RESEARCH PAPER

Assessment of Anti-Obesity and Hypolipidemic Effects of Bombax Ceiba Flower Extracts In Experimental Rats

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ABSTRACT

Obesity is a chronic metabolic disorder associated with excessive fat accumulation, dyslipidemia, oxidative stress, and increased risk of cardiovascular diseases. The present study was designed to evaluate the physicochemical properties, phytochemical constituents, total phenolic content, and anti-obesity potential of Bombax ceiba flower extracts using a high fat diet (HFD)-induced obesity model in Wistar albino rats. Preliminary phytochemical screening revealed the presence of flavonoids, tannins, phenolics, triterpenes, steroids, proteins, carbohydrates, and saponins in different extracts. Total phenolic content estimation by Folin–Ciocalteu method showed that the methanolic extract possessed the highest phenolic content (97.14 ± 4.28 mg GAE/g). Anti-obesity activity was evaluated in HFD-induced obese rats for 45 days. Animals treated with methanolic extract of Bombax ceiba (MBC) and aqueous extract (ABC) at doses of 150 and 300 mg/kg showed significant reduction in body weight gain, food intake, liver weight, and epididymal adipose tissue weight compared with the HFD group. Biochemical analysis demonstrated significant improvement in serum lipid profile, including reduction in total cholesterol, triglycerides, LDL, atherogenic index, and improvement in HDL levels. The extracts also reduced elevated liver enzyme markers such as SGOT, SGPT, and bilirubin, indicating hepatoprotective activity. Among all treatments, the methanolic extract at 300 mg/kg exhibited the most significant anti-obesity effect, comparable to the standard drug orlistat. The findings suggest that Bombax ceiba flower extracts possess promising anti-obesity, and hypolipidemic, activities, possibly due to the presence of phenolic and flavonoid constituents. The study supports the therapeutic potential of Bombax ceiba as a natural agent for the management of obesity and associated metabolic disorders.

Keywords: Bombax ceiba, Anti-obesity activity, High fat diet, Dyslipidemia

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1.INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The disease is associated with disturbances in carbohydrate, lipid, and protein metabolism, leading to long-term complications including nephropathy, neuropathy, retinopathy, and cardiovascular diseases. Oxidative stress plays a significant role in the pathogenesis and progression of diabetes mellitus. Hyperglycemia induces excessive production of reactive oxygen species (ROS), which contributes to β-cell dysfunction and insulin resistance [1-3].

In recent decades, large increases in diabetes prevalence have been demonstrated in virtually all regions of the world, with 415 million people worldwide now living with diabetes. This is most concerning because an increase in diabetes prevalence will increase the number of chronic and acute diseases in the general population, with profound effects on quality of life, demand on health services and economic costs. Macrovascular complications of diabetes, including coronary heart disease, stroke and peripheral vascular disease, and microvascular complications, such as end-stage renal disease (ESRD), retinopathy and neuropathy, along with lower-extremity amputations (LEA), are responsible for much of the burden associated with diabetes. There is also growing recognition of a diversifying set of causally-linked conditions, including cancers, ageing-related outcomes (e.g. dementia), infections and liver disease. Since current data suggests that rates of all-cause and cardiovascular disease (CVD) mortality are decreasing in individuals with diabetes, trends in other complications of diabetes may become proportionately more prominent in the future [4-5].

Despite widespread international assessment of the growth of diabetes prevalence, quantification of the international burden and variation in the incidence of diabetes-related complications is notably lacking. This stems largely from the fact that data systems and population-based studies assessing diabetes complications are concentrated in Europe, North America and other high-income countries, with little to no availability in low- and middle-income countries, where the absolute increase in diabetes prevalence is largest. The lack of both uniform diagnosis of diabetes and of standardised measurement of diabetes-related complications has caused additional barriers in comparing trends worldwide [6-7].

Diabetes mellitus, long considered a disease of minor significance to world health, is now taking its place as one of the main threats to human health in the 21st century. It is the most common non-communicable disease worldwide and the fourth to fifth leading cause of death in developed countries. The global figure of people with diabetes is set to rise from the current estimate of 150 million to 220 million in 2010 and 300 million in 2025. Developing countries such as India have had the maximum increases in the last few years. The current prevalence of type 2 diabetes is 2.4% in the rural population and 11.6% in the urban population of India. It has been estimated that by the year 2025, India will have the largest number of diabetic subjects in the world. Diabetes mellitus is a heterogenous group of disorders characterized by high blood glucose levels. Though the pancreatic beta cell and its secretory product insulin are central in the pathophysiology of diabetes, the pathogenic mechanisms by which hyperglycemia arises differ widely. Several distinct forms of diabetes exist which are caused by a complex interaction of genetics, environmental factors, and life-style choices. Some forms are characterized by absolute insulin deficiency or a genetic defect leading to defective insulin secretion, while other forms share insulin resistance as their underlying etiology [8-10].

Medicinal plants have gained considerable importance as alternative therapeutic agents due to their safety, efficacy, and affordability. Among these medicinal plants, *Gardenia gummifera* has been traditionally used in Ayurvedic medicine for wound healing, digestive disorders, inflammatory diseases, and metabolic disorders. The plant contains several bioactive compounds such as flavonoids, phenolics, tannins, alkaloids, terpenoids, and glycosides, which may contribute to its pharmacological activities [11].

Natural antioxidants are capable of scavenging free radicals and protecting biological systems from oxidative damage. Similarly, plant-derived antidiabetic agents can improve glycemic control by inhibiting carbohydrate hydrolyzing enzymes, enhancing insulin secretion, improving glucose uptake, and reducing oxidative stress [12].

Gardenia gummifera is medicinal plant belonging to family Rubiaceae. It's aften called adhesive shrub orgummy gardenia. Gardenia gummifera, is average sized trees growing everywhere Republic of India. The gum-resin oozing out from the leaf buds of those trees is termed Dikamali. It's marketed within the sort of lumps that are unit yellow in colour. It's associate degree offensive odour and sharp pungent style. Dikamali is said to own a many medicative properties that embrace medicament, carminative, anthelmintic, diaphoretic and medicinal drug. it's additionally claimed to be helpful in stomach upset, flatulence for cleanup foul ulcers and wounds, and to stay off fliesfrom wounds in veterinary observe “unmadanashakghrita” that is indicated for the treatment of mania, encephalopathy and alternative systema nervosum centrale disorders. Variety of Flavanoids were isolated from Dikamali within the past Recently, variety of recent cycloartanes were rumored from this supply of that Dikamaliartane A is that the main cycloartane [13-16]. Therefore, the present study was designed to evaluate the antioxidant and antidiabetic potential of different extracts of *Gardenia gummifera* through detailed phytochemical, in-vitro, and in-vivo experimental investigations.

2. MATERIALS AND METHODS

Collection and authentication of Plant material: Bombax Ceiba Flower were collected from the Bhopal region, Madhya Pradesh, and authenticated by a qualified botanist. Plant materials were shade-dried, powdered, and stored in airtight containers for further studies.

Physicochemical Evaluation: Physiochemical values such as ash value and extractive values were determined for all three selected plant drugs according to the official methods and as per WHO guidelines on quality control methods for medicinal plant materials. Ash values (Total ash, Acid insoluble ash and Water soluble ash), Extractive values, Loss on drying and pH were determined for plant materials.

Determination of extractive values: Considering the diversity and chemical nature of the constituents present in crude drug. Solvents of different polarity viz. Petroleum ether, chloroform, ethyl acetate and methanol were used for determination of extractive values. Dried, coarsely powdered *Bombax Ceiba Flower* (20 g) was subjected continuous soxhlet extraction with 200 ml of Petroleum ether, chloroform, ethyl acetate and methanol as solvents. Aqueous extract was obtained by using maceration method with water. The extracts were concentrated in rotary evaporator and dried in vacuum desiccator. The extractive values were calculated as percentage w/w of solvent soluble extractive with reference to the air dried drug.

Preliminary phytochemical screening: Qualitative Phytochemical analysis of any plant species is a necessary process as it provides the preliminary information about presence of various chemical constituents present and also provides further prospects of the particular plant species in its future research investigations. The extracts obtained by successive solvent extraction were subjected to various qualitative tests to detect the presence of chemical constituents.

Total phenolic compound estimation: Phenolic content of extracts were determined with some modification by Folin-Ciocalteu method.

Anti-obesity Studies

Experimental Animals: Wistar albino rats (200–250 g) were housed under controlled conditions and acclimatized for one week. The study protocol was approved by IAEC as per CPCSEA guidelines.

Acute Oral Toxicity Study: Performed according to OECD guidelines (500, 1000, 2000 mg/kg). The experimental dose was selected as 1/10th of LD50.

Effect of plant extract on High fat diet induced Obesity: Obesity was induced by high Fat diet, composition of the HFD (g/kg diet) was according to the formula of Srinivasan et al. with some modifications. In the in vivo anti-obesity study the control rat will receive either a control diet (CD) or the treated animals will get high fat diet (HFD) for a period of 45 days. As a positive control, orlistat will be administered. Control diet and high fat diet (HFD) were prepared freshly in laboratory. Nutritional content was maintained similar to those of control diet except inducing agent plant extract content.

Animals and diet:. Animals were divided randomly into groups containing 6 animals in each group. Initially one week CD to animals of all groups followed by 45 days feeding of the respective diet as per group division and drug treatment. At the start of the experiment, control groups were fed with standard pellet diet and the other groups were fed with high fat diet and water *ad libitum*. The diets were prepared fresh every day. Control diet was formulated to fulfill the nutritional requirements of rats according to NRC (1995) as shown in Table. Induction of obesity in the rats was achieved by feeding HFD. All diets were given to rats ad libitum. High Fat Diet (HFD) is a hyper caloric diet. The feed was prepared, dried and administered every day morning for 45 days to the experimental rats with water ad libitum

Groups for antiobesity activity of Bombax Ceiba Flower (Six animals per group)

Normal Control: Control diet

High Fat Diet: HFD

Standard: HFD + (orlistat) (10 mg/kg bw)

MBC 150 mg/kg: HFD + methanol extract of Bombax Ceiba Flower (150 mg/kg bw)

MBC 300 mg/kg: HFD + methanol extract of Bombax Ceiba Flower (300 mg/kg bw)

ABC 150 mg/kg: HFD + aqueous extract of Bombax Ceiba Flower (150 mg/kg bw)

ABC 300 mg/kg: HFD + aqueous extract of Bombax Ceiba Flower (300 mg/kg bw)

Parameters to Assess Obesity

Body weight: Body weight of all animals were monitored on every week for the entire period of study and expressed as g/g. Feed intake measurements for individual rat were recorded Bi weekly.

Determination of food intake: Food consumption were calculated daily at the same time by subtracting the amount of food/and water left over in each cage barrier for each mouse from the measured amount of food/water provided at the previous day (gm/day/mouse). The mean, of food/water consumption per each mouse was considered by dividing the amount of food/water eaten in a week by 7. Food intake and Water intake were determined at 4 to 24 weeks of age weekly. The mean daily food intake per mouse calculated in unit of g/day/mouse where mean daily water intake per mouse calculated in unit of ml/day/mouse.

Organ weights: At the end of study, the animals were sacrificed by cervical dislocation after collecting blood via retro-orbital puncture. Orangs such as Liver, Kidney, pancreas, and Epididymal adipose tissue was dissected from the sacrificed animals and rapidly stored at -80ºC till further use. Weights of individual organs such as liver, kidney, pancreas and epidydymal adipose tissue were recorded at the time of sacrifice.

Biochemical Assays: Combined with haematology parameters, biochemical parameters are major indicators for most diagnostic investigations. Many biochemical parameters tend to have specificity for an organ and/or a limited range of the pathological processes. Interpretation of diagnostic biochemical patterns requires an understanding of the pathological implications of each abnormal result. Blood samples were collected at the end of the study, from the Retro-Orbital and the serum was separated after 30 min of stabilization by 3000 rpm centrifugation..

3. RESULTS

Collection and authentication of Plant material: *Bombax Ceiba Flower* were collected from local market of Bhopal and authenticated by Botanist. Plant materials were dried and inspect for any foreign organic matter if present. The *Bombax Ceiba Flower* were subjected to studies organoleptic characters viz., color, odour, appearance, taste, texture etc. Plant materials were dried in shade and griended and stored in air tight container till further use.

Figure 1: Morphological evaluation of *Bombax Ceiba Flower*

Physicochemical Evaluation

Physiochemical values such as ash value and extractive values were determined for selected plant drugs according to the official methods and as per WHO guidelines on quality control methods for medicinal plant materials. Ash values (Total ash, Acid insoluble ash and Water soluble ash), Extractive values, Loss on drying and pH were determined for *Bombax Ceiba Flower*. All parameters for both plants were found within the limits as per specific mentioned in standard books.

Preliminary Phytochemical Analysis of extracts:

Extracts (Petroleum ether, chloroform, ethyl acetate, and methanol extract) of selected plant drugs obtained by continuous soxhlet were subjected to qualitative phytochemical tests to identify the presence of secondary metabolite (viz., alkaloids, glycosides, tannins, flavonoids, sterols, fats, oils, phenols and saponins) present in them. Phytochemical screening of *Bombax Ceiba Flower* showed the presence of triterpenes and steroids in chloroform extract; triterpenes, tannins and flavanoids in ethyl acetate extract; carbohydrate, tannin flavanoid, protein and saponin in methanol extract.

Total phenolic compound estimation

Total Phenolic content was calculated as Gallic acid equivalent mg/100mg using the equation based on the calibration curve. Bombax Ceiba flower methanol extract having 97.14 ± 4.28 mg GAE /g total phenolic content which were found higher than other extract. Petroleum ether extract have lowest amount of total phenolic content in both the plant.

Anti-obesity activity screening:

Effect of plant extract on High fat diet induced Obesity: Obesity was induced by high fat diet (HFD). In the in vivo anti-obesity study the control rat will receive either a control diet or the treated animals will get high fat diet (HFD) or plant extract along with high fat diet for a period of 45 days. As a standard, orlistat has been administered along with high fat diet.

MBC: methanol extract of Bombax Ceiba Flower

ABC: aqueous extract of Bombax Ceiba Flower

Effect on Body Weight:

Methanolic extract produced a dose-dependent reduction in body weight compared with the HFD group. The higher dose showed greater weight reduction, suggesting improved metabolic regulation. The reduction in weight gain may be attributed to decreased lipid absorption, improved lipid metabolism and possible appetite suppression or increased energy utilization. The aqueous extract showed slightly less reduction compared to the methanolic extract, suggesting that methanol may extract more active lipophilic phytoconstituents such as flavonoids, phenolics, and sterols responsible for anti-obesity activity.

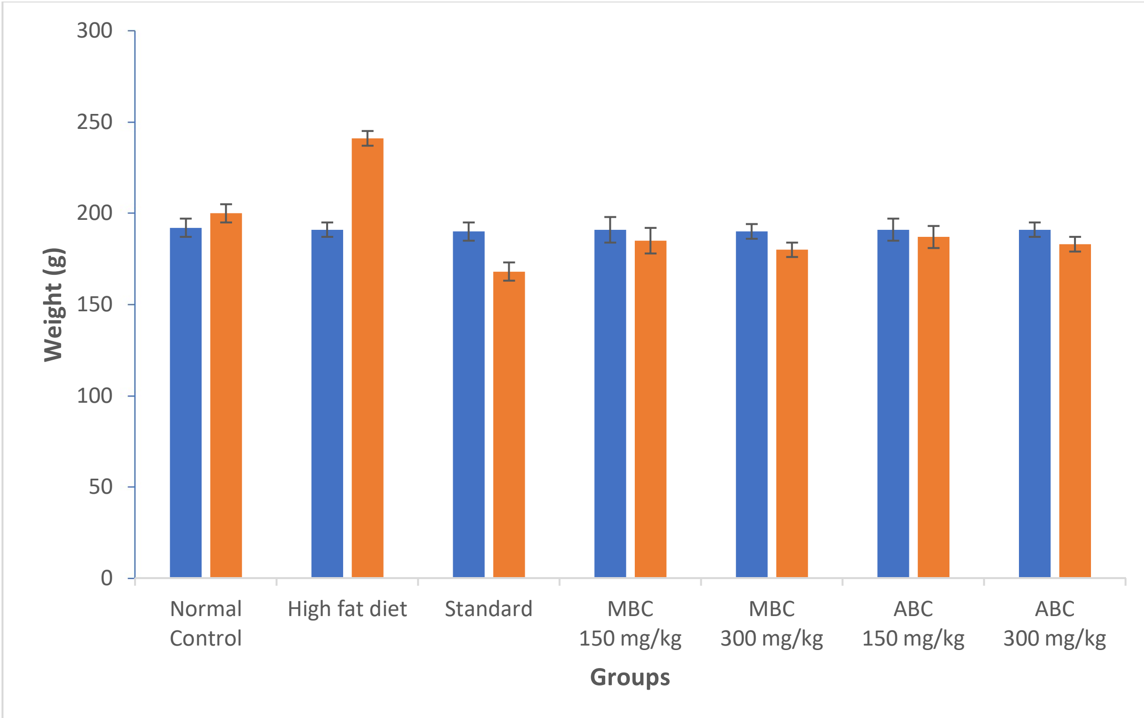

Figure 2: Effect of High Fat diet and *Bombax Ceiba Flower* extract on animal weight

Overall trend of weight gain reduction: Standard > MBC 300 > ABC 300 > MBC 150 > ABC 150 > HFD. The findings suggest that *Bombax ceiba* flower extracts possess promising anti-obesity potential by preventing excessive weight gain in high-fat diet-induced obese animals.

Determination of food intake

The food consumption calculated daily through deducting the amount of food leftover in each cage per rat (gm/rat/ day) given on the previous day. Mean for the food consumption per rat calculated by separating the amount of food in a week by seven. The normal control group showed a gradual reduction in food intake from week 1 to week 6, which reflects normal physiological regulation of appetite and adaptation to diet. In contrast, the HFD group exhibited a progressive increase in food intake, reaching the highest value by week 6 (10.91 ± 0.64 g/100 g body wt). This increase confirms the hyperphagic effect of high-fat feeding and validates successful induction of obesity.

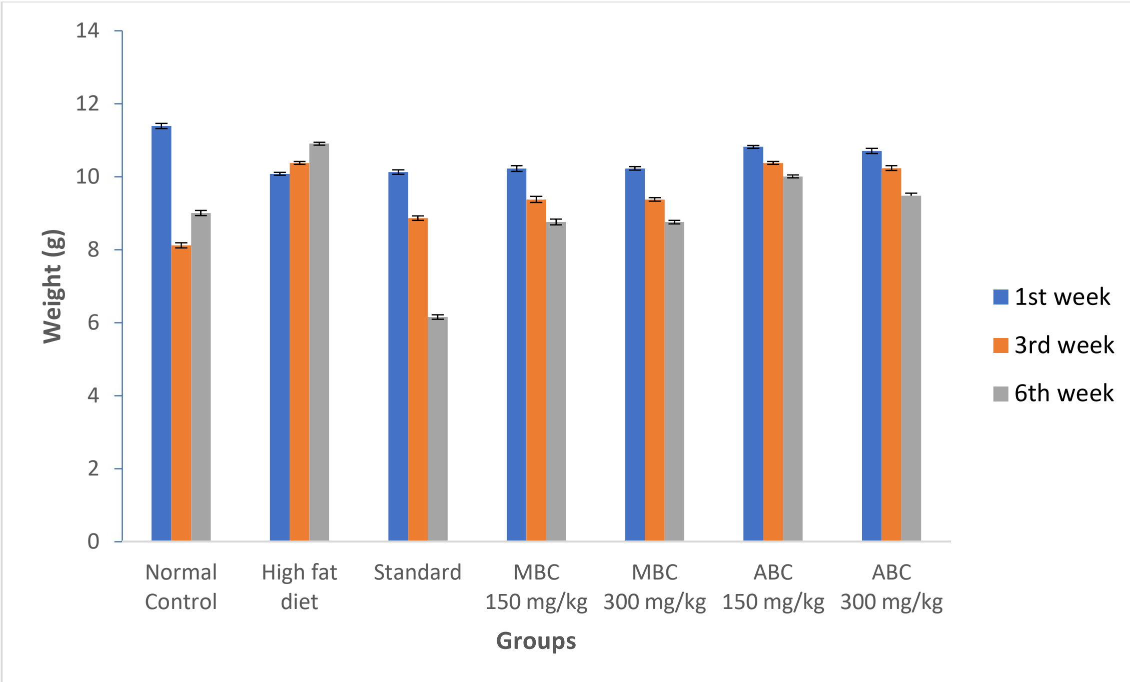

Figure 3: Effect of Bombax Ceiba Flower extract on the average food intake of high-fat diet induced obesity in rat

Effect on Liver Weight The animals of the High fat diet group showed a significant ($p < 0.05$) increase in weight of Liver. The results observed in the group that received the experimental diet significantly reduced weight of Liver ($p < 0.01$), as compared to High fat diet group; while no significant changes showing when compared to normal control group.

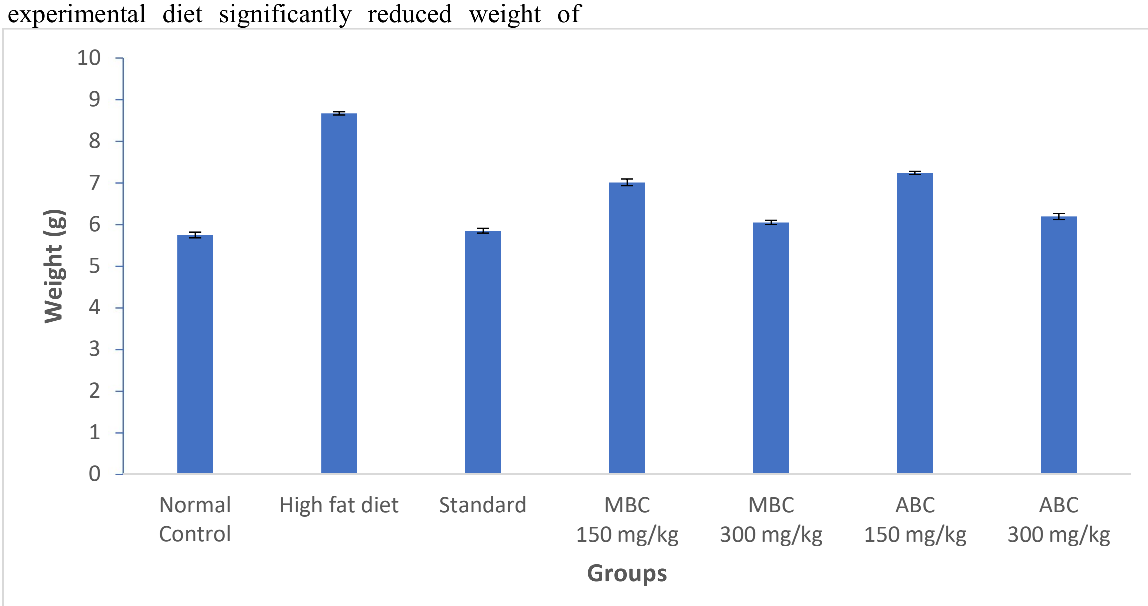

Figure 4: Effect of *Bombax Ceiba Flower* extract on Liver Weight of high-fat diet induced obesity in rat

Effects on Epidydymal adipose tissue: The weight of epidydymal adipose tissue of High Fat Diet group animals group showed a significant ($p < 0.05$) increase.

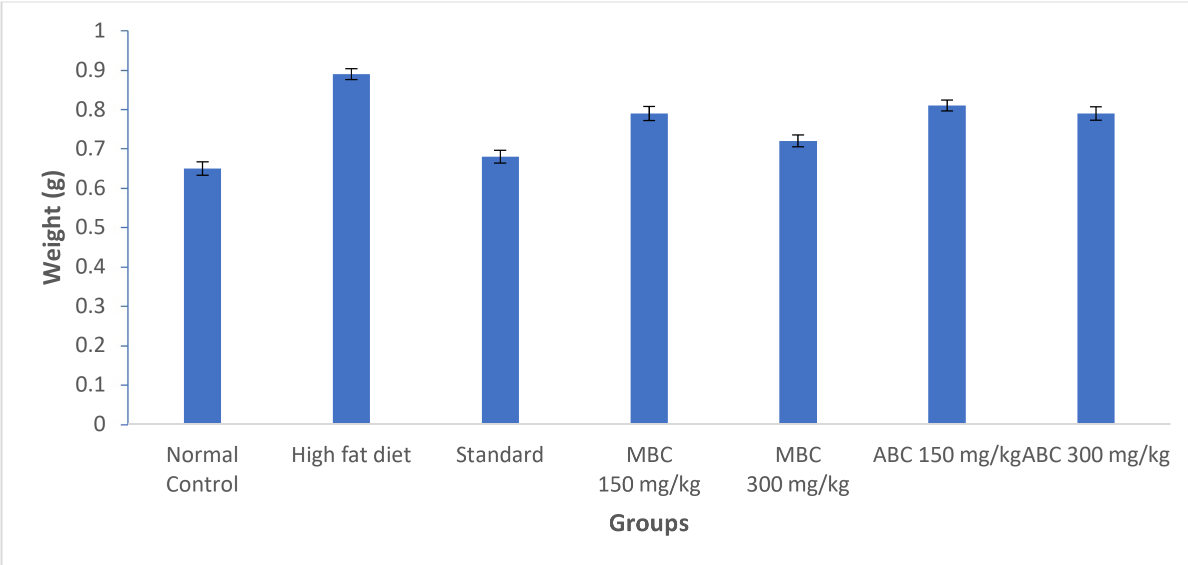

Figure 5: Effects of Bombax Ceiba Flower extract on Epidydymal adipose tissue of high-fat diet induced obesity in rat

The results observed in the group that received the diet having significantly reduced weight of epidydymal adipose tissue ($p < 0.01$), as compared to High Fat Diet group; while no significant changes showing when compared to standard.

Biochemical Assays

Effect of Plant extract on plasma lipoproteins levels:

Total cholesterol, Triglyceride (TG), Low density lipoprotein (LDL), high density lipoprotein (HDL) level and Atherogenic Index (AI) were estimated in all group. Levels of serum cholesterol parameters elevated significantly ($P < 0.005$) in the animals fed with high fat diet compared to the normal control group and decreased in the animals group treated with diet contained methanol extract of Bombax Ceiba Flower.

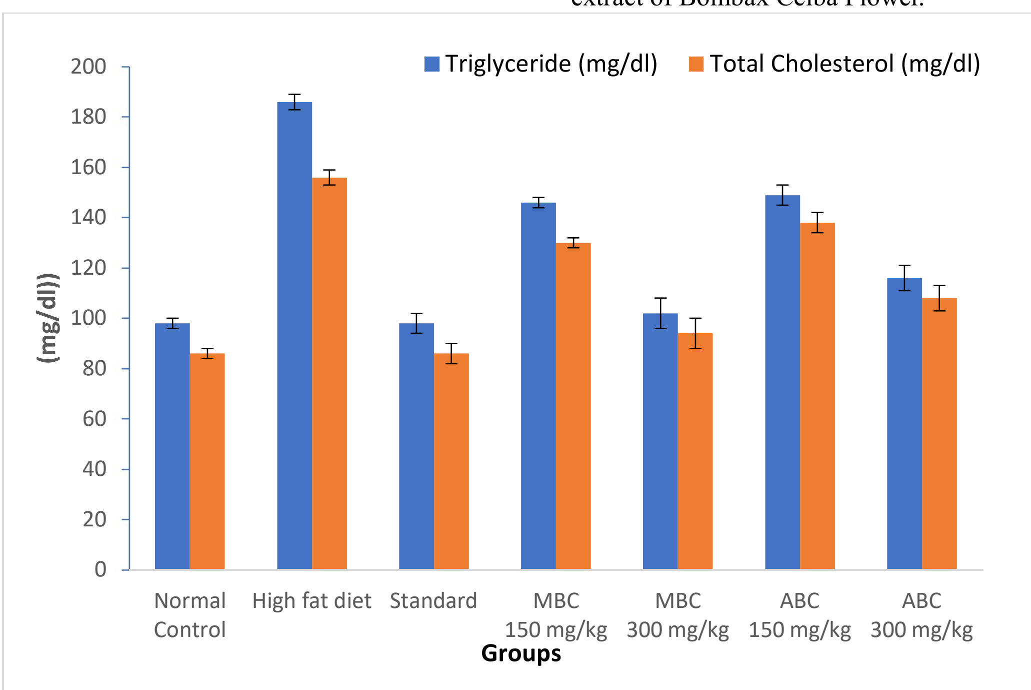

Figure 6: Effects of *Bombax Ceiba Flower* extract on Triglyceride and total Cholesterol of high fat diet induced obese rats

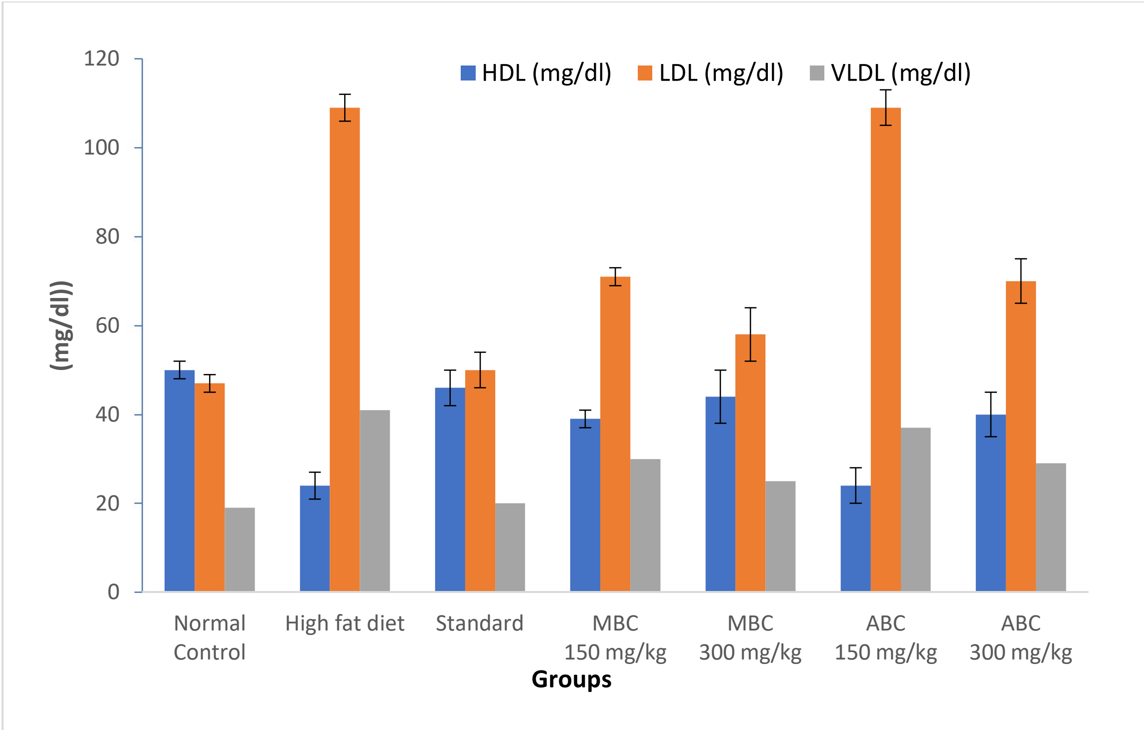

Figure 7: Effects of *Bombax Ceiba Flower* extract on the serum cholesterol parameters of high fat diet induced obese rats

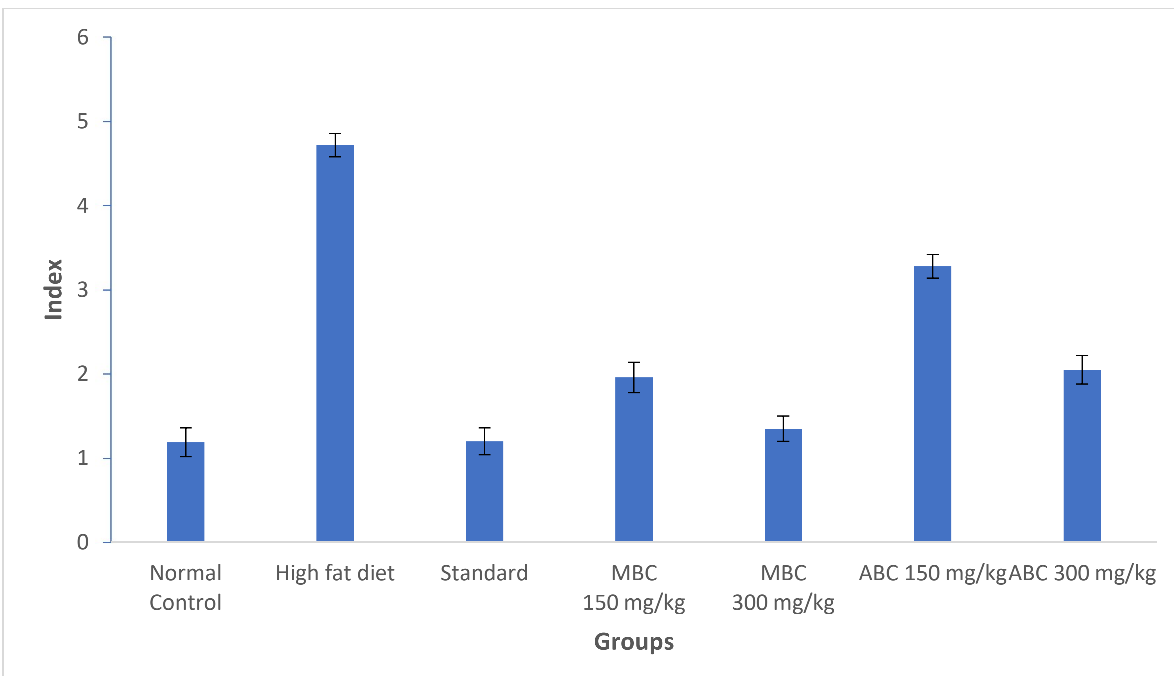

Figure 8: Effects of Bombax Ceiba Flower extract the Atherogenic Index (AI) of high fat diet induced obese rats

The triglyceride levels remarkably increased in HFD diet fed animals compared to normal control group and normalize in the animals fed with MESA 200 mg/kg and MEBL 200 mg/kg extract. The animals fed with HFD diet and treated with experimental diet contained MESA and MEBL showed a reduction in HDL levels compared to normal control group animals. The LDL plasma levels elevated significantly in HFD diet-fed animals compared to normal control group animals. Experimental diet contained methanol extract of Bombax Ceiba Flower was found more effective in reduction of plasma lipoprotein level in high fat induce obesity. The atherogenic index of plasma (AIP) is calculated as log (TG/HDL) and reflects the levels of TG and HDL-C cholesterol. AIP, as a robust biomarker of dyslipidemia, has been used to quantify comprehensive lipid levels. It is also considered a biomarker of coronary syndrome and metabolic syndrome

Effect of plant extract on Liver Enzymes:

SGPT and SGOT are certain enzymes that are produced by the liver and its cells and leak out of cells and mixes in blood when liver cells gets injured. Elevated SGPT and SGOT levels are an indication of liver cell injury or damage.

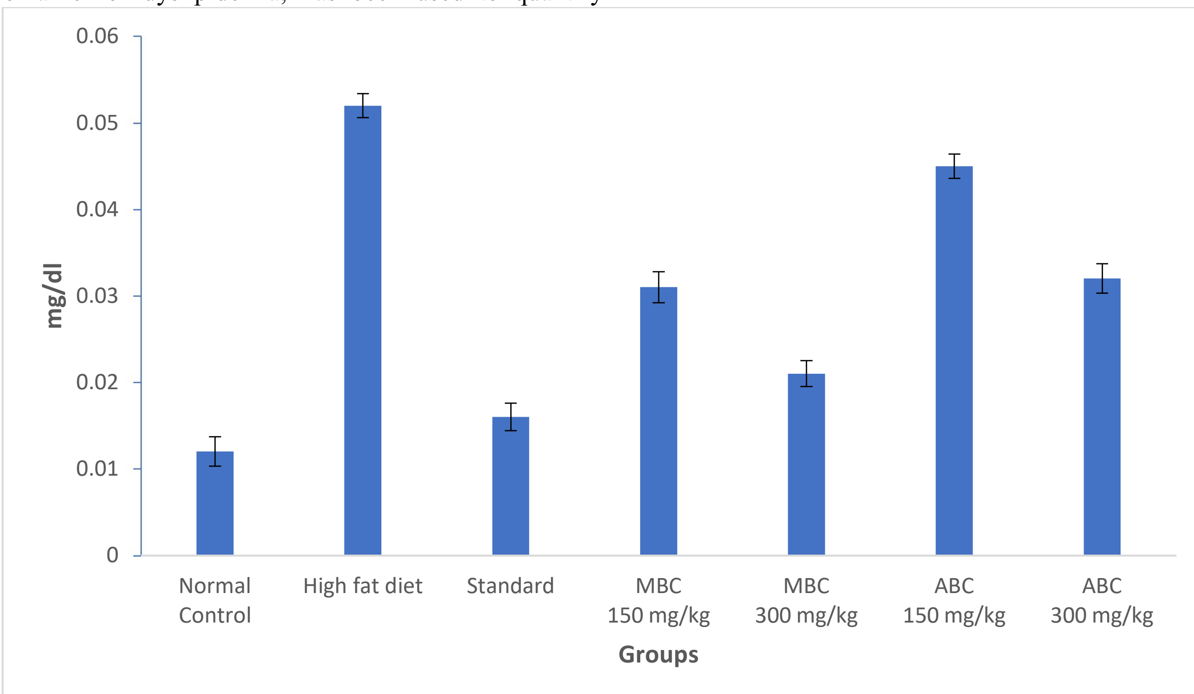

Figure 9: Effects of *Bombax Ceiba Flower* extract on the liver parameters (Bilirubin) of high fat diet induced obese rats

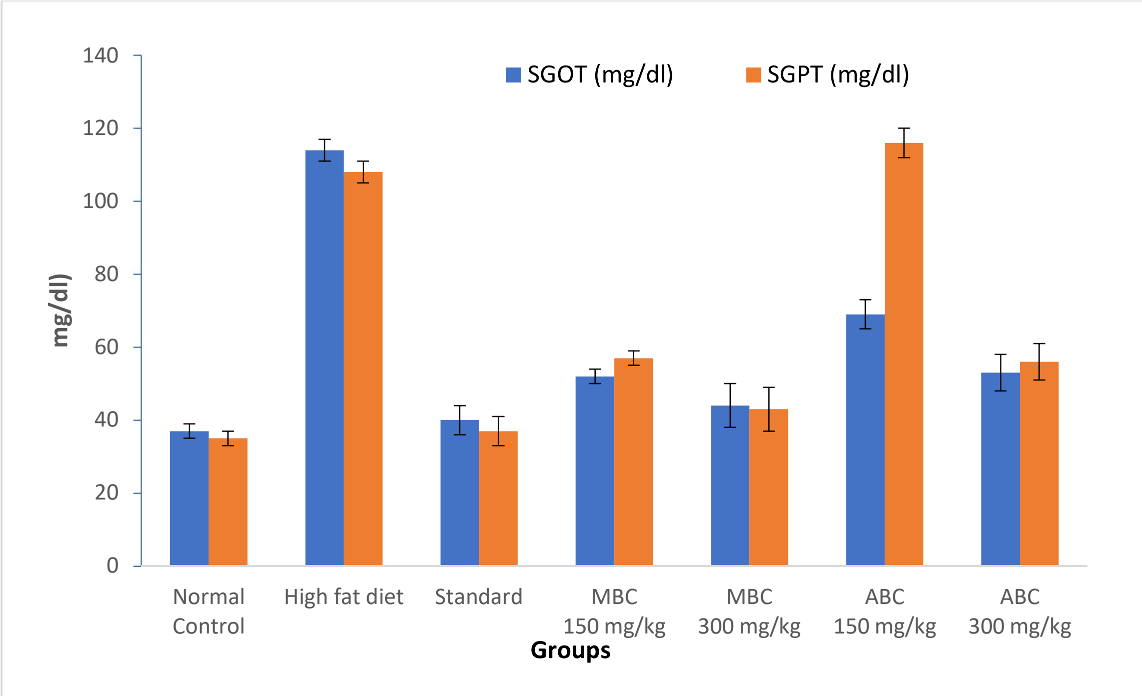

Figure 10: Effects of *Bombax Ceiba Flower* extract on the liver parameters of high fat diet induced obese rats

Bilirubin is the primary bile pigment which, when elevated causes the yellow discoloration of the skin, commonly known as jaundice and is a byproduct of the normal breakdown of red blood cells in the body. Bilirubin can be elevated in many forms of liver or biliary diseases. Methanol extract of Bombax Ceiba Flower extract contain diet decreased liver enzymes levels more effectively than aqueous extract.

4. DISCUSSION

The present investigation demonstrated the anti-obesity potential of *Bombax ceiba* flower extracts in high fat diet-induced obese rats. Obesity induced by chronic consumption of high fat diet resulted in significant increase in body weight, food intake, adipose tissue accumulation, liver weight, and altered serum lipid parameters. These findings are consistent with previous reports indicating that prolonged intake of energy-dense diets promotes excessive fat deposition and metabolic disturbances.

Physicochemical evaluation of the plant material confirmed that all quality control parameters were within acceptable limits according to WHO guidelines, indicating purity and suitability of the crude drug for further pharmacological studies. Preliminary phytochemical screening revealed the presence of flavonoids, tannins, phenolic compounds, triterpenes, steroids, and saponins in the extracts. These phytoconstituents are known to possess antioxidant, hypolipidemic, and anti-obesity activities. The methanolic extract showed the highest total phenolic content, suggesting that methanol efficiently extracted bioactive polyphenolic compounds responsible for the observed biological activity.

Administration of methanolic and aqueous extracts of *Bombax ceiba* significantly reduced body weight gain in HFD-fed rats. The methanolic extract exhibited greater efficacy than the aqueous extract, particularly at the dose of 300 mg/kg. The reduction in body weight may be attributed to inhibition of lipid absorption, suppression of appetite, enhanced lipid metabolism, and increased energy expenditure. The reduction in food intake observed in extract-treated groups further supports the possibility of appetite-regulating activity.High fat diet significantly increased liver weight and epididymal adipose tissue weight due to excessive fat accumulation. Treatment with *Bombax ceiba* extracts markedly reduced organ and adipose tissue weights, indicating decreased lipid deposition. These results suggest the potential role of the extracts in preventing adipocyte hypertrophy and hepatic steatosis associated with obesity.

Serum biochemical analysis demonstrated that HFD caused marked elevation of total cholesterol, triglycerides, LDL, and atherogenic index along with reduction in HDL levels. Such dyslipidemia is a characteristic feature of obesity and contributes to cardiovascular complications. Treatment with *Bombax ceiba* extracts significantly improved lipid profiles, especially in the methanolic extract-treated groups. The hypolipidemic effect may be related to the presence of flavonoids and phenolic compounds which are known to modulate lipid metabolism and inhibit oxidative stress.Elevated levels of SGOT, SGPT, and bilirubin in HFD-fed animals indicated hepatic injury caused by excessive fat accumulation and oxidative stress. Administration of the extracts significantly reduced these liver enzyme levels, suggesting hepatoprotective activity. The antioxidant properties of phenolic compounds present in the extracts may protect hepatocytes from oxidative damage and improve liver function.

The results indicate that *Bombax ceiba* flower extracts possess significant anti-obesity activity and improve obesity-associated metabolic abnormalities. The methanolic extract demonstrated superior efficacy, likely due to higher concentration of bioactive phytoconstituents. These findings scientifically validate the traditional medicinal use of *Bombax ceiba* and support its further development as a natural therapeutic agent for obesity management.

5. CONCLUSION

The present study concludes that *Bombax ceiba* flower extracts possess significant anti-obesity activity against high fat diet-induced obesity in experimental rats. Physicochemical and phytochemical evaluations confirmed the quality and presence of important secondary metabolites such as flavonoids, phenolics, tannins, steroids, and triterpenes. The methanolic extract exhibited the highest phenolic content and showed superior pharmacological activity compared to the aqueous extract. Treatment with *Bombax ceiba* extracts significantly reduced body weight gain, food intake, liver weight, epididymal adipose tissue accumulation, and improved serum lipid profile in obese rats. The extracts also demonstrated hepatoprotective effects by reducing elevated liver enzyme levels and bilirubin. Among all tested groups, the methanolic extract at 300 mg/kg produced the most pronounced anti-obesity effect, comparable to the standard drug orlistat. The anti-obesity activity of *Bombax ceiba* may be attributed to its rich phytochemical composition and antioxidant properties, which help regulate lipid metabolism and reduce fat accumulation. Therefore, *Bombax ceiba* flower extract can be considered a promising natural therapeutic candidate for the management of obesity and related metabolic disorders. Further studies are recommended to isolate and characterize the active constituents and to elucidate the precise molecular mechanisms involved in its anti-obesity action.

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