diarrheal activity [6, 7].

2. MATERIAL AND METHODS

2.1. Plant collection and authentication

Bark of *Pongamia glabra* was collected from the medicinal garden of Smriti College of Pharmaceutical Education, Indore and authentified by Dr. S.N. Dwivedi, Head of the Department, Department of Botany, Janata PG College, A.P.S. University, Rewa, M.P. India (Voucher Specimen Number J/Bot./2019-004PGB).

2.2. Extraction method

The experiments were carried out using shade dried bark of *Pongamia glabra* which was then reduced to moderately coarse powder using mechanical grinder. Coarse powder produced was stored in opaque air tight container until used. About 500 g of dried powder drug was extracted with mixture of 50% ethanol + 50% distilled water in a soxhlet extractor. The process of extraction was carried till the solvent in the thimble became clear. Post extraction, the extract was allowed tofiltered and solvent was allowed to distilled off in rotary evaporator at 50°C. The extract was freeze dried and percentage yield was calculated. The percentage yields of the extracts were calculated with reference to air dried powder.

2.3. Preliminary phytochemical studies

The Preliminary phytochemical tests were performed [14] for the identification of the presence of alkaloids, Flavonoids, Carbohydrates, Saponins, phenolic compounds and Tannins.

2.4. Pharmacological studies

Healthy adult wistar albino rats (150-200 gm) were used for the study. The animals were stabilized for 1 week, housed in polypropylene cages, maintained under standard conditions of light and temperature as 12 h light and 12 h dark cycle, 25±30°C. The animals were fed with standard pellet diet and water *ad-libitum* throughout the course of the study. The handlings of the animals were done gently in order to avoid over stress condition and consequent increased adrenal output. The experiment was approved by Institutional animal ethical committee of B.R. Nahata College of Pharmacy, Mandsaur with letter number IAEC/BRNCOP/2020 /010 with CPCSEA registration number 918/PO/ Re/S/05/CPCSEA.

2.4.1. Acute toxicity study

The acute toxicity study is used to establish the therapeutic index of any drug, i.e. ratio between the pharmacologically effective dose and the lethal dose on the same strain and species (LD_{50}/ED_{50}). Greater is the index safer is the compound and vice versa. The acute toxicity study was done according to OECD guidelines 425- Fixed Dose Procedure (FDP) as in annex 2D. Healthy swiss albino rats were divided into two groups each containing 6 rats. The defined/fixed dose level of extract (2000 mg/kg) was given through oral route in order to identify a dose that is responsible for generating evident toxicity. The observation of animals was done continuously for a time period of around 2 hours in order to get behavioral, neurological and autonomic profile. The toxicity signs were observed after 24 hours, till 14 days for any lethality or death [8, 9].

2.4.2. Anti-obesity studies

2.4.2.1. Induction of Obesity

2.4.2.1.1. By High fat diet

Rats were maintained for 2 weeks with sufficient supply of diet and free access of water prior to experiment. Rats were housed in the air-conditioned animal room having a 12 h light/12 h dark cycle at 25±2°C temperature and 50±5% humidity.

Rats were feed with high fat diet consisting of 60% fat, 20% carbohydrate and 20% protein. The rat was weighed initially and also after keeping them on high fat diet regularly. The experiment was initiated when the weight of rat reached up to 28-29 g by feeding with high fat diet.

Randomly selected animals were divided into 12 groups containing 6 animals each. Regular pellet diet with required minerals and vitamins to the Normal control group was fed and administered with vehicle. Other

groups were fed with High fat diet from which, one group was be administered by vehicle (control group), one with standard drug and another with the plant extract [10].

Grouping and treatment pattern of animals is mentioned in the table 2.

Table 1: Grouping and treatment pattern of animals with different extracts and drugs

Group no.	Group	Treatment	No. of Animals
Group-1	Control	Vehicle	6
Group-2	Positive Control	Standard Drug Sibutramine (10mg/kg, orally)	6
Group-3	Normal Diet	Hydroalcoholic extracts of *Pongamia glabra Vent.* (Bark) 250mg/kg Treated	6
Group-4	High Fat Diet	Hydroalcoholic extracts of *Pongamia glabra Vent.* (Bark) 250mg/kg Treated	6
Group-5	Normal Diet	Hydroalcoholic extracts of *Pongamia glabra Vent.* (Bark) 500mg/kg Treated	6
Group-6	High Fat Diet	Hydroalcoholic extracts of *Pongamia glabra Vent.* (Bark) 500mg/kg Treated	6

2.4.2.1.2. By DPMA

Depo-medroxyprogesterone acetate (DPMA) at a dose of 10 mg/kgbw was injected by subcutaneous route of administration. The procedure was repeated daily after 30 minutes of oral administration of the extracts for 28 days except for the control group (which were not administered with the extract).

2.4.2.2. Biochemical Analysis

Serum Lipid Profile i.e. level of Total cholesterol (TC), High Density Lipoprotein (HDL) cholesterol, Low Density Lipoprotein (LDL) cholesterol and Triglyceride (TG) in blood serum was analyzed in obese and extract treated rat.

2.4.2.2.1. Analysis of Serum Lipid Profile

TC, HDL, LDL, and TG level was analyzed initially on day zero, after 28 day of feeding on high fat diet and finally at the end of extract treatment in both control and experimental groups. The blood was collected by retro-orbital route in 1.5 ml eppendrof tubes and centrifuged at 3000 rpm for 15 minutes at room temperature. The serum was separated from blood cells on centrifugation. Separated serum was collected with the help of culture needle and store in sterilized tube at -80°C for further biochemical analysis. Serum triacylglycerol (TG), total cholesterol (TC), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) were measured by using Hitachi 7080 analyzer (Hitachi, Japan)/ or enzymatic methods using commercially available kits by using auto-analyzer [11].

2.4.2.3. Determination of AI and CRI

Atherogenic index (AI) and coronary risk (CRI) were calculated by following formula:

Atherogenic index (AI) = (TC-HDL)/HDL

% of protection= {(AI of HFD control-AI of Treatment group)/ AI of HFD control} x 100

CRI= TC (mg/dl)/HDL-c (mg/dl)

2.4.2.4. Determination of Adiposity Levels

The determination of adiposity level was done by the help of Lee index. It can be defined as the cubic root of body weight in grams divided by the nano-anal length in millimeters multiplied by 10^4. The Lee index is highly correlated with the percentage of body fat.

Mathematically, Lee index (LI) is expressed as:

$$\frac{\sqrt[3]{\text{Body weight (g)}}}{Nano-anal\ length\ (mm)} \times 10^4$$

2.4.2.5. Fat Depot and Liver weight/Body weight Ratio (%)

To evaluate the effect of HFD (High fat deposit) and drug treatment, adipose tissue as epididymal, retroperitoneal and mesenteric fat depots were allowed to be isolated and freed from the surrounding tissues. Later they were weighed individually and total weight was calculated. Further, the isolation of liver was done and again it was freed from surrounding tissues and allowed to be weighed and preceded for the calculation of the Liver weight/Body weight Ratio (%) [12].

2.4.2.6. Histopathological analysis of liver and adipose tissues

At the end of the treatment phase, animals were sacrificed and study organ (liver, adipose tissue, etc.) of

one animal from each group were excised and stored in 10% formalin solution. Slides to study the morphology of particular organs were prepared and studied under electronic microscope.

2.4.2.6.1. Procedure for Liver

Rat was sacrificed by cervical dislocation method, dissected and the liver was isolated. The liver was fixed in 10% formalin solution and embedded in paraffin wax. Liver was sliced into 2 μm thick sections by using microtome and the slide was prepared. Slide was dried at 60°C for 1 hour and deparaffinized using xylene and gradient concentrations of ethanol. The slides were stained with hematoxylin and eosin dye and observed under electronic/optical microscope.

2.4.2.6.2. Procedure for Adipose tissue

The animal was anesthetized with isoflurane and was sacrificed, dissected and the adipose tissue was removed (fat pads), weighed and stored at -80°C. For histological analysis, the adipose tissue was fixed in 10% formalin solution and embedded in paraffin wax. Tissue was sliced into 2 μm thick sections by using microtome and the slide was prepared. Slide was dried at 60°C for 1 hour and deparaffinized using xylene and gradient concentrations of ethanol. the slides were stained with hematoxylin and eosin dye and observed under electronic microscope [13].

3. RESULTS AND DISCUSSION

3.1. Preliminary phytochemical studies

Many studies have reported plants with phytochemicals like flavonoids, alkaloids, saponins, tannins, steroids, and phenols to have antiobesity effects [15]. In the present study phytochemical tests suggested the presence of Alkaloids, Flavonoids, carbohydrates and Phenolic compounds in the hydroalcoholic bark extract of *Pongamia glabra* that may be responsible for antiobesity activity.

Table 2: Preliminary phytochemical tests of hydroalcoholic extract of *Pongamia glabra* bark.

S. No.	Phytochemical Compounds	Present (+) or Absent (-)
1.	Alkaloids	+
2.	Flavonoids	+
3.	Carbohydrates	+
4.	Saponins	-
5.	Phenolic compounds	+
6.	Tannins	-

3.2. Pharmacological studies

3.2.1. Acute toxicity study

The acute oral toxicity study (LD_{50}) of hydroalcoholic extract of *Pongamia glabra* bark was determined as per OECD guidelines 425. Animals did not show any mortality at the dose of 500 mg/kg;bw. As the safe dose was found to be upto 500 mg/kg; bw, the dose of 250 mg/kg; bw was selected for further experiments.

3.2.2. Anti-obesity study

3.2.2.1. Induction of Obesity

Obesity was induced by feeding the animals with high fat diet. Effect of normal diet and high fat diet on body weight of animals is mentioned in the table 3.

Table 3: Effect of normal diet and high fat diet on body weight of animals

Groups (n=6)	Normal control (Normal diet)	High fat diet
Initial body weight (gm)	113.89 ± 5.40	168.78 ±5.22
Final body weight (gm)	117.21 ± 6.15	210.27 ±3.59
% Change in body weight	2.81 ±0.88	24.79 ±2.01
Food intake (g/day/group)	53.25 ±0.70	40.5 ± 0.52

3.2.2.2. Biochemical analysis

3.2.2.2.1. Analysis of Serum Lipid Profile (TC, HDL cholesterol, LDL cholesterol and TG)

Serum Lipid Profile was analyzed by studying level of Total cholesterol, High Density Lipoprotein, Low Density Lipoprotein and triglyceride in blood serum. Results obtained from analysis of Serum Lipid Profile are summarized in table 4. The obese rat had higher level of TC, TG and LDL as compared to the normal group of rat. Treatment with standard and hydro-alcoholic extracts of *Pongamia glabra* bark decreased serum TC, TG, and LDL level ($p<0.01$) and a significant increase in serum HDL levels ($p<0.01$) as compared with HFD and HFD-ND groups respectively ($p<0.01$). The *Pongamia glabra* bark at the dose of 500 mg/kg body weight showed strongest reducing effect on serum TC, TG and LDL levels among the treatments.

3.2.2.3. Determination of AI and CRI

The atherogenic index and coronary risk index are strong and reliable indicators of whether or not cholesterol is deposited into tissues or metabolized and excreted. The administration of hydroalcoholic, extracts of *Pongamia glabra* bark to obese rat caused significant reduction ($p<0.01$) in both AI and CRI and the results obtained are mentioned in table 5.

Treatment of hydroalcoholic extract of *Pongamia glabra* bark to obese rat caused significant reduction in atherogenic index and coronary risk index. More reduction is observed in VIII week of treatment at a dose of 500 mg/kg;bw as compared to Normal control and HFD group.

Table 4: Effect of various treatments of hydroalcoholic extract of *Pongamia glabra* bark on Serum Lipid Profile

		Normal control	HFD	Std. HFD	250 HFD	500 HFD	HFD ND	Std. ND	250 ND	500 ND
TC (mg/dl)	IV week	89.07 ±0.90	150.09 ± 2.50	149.19 ± 2.26	144.29 ± 1.75	147.29 ± 1.26	157.97 ± 1.27	149.06 ± 2.26	145.53 ± 0.90	143.22 ± 1.22
	VIII week	95.84 ±0.62	191.45 ± 1.75	105.30 ± 1.25	114.20 ± 1.85	79.81 ± 1.06	146.16 ±1.25	112.57 ±1.15	120.32 ±0.52	82.66 ± 0.80
				-45.00 [a]	**-58.31** [b]	**-58.31** [b]	**-23.66** [b]	**-41.20** [b]	**-41.20** [b]	**-56.82** [b]
HDL (mg/dl)	IV week	30.26 ±0.74	25.41 ±1.06	25.44 ±0.93	27.28 ±0.51	27.48 ±0.88	28.96 ±1.44	25.89 ±1.61	24.97 ±0.47	25.27 ±2.11
	VIII week	46.04 ±1.16	21.14 ±0.63	52.95 ±0.39	38.22 ±1.34	47.58 ±0.99	29.12 ±0.75	48.73 ±1.13	37.24 ±1.23	44.59 ±0.96
				60.08 [a]	**44.69** [b]	**55.57** [b]	**27.40** [b]	**56.62** [b]	**43.23** [b]	**52.59** [b]
LDL (mg/dl)	IV week	42.05 ±1.06	101.65 ±1.69	101.70 ±3.30	95.05 ±1.25	97.08 ±2.77	109.70 ±2.30	98.66 ±2.55	97.19 ±2.55	93.52 ±2.54
	VIII week	39.86 ±1.06	136.01 ±1.55	45.79 ±1.32	63.26 ±2.81	23.99 ±0.78	98.12 ±1.94	56.68 ±1.94	67.74 ±1.24	26.38 ±1.77
				-54.21 [a]	**-36.74** [b]	**-76.01** [b]	**-1.88** [b]	**-43.32** [b]	**-32.26** [b]	**-73.62** [b]
TG (mg/dl)	IV week	67.05 ±1.41	120.28 ±0.49	125.26 ±1.09	118.93 ±0.84	125.70 ±0.49	107.23 ±0.54	123.44 ±0.44	117.53 ±0.71	128.67 ±0.65
	VIII week	40.66 ±0.60	135.00 ±1.55	45.79 ±1.32	63.26 ±2.81	23.99 ±2.81	98.12 ±1.95	56.66 ±1.12	67.37 ±1.47	27.38 ±1.82
				-113.40 [a]	**-462.73** [b]	**-37.59** [b]	**-138.26** [b]	**-100.39** [b]	**-393.06** [b]	**-113.40** [b]

Values are expressed as mean ±SEM; [a] = $p<0.01$(when compared to HFD); [b] = $p<0.01$ (when compared to HFD-ND); [c] = $p<0.05$ (when compared to normal HFD-ND); [d] = $p<0.01$ (when compared to normal control)

Table 5: Effect of various treatments of hydroalcoholic extract of *Pongamia glabra* bark on AI and CRI

		Normal control	HFD	Std. HFD	250 HFD	500 HFD	HFD ND	Std. ND	250 ND	500 ND
Atherogenic Index	IV week	1.37 ±1.02	4.84 ±0.19	4.66 ±0.42	3.85 ±0.09	3.95 ±0.12	3.96 ±0.27	3.64 ±0.22	3.92 ±0.14	3.92 ±0.11
	VIII week	1.94 ±0.12	7.82 ±0.13	1.86 ±0.06	1.99 ±0.14	0.87 ±0.02	3.57 ±0.18	2.18 ±0.14	2.11 ±0.11	0.93 ±0.05
	% Change			**-98.14** [a]	**-98.01** [b]	**-99.13** [b]	**-96.43** [b]	**-97.82** [a]	**-96.08** [b]	**-99.07** [b]
Coronary Risk Index	IV week	2.72 ±1.03	6.51 ±1.18	6.43 ±0.13	5.96 ±0.22	5.89 ±0.27	5.79 ±0.22	5.82 ±1.23	5.88 ±0.16	5.99 ±0.93
	VIII week	2.30 ±0.06	11.31 ±1.26	2.11 ±1.09	3.57 ±0.26	1.88 ±0.23	5.65 ±1.91	2.47 ±0.25	3.56 ±0.35	1.49 ±0.14
	% Change			**-100** [a]	**-96.43** [b]	**-98.12** [b]	**-94.35** [a]	**-97.53** [a]	**-96.44**	**-98.51** [b]

Values are expressed as mean ±SEM; [a] = $p<0.01$(when compared to HFD); [b] = $p<0.01$ (when compared to HFD-ND); [c] = $p<0.05$ (when compared to normal HFD-ND); [d] = $p<0.01$ (when compared to normal control)

3.2.2.4. Determination of Adiposity Levels

Lee index was assessed at the end of fourth week (day 28). A significant increase ($p<0.05$) in Lee index was observed in rat fed with high fat dies when compared to the rat which were fed on normal diet. Results observed are mentioned in the table 6.

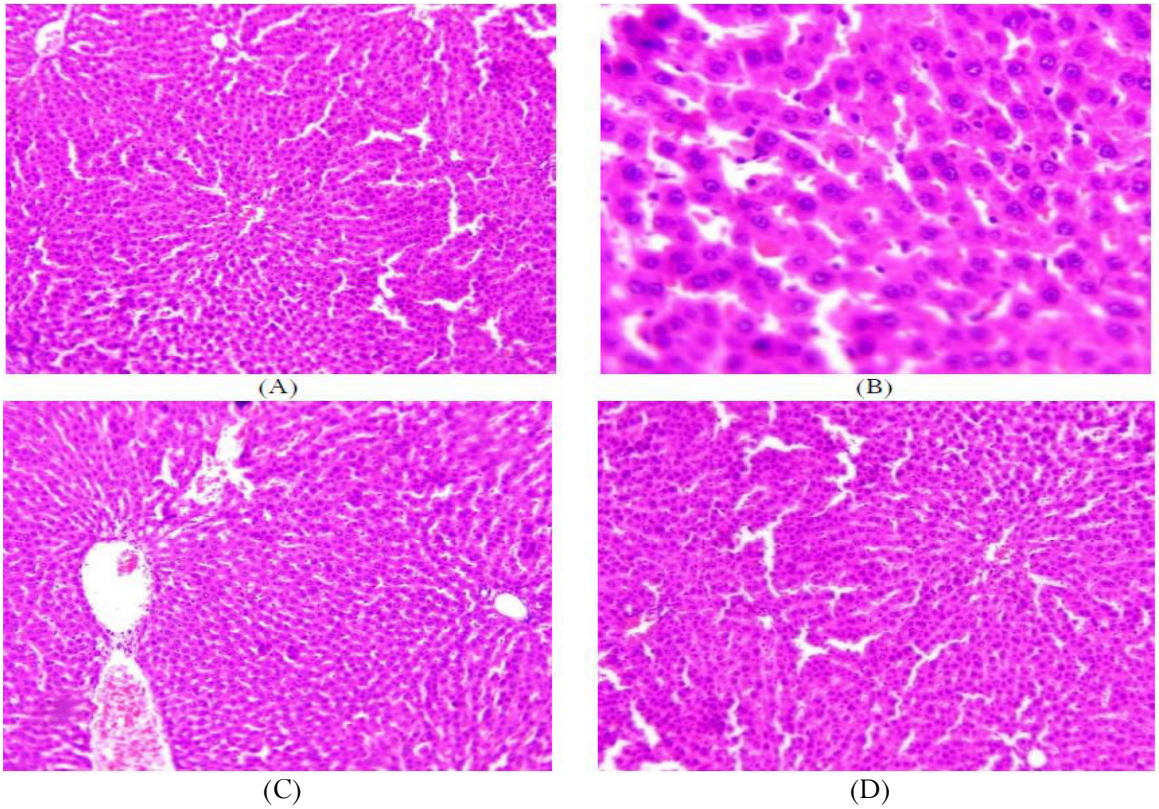
The reduction in Lee index was observed in animal group treated with hydroalcoholic extract of *Pongamia glabra* bark and more significant reduction was shown on animal group treatment at a dose of 500 mg/kg;bw. Reduction in Lee index indicated the decrease in adiposity level and thus anti-obesity potential of *Pongamia glabra* bark extract could be assessed with this finding.

3.2.2.5. Fat Depot and Liver weight/Body weight Ratio (%)

Weight of different body fat depots i.e.epitdidymal, retroperitoneal, mesenteric fat depot and total fat were significantly increased ($p<0.01$) in HFD group as compared to the normal control group of rat. Treatment with hydroalcoholicextract of *Pongamia glabra* bark at the dose of 500 mg/kg body weight produced significant decrease ($p<0.01$) in body fat depots and liver weight/body weight ratio (%). Results are mentioned in the table 7.

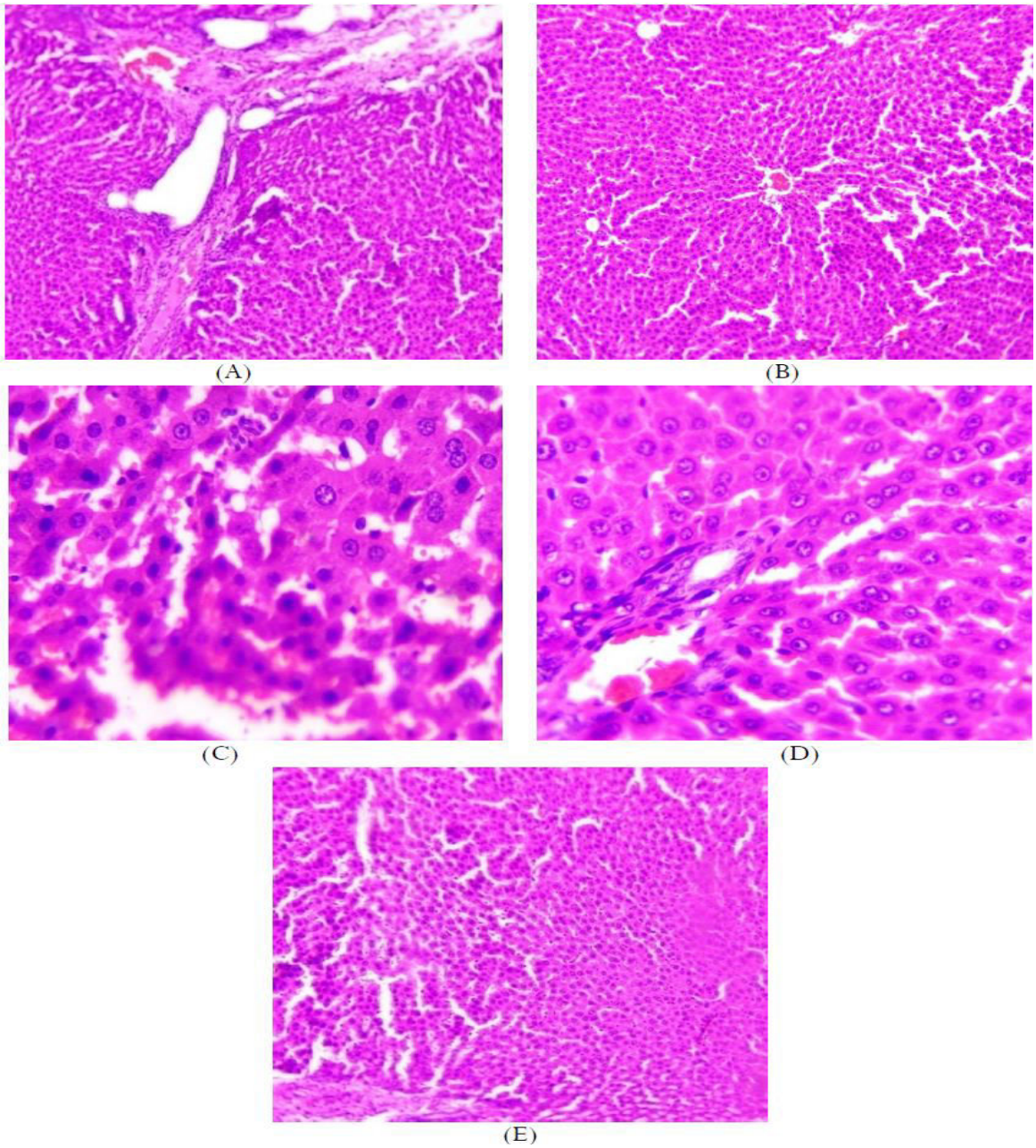
3.2.2.6. Histopathological analysis of liver and adipose tissues

Livers were removed from rat from all groups and subjected to histopathology as shown in Photo-microgram 1 and 2 to see the effects of hydroalcoholic extracts of *Pongamia glabra* bark on hepatic tissues. In rat fed with normal diet, liver secretions exhibited normal histological features. By contrast, most of the hepatocytes were enlarged and contained micro and macro vesicles of fats in rat fed with high fat diet only. The increased size of hepatocytes and steatosis with micro and macro vesicles in the high fat diet groups were normalized by administration of hydroalcoholic extracts of *Pongamia glabra* bark in dose dependent manner. These findings indicate the rescue effects of different extracts of *Pongamia glabra* bark extracts to suppress the enlargement of hepatocytes and the accumulation of vesicles in the hepatic tissues.



Representative micrographs of rat liver fed with (A) Normal Diet (ND), showing normal liver architecture (B) High Fat Diet (HFD), showing enlarged hepatocytes containing micro and macro vesicles of fats indicating steatosis (C) Standard HFD; Sibutramine treated animals liver indicating nearly normalized hepatocytes (D) Standard ND; Sibutramine treated animals, liver indicating nearly normalized hepatocytes

Photomicrogram 1: Histopathology of Liver tissues of rat fed with the experimental diets for 8 weeks



Representative micrographs of rat liver fed with (A) Pongamia glabra hydroalcoholic extract 250 HFD, Unchanged hepatocytes showing diffused cytoplasmic vacuolization and steatosis indicating degenerative changes (B) Pongamia glabra hydroalcoholic extract 500 HFD, (F) HFD-ND, normalized liver architecture (C) Standard ND; Sibutramine treated animals, Amelioration of hepatocytes when shifted to normal diet (D) Pongamia glabra hydroalcoholic extract 250 ND, Unchanged hepatocytes showing diffused cytoplasmic vacuolization and steatosis indicating degenerative changes (E) Pongamia glabra hydroalcoholic extract 500 ND; Liver architecture resembling normal control animals

Photomicrogram 2: Histopathology of Liver tissues of rat fed with the experimental diets for 8 weeks

Table 6: Determination of adiposity level in rat treated with hydroalcoholic extract of *Pongamia glabra* bark

	Normal control	HFD	Std. HFD	250 HFD	500 HFD	HFD ND	Std. ND	250 ND	500 ND
Lee Index	0.289 ±3.44	0.440[a] ±2.45	0.412[a] ±2.16	0.422[a] ±3.39	0.314[a] ±3.50	0.316[a] ±4.62	0.324[a] ±5.22	0.312[a] ±5.42	0.301[a] ±3.58

Values are expressed as mean ±SEM; [a] = p<0.01(when compared to normal control)

Table 7: Effect of treatment with hydroalcoholic extract of *Pongamia glabra* bark on Fat depot and Liver weight/Body weight ratio (%)

Parameters	Normal control	HFD	Std. HFD	250 HFD	500 HFD	HFD ND	Std. ND	250 ND	500 ND
Epididymal fat (gm)	0.58 ±0.12	1.66[d] ±0.05	0.77[a] ±0.15	1.27[a] ±0.04	0.77[a] ±0.12	1.59 ±0.02	0.98[b] ±0.06	1.37[c] ±0.02	0.55[b] ±0.13
Mesenteric fat (gm)	0.72 ±0.04	1.52[d] ±0.02	0.84[a] ±0.04	1.11[a] ±0.01	0.67[a] ±0.01	1.34 ±0.02	0.73[b] ±0.02	1.16[c] ±0.04	0.82[b] ±0.02
Perirenal fat (gm)	0.86 ±0.01	1.91[d] ±0.02	1.05[a] ±0.01	1.72[a] ±0.02	0.84[a] ±0.02	1.87 ±0.04	1.11[b] ±0.02	1.54[b] ±0.01	0.79[b] ±0.02
Liver weight (g/100g BW)	3.10 ±0.13	4.60[d] ±0.11	2.08[a] ±0.08	3.90[a] ±0.04	3.40[a] ±0.06	4.31 ±0.02	2.74[b] ±0.15	4.01[ns] ±0.24	3.36[b] ±0.19

Values are expressed as mean ±SEM; [a] = p<0.01(when compared to HFD); [b] = p<0.01 (when compared to HFD-ND); [c] = p<0.05 (when compared to normal HFD-ND); [d] = p<0.01 (when compared to normal control); [ns]= p>0.05 (when compared to HFD-ND)

4. CONCLUSION

The present study demonstrated *Pongamia glabra* stem bark extract may prevent high fat diet induced obesity/ increase in body weight and fat storage in adipose tissue by inhibiting intestinal absorption of dietary fat through the inhibition of pancreatic lipase activity and also reduced appetite by boosting feeling of satiety. The activity of hydroalcoholic extract of *Pongamia glabra* (500 mg) was found to be highly significant ($p < 0.01$). The present study thus clearly indicates that *Pongamia glabra* stem bark has a significant anti-obesity effect which supports its traditional uses. Hence, it might help in preventing complications in obesity and serve a good adjuvant in the present armamentarium of anti-obesity drugs. The results of the study can be used in the formulation of herbal remedies for the management and treatment of obesity by the use of hydroalcoholic extract of *Pongamia glabra* bark.

Conflict of Interest

The author(s) declare that there is no conflict of interest.

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