



# Anti obesity prospective of *Dalbergia latifolia* (Roxb.) hydroalcoholic bark extract in high fat diet induced obese rats

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## Abstract

Obesity is an alarming sign and considered as a threat world wide. Since it not only hurt the human body but plays as a basis for other serious diseases like cardiovascular and many more. The 50% hydro-ethanolic extract of *Dalbergia latifolia* bark (*D. latifolia*) (DLBE; %yield= 16.34) and methanolic extract (4.32%) of *D. latifolia* were made. The DLBE was used for the acute oral toxicity and anti-obesity activity in the rodent. However, methanolic extract was used for characterization by high-performance thin layer chromatography (HPTLC) method. During acute toxicity study, it was shown that certainly there was no mortality or morbidity observed up to the maximum dose of 2000 mg/kg after administration of DLBE. The ultimate body weight, food intake, liver weight, total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), triglycerides (TG), aspartate aminotransferase (AST), alanine transaminase (ALT), serum creatinine and blood urea nitrogen (BUN) of rats treated with DLBE at a dose of 200 and 400 mg/kg respectively was considerably diminished to  $p < 0.01$  and  $p < 0.05$  as compared with high-fat diet (HFD) induced obese animals. However, DLBE treated with quite smaller dose revealed a non-significant ( $p > 0.05$ ) effects on above parameters. The histopathological findings of the study from the cross section of liver and kidney show normal architecture in the cells treated with DLBE at a dose of 200 and 400 mg/kg respectively. Thus we can conclude that the bark extract of *D. latifolia* can be used for the treatment of obesity and a novel approach for further investigations of its pathology.

**Keywords** Biochemical estimations · Histopathology · HPTLC · Methanolic bark extract · Obesity

## Introduction

Obesity is defined as an abnormal increase in body fat due to imbalance in energy intake and expenditure (Maffetone et al. 2017). As per weight classification of World Health Organization (WHO), an average weight adult have a body fat percentage in a range of 15–20% and 25–30% respectively for

male and female (Kalluri et al. 2018). It is a multifactorial condition that serves as a profusion of different diseases comprising of hyperglycemia, hypertension, hepatic disease, and cancer etc. (Bluher 2019; Chooi et al. 2018; Shoaib et al. 2020). It is an important health challenge during this era because it affects approximately 312 million subjects worldwide (El-shiekh et al. 2019) and a major cause of mortality and non-fatal health problems (Abdelaal et al. 2017). There are different medical issues which are associated with obesity like apnea, respiratory dysfunctioning, joint issues and several disorders related to the reproductive system (Savini et al. 2013). The approved anti-obesity drugs are orlistat, fluoxetine phentermine or topiramate, sibutramine, bupropion or naltrexone, lorcaserin, and liraglutide (Valsamakis et al. 2017; Park et al. 2020). The lifestyle modifications and surgery are used for the management of obesity (Li and Cheung 2011). However, the associated side effects of these medicine are not limited to nausea, dizziness, insomnia, diarrhea, dyspepsia, constipation and many more (Kang and

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Park 2012). The researchers are doing great efforts to unmet the need for developing a novel herbal anti obesity drugs. Because being natural they must have a desirable pharmacological effect with least side-effects along with different methods of combating obesity (Chandrasekaran et al. 2012). In search of that, we found a genus *Dalbergia* that consists of more than 300 species amongst them about 25 species are found in India.

*Dalbergia latifolia* (Roxb) belongs to family Fabaceae; is an imperative timber tree, treasured for its decorative purpose and frequently used for fragrant wood that is a rich source of aromatic oils basically native of tropical Asia and mostly found in Nepal, India and Indonesia (Anonymous 1972; Chopra et al. 1980). Traditionally it is used to treat diarrhea, indigestion and leprosy. Its ethnomedical properties are; it works as a vermifugal, to increase appetite, cough suppressant, nausea, gastric upset, blood born disease, anti-bacterial, skin disorders etc. (Nadkarni et al. 1954; Parrotta 2001). The above listed medicinal properties are due to the occurrence of flavonoids, isoflavonoids, glycosides and steroids. The chemical constituents which are present in *D. latifolia* are dalbinol, sisafolin coumarin,  $\beta$ -sitosterol, lupeol, latifolin, and dalbergin, latinone, neoflavonoid dalcridon and latinone (Khalid et al. 2015; Dewangan and Acharya 2017). The data from the literature suggested that the flavonoids, sitosterols, tannins, and saponins shown positive possessions in the mechanism to tackle obesity.  $\beta$ -Sitosterol (a natural sterol compound) is structurally similar to the dietary fat which does corporal competition in the gastric tract and thus reduces the absorption of fat in the gastric antrum and act as anti-obesity agent (Chidrawar et al. 2011).

Thus, this contemporary study was aimed to uncover the HPTLC analysis of methanolic bark extract of *D. latifolia* and its quantitative comparison with  $\beta$ -sitosterol. Along with the possible anti-obesity outcome of ethanolic bark extract of *D. latifolia* (DLBE) on HFD induce animal model.

## Materials and methods

### Chemicals and reagents

The ethanol was attained from SD fine chemicals Mumbai, India. The kits for the estimation of biochemical parameters were of span diagnostic kit. All the reagents used during this research were of high quality analytical grade.

### Collection of bark and preparation of extract

*Dalbergia latifolia* barks were collected from the southern part of India (Tamil Nadu). Plant authenticity was confirmed by the National Botanical Research Institute, Lucknow, India and a voucher specimen (NBRI/CIF/90183/2009) was

deposited at the same place for future reference. One gram dried bark powder remained on refluxed by means of 50% aqueous ethanolic solution (10 ml) and methanol both at 35 °C and filtered. The filtrate was collected and kept to be concentrated by the means of rotary evaporator under vacuum (BUCHI Rotavapor). The methanolic extract was made and further used for characterization using HPTLC method.

### Exploration of HPTLC

The methanolic bark extracts of *D. latifolia* and  $\beta$ -sitosterol (standard) were used for thin-layer chromatography by using solvent system toluene, ethyl acetate and formic acid in a ratio of 7.5, 2, and 0.5 correspondingly. The samples were applied on the precolated silica gel plates by the means of a device (Linomat 5) and then further screening was done by the support of Camag HPTLC scanner 3 (win CATS software) at different wavelengths i.e. 254 and 366 nm (Mujumdar et al. 2005). The retention factor ( $R_f$ ) values of the chromatogram were recorded for further investigations.

### Experimental animals

SD rats (weighing  $150 \pm 10$  g) were gained from the National Laboratory Animal Centre (NLAC), Central Drug Research Institute, Lucknow, India. The approval was obtained from Institutional Animal Ethical Committee (IAEC) (IU/Pharma/PhD./CPCSEA/10/18), Integral University, Lucknow. Later on the animals were kept for acclimatization at standard laboratory conditions.

### Acute toxicity study

Acute oral toxicity was done by administering 50% hydro-ethanolic extract of *D. latifolia* in Swiss albino mice having a weight of 25–30 g of either sex ( $n = 6/\text{group}$ ), as per Organization for Economic Co-operation and Development (OECD) 423. The bark extract was directed with 0.3% carboxyl methylcellulose (CMC) suspension at different doses mentioned in the guideline viz., 5, 50, 300 and 2000 mg/kg respectively in all groups, while the normal control group was merely treated with CMC suspension. Mice were observed initially for 4 h and subsequently till 14 days or the commencement of death or what one was earlier (OECD Guideline for testing of Chemicals 2001).

### Experimental procedure

The animals were treated daily for a period of 2 months. During this tenure different parameters were monitored for individual animals, such as body weight, daily intake of food and water. The sample (blood) was collected from the tail vein subsequently on the 60th day of induction for

the estimation of general biochemical parameters. Now the animals were sacrificed and physiological changes were observed.

## Parameters

### Determination of diet and liquid intake

The rats were witnessed daily for their general behavior. The diet and liquid intake were documented during the initial first week of experimentation.

### Estimation of body, organ and fat pad weights

The body weight of each animal was logged every day for all groups. On the last day of dosing the rats were sacrificed for the purpose to isolate the organs viz., heart, liver, kidney, uterus and fat pads further these were washed with saline and weighed by the means of electronic balance (Kaur and Kulkarni 2000).

### Estimation of bio-chemical parameters

Animal blood serum was analyzed for total cholesterol (TC) (Wybenga et al. 1970); high-density lipoprotein (HDL) (Warnick et al. 1985), low-density lipoprotein (LDL) and VLDL (Friedwald et al. 1972), aspartate transaminase (AST) and alanine transaminase (ALT) (Reitman and Frankel 1957), blood urea nitrogen (BUN) and creatinine as per Singh et al. (2010).

### Histopathological examinations

For microscopic examinations, the above-said organs (especially liver and kidney) were cut into minor sections of tissues and then further stored in 10% formalin and subjected for histopathological findings (Lee et al. 2011).

### Statistical analysis

All the data were represented as mean  $\pm$  SEM. The statistical significance among different sets were scrutinized by the means of one-way analysis of variance (ANOVA) followed

by Dunnett's test software graph pad version-3.0 ( $p < 0.05$  was taken as significant).

## Results

### Percentage yield of the extract

The extractive values of DLBE were found to be 16.34% whereas the percentage yield of methanolic extract was noted as 4.32%. For the further pharmacological activity, we used DLBE extract as it possess higher yield as compared to that of methanol. Whereas methanolic extract of *D. latifolia* was used for characterization using HPTLC.

### HPTLC analysis

The  $R_f$  values were recorded by HPTLC fingerprinting techniques and estimated by using methanolic extract of *D. latifolia* at 254 nm and 366 nm (Table 1; Figs. 1 and 2). The peaks of the methanolic extract of *D. latifolia* was found to be similar as the peaks of  $\beta$ -sitosterol (Table 2; Fig. 3).

### Toxicological studies

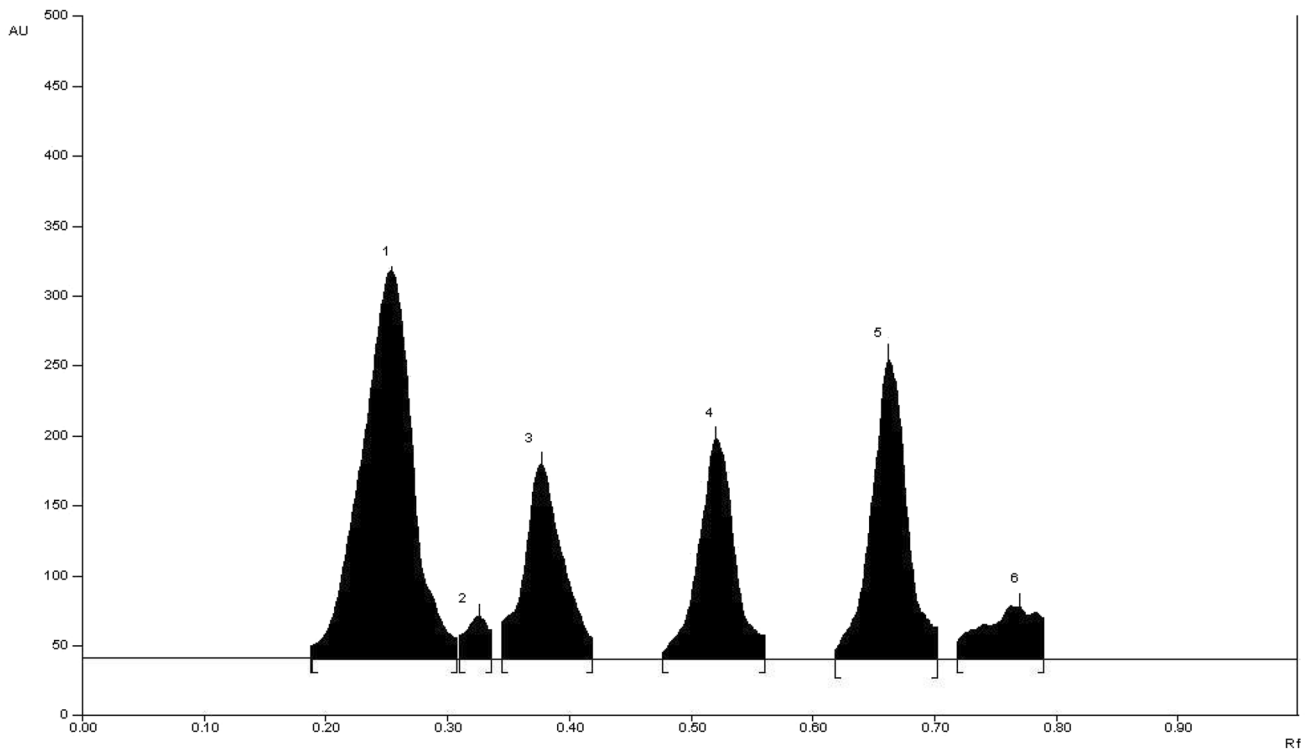
During the observation period, we did not found any abnormality in the behaviour of animals and no mortality was seen at a dose of 50, 300 and 2000 mg/kg respectively. For further anti-obesity study, we used one-tenth and one-fifth of the highest dose i.e. 200 and 400 mg/kg respectively.

### Effects of *D. latifolia* bark extract on body weight of rats

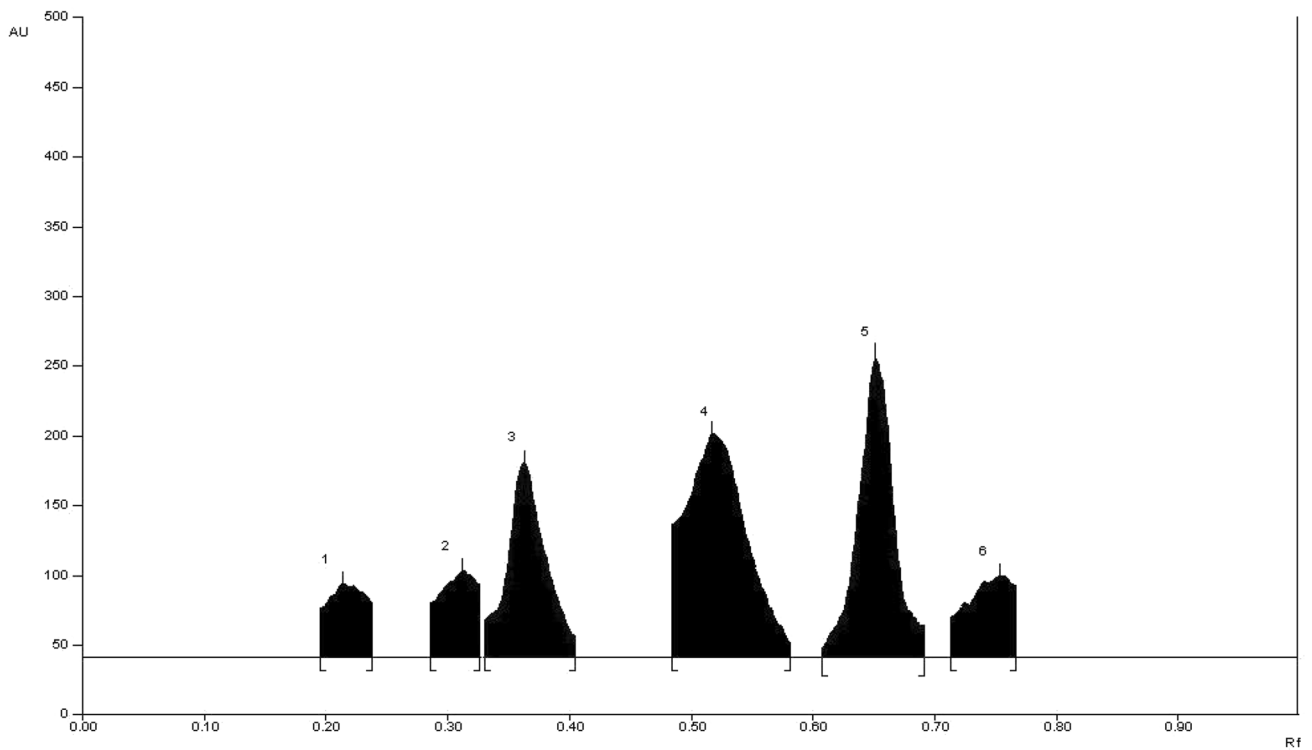
The preliminary and ultimate weight of animals was recorded and mentioned in Table 3. It was documented that the absolute body weight of group II animals treated with HFD considerably enhanced ( $p < 0.01$ ) as compared with group I rats. The group III, V and VI rats showed a significant decline ( $p < 0.01$ ) in the body weight as compared with group II rats. Whereas group IV rats showed non-significant influence on the body weight as compared with group II rats.

**Table 1**  $R_f$  values and area under the curve of each spot of HPTLC fingerprinting of methanolic extract of *D. latifolia* at 254 and 366 nm

S. No.	Extract	$\lambda$ (nm)	$R_f$ values	Area under the curve
1	<i>D. latifolia</i>	254	0.25, 0.33, 0.37, 0.53, 0.68, 0.77	7625.91, 825.62, 5638.13, 5784.21, 6195.24, 1245.95
2		366	0.21, 0.33, 0.38, 0.51, 0.68, 0.78	4105.88, 215.63, 4254.21, 232.23, 3127.54, 6992.74



**Fig. 1** The HPTLC densitogram of methanolic extract of *D. latifolia* showing the presence of different bioactive compounds at 254 nm



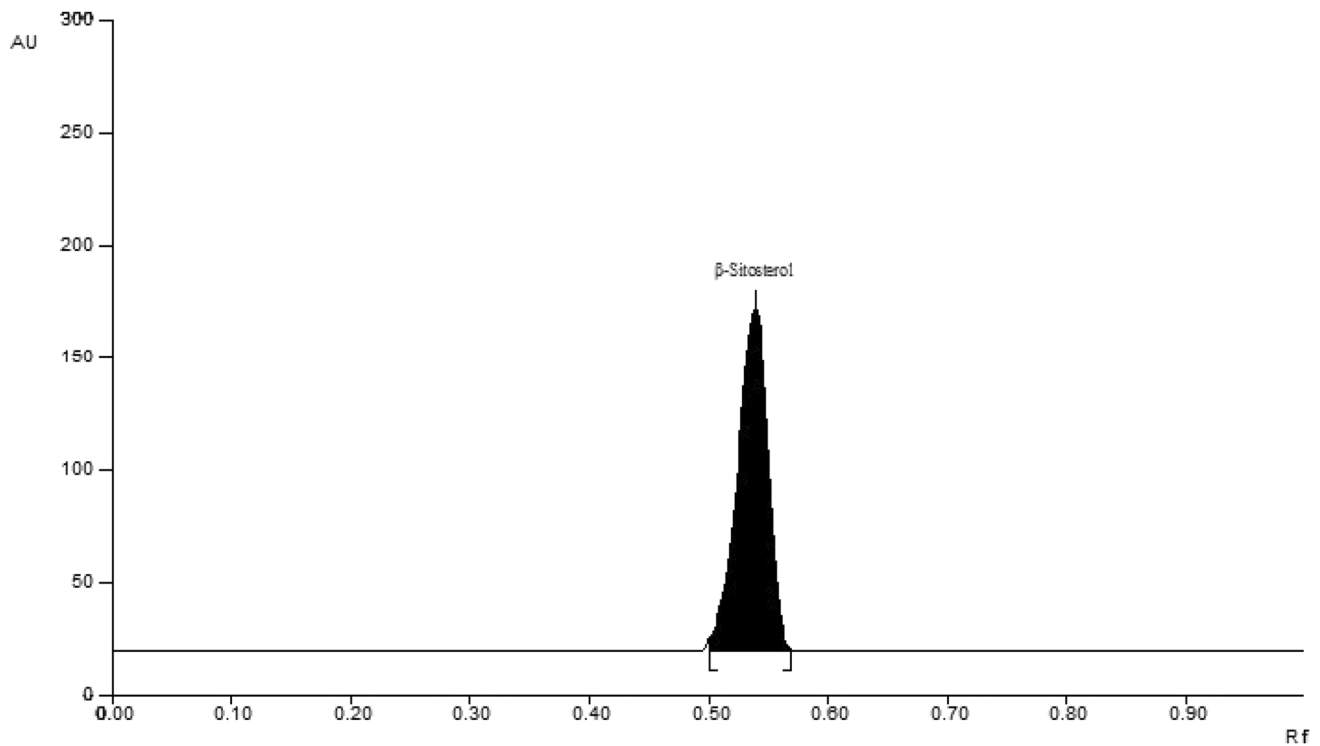
**Fig. 2** HPTLC fingerprinting profile of methanolic extract of *D. latifolia* resembling different constituents at 366 nm

**Table 2**  $R_f$  values and area under the curve of  $\beta$ -sitosterol (major constituent of *D. latifolia*)

S. No.	Standard	$\lambda$ (nm)	$R_f$ values	Area under the curve
1	$\beta$ -Sitosterol	254	0.53	5784.21

**Effect of *D. latifolia* bark extract on food intake**

The food intake pattern of group II is significantly improved ( $p < 0.01$ ) as compared with group I animals whereas group III, V and VI showed a significant reduction ( $p < 0.01$ ) in food consumption as compared with HFD group II animals.

**Fig. 3** HPTLC densitogram of  $\beta$ -sitosterol (major constituent of *D. latifolia*) at 254 nm**Table 3** Effects of *D. latifolia* bark extract (DLBE) on body weight profile in SD rats after 60 days of treatment

Groups	Treatments	Initial body weight (g)	Final body weight (g)	% increase in body weight	% decrease in body weight
I	Normal control (NC)	135.41 $\pm$ 2.12	206.42 $\pm$ 4.84	52.44	–
II	High fat diet (HFD)	135.00 $\pm$ 2.01	315.00 $\pm$ 6.04*	133.34	–
III	HFD + sibutramine (5 mg/kg)	135.60 $\pm$ 2.54	221.25 $\pm$ 5.25 <sup>##</sup>	63.16	71.14
IV	HFD + DLBE (100 mg/kg)	140.18 $\pm$ 2.54	293.83 $\pm$ 5.81 <sup>ns</sup>	109.60	23.74
V	HFD + DLBE (200 mg/kg)	133.17 $\pm$ 1.54	232.69 $\pm$ 5.75 <sup>##</sup>	74.73	58.61
VI	HFD + DLBE (400 mg/kg)	135.29 $\pm$ 1.53	243.42 $\pm$ 4.93 <sup>#</sup>	79.92	53.42

Data are expressed as mean  $\pm$  SEM of six rats in each group

*ns* non-significant compared with group II

\* $p < 0.01$  showed significant compared with group I

<sup>#</sup> $p < 0.05$ ; <sup>##</sup> $p < 0.01$  showed significant compared with group II

**Table 4** Effects of *D. latifolia* bark extract (DLBE) on food intake profile in SD rats after 7 days of treatment

Groups	Treatments	Initial day (g) 0 day	Final day (g) 7th day
I	Normal control (NC)	09.43 ± 0.48	10.60 ± 1.43
II	High fat diet (HFD)	10.21 ± 0.93	17.72 ± 2.11*
III	HFD + sibutramine (5 mg/kg)	09.27 ± 0.69	11.61 ± 1.33 <sup>##</sup>
IV	HFD + DLBE (100 mg/kg)	08.09 ± 0.75	14.97 ± 1.94 <sup>ns</sup>
V	HFD + DLBE (200 mg/kg)	09.27 ± 0.52	12.97 ± 1.37 <sup>##</sup>
VI	HFD + DLBE (400 mg/kg)	08.58 ± 0.61	13.63 ± 1.73 <sup>#</sup>

Data are expressed as mean ± SEM of six rats in each group

*ns* non significant compared with respective HFD group II

\**p* < 0.01 compared with respective normal group I

<sup>#</sup>*p* < 0.05; <sup>##</sup>*p* < 0.01 compared with respective HFD group II

However, group IV animals expended more food with non-significant effects when compared with HFD group II animals (Table 4).

### Effect of *D. latifolia* bark extract on organs fat pad weight

The fat pad weight of different organs (heart, liver, kidney, and uterus) isolated from group II animals showed a significant enhancement (*p* < 0.01) as compared with group I SD rats. The opposite effect was observed in group III and V treated animals i.e. they showed a decline (*p* < 0.01) whereas group VI showed a decrease in the same (*p* < 0.05) in weight of fat pad of various above mentioned organs as compared with group II SD rats. The group IV animals demonstrate a non-significant effect on the fat pad weight of heart, liver, kidney, and uterus as compared with group II SD rats (Table 5).

### Effects of *D. latifolia* bark extract on lipid profile

Group II animals showed a significant improvement (*p* < 0.01) in the total cholesterol, low-density lipoprotein, very low-density lipoprotein and triglyceride along with that significant decline (*p* < 0.01) in high-density lipoproteins

level as compared with normal control group I SD rats. The group III animals showed a significant decrease (*p* < 0.01) in TC, LDL, VLDL, and TG, whereas significant elevated (*p* < 0.01) level of HDL level was observed as compared with group II SD rats. However, treated group (V and VI) with DLBE along with HFD significantly reduced (*p* < 0.01 and *p* < 0.05) the TC, LDL, VLDL, TG levels and elevates (*p* < 0.01 and *p* < 0.05) the level of serum HDL respectively when compared with group II animals. Apart from these effects, the treated group IV showed a non-significant effect on serum levels of TC, LDL, VLDL, TG and HDL compared with group II SD rats (Figs. 4, 5).

### Effects of *D. latifolia* bark extract on liver and kidney biomarkers

The group II animals showed a significant increase (*p* < 0.01) in AST and ALT levels as compared to group I animals. The standard plus HFD treated group III represents a significant decrease (*p* < 0.01) in the level of liver biomarkers such as AST and ALT comparing with the levels of group II animals. Group IV animals resembles a slight reduction (*p* < 0.01, *p* < 0.05) in the serum level of AST and ALT whereas the administration of DLBE treated group V with HFD showed

**Table 5** Effects of *D. latifolia* bark extract (DLBE) on the visceral fat pad in SD rats after 60 days of treatment

Groups	Treatments	Heart (g)	Kidney (g)	Liver (g)	Uterus (g)
I	Normal control (NC)	1.56 ± 0.07	1.14 ± 0.71	1.54 ± 0.11	1.45 ± 0.63
II	High fat diet (HFD)	2.35 ± 0.26*	1.64 ± 1.33*	2.68 ± 1.68*	2.72 ± 0.31*
III	HFD + sibutramine (5 mg/kg)	1.61 ± 0.08 <sup>##</sup>	1.21 ± 0.82 <sup>##</sup>	1.56 ± 1.12 <sup>##</sup>	1.47 ± 0.05 <sup>##</sup>
IV	HFD + DLBE (100 mg/kg)	2.23 ± 0.05 <sup>ns</sup>	1.46 ± 1.25 <sup>ns</sup>	2.07 ± 1.11 <sup>ns</sup>	2.61 ± 0.11 <sup>ns</sup>
V	HFD + DLBE (200 mg/kg)	1.59 ± 0.08 <sup>##</sup>	1.24 ± 0.83 <sup>##</sup>	1.58 ± 1.13 <sup>##</sup>	1.49 ± 0.13 <sup>##</sup>
VI	HFD + DLBE (400 mg/kg)	1.65 ± 0.09 <sup>#</sup>	1.29 ± 0.78 <sup>#</sup>	1.74 ± 1.10 <sup>#</sup>	1.53 ± 0.11 <sup>#</sup>

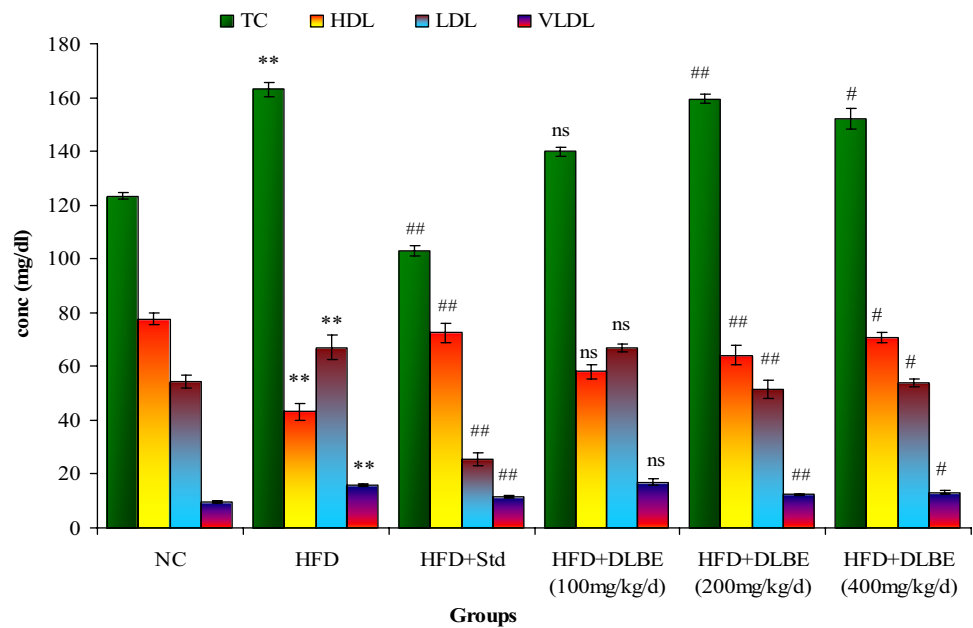
Data are expressed as mean ± SEM of six rats in each group

*ns* non significant compared with respective HFD group II

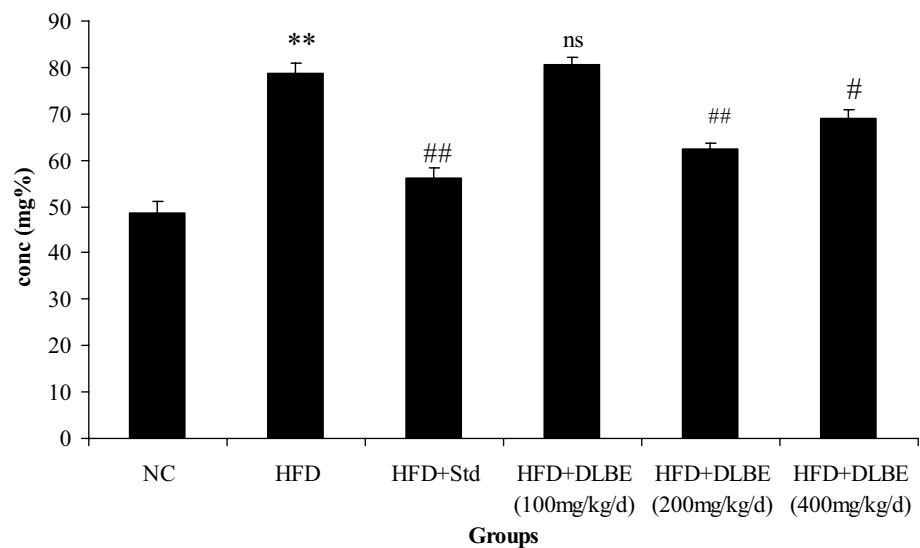
\**p* < 0.01 compared with respective normal control group I

<sup>#</sup>*p* < 0.05; <sup>##</sup>*p* < 0.01 compared with respective HFD group II

**Fig. 4** Effects of *D. latifolia* bark extract (DLBE) on lipid profile in albino SD rats after 60 days of treatment. All values are expressed as mean  $\pm$  S.E.M. values ( $n=6$ ). *ns* non significant, when compared with obese control (group II).  $**p < 0.01$  = highly significant when compared with normal control (group I).  $\#p < 0.05$  = significant when compared with obese control (group II).  $\#\#p < 0.01$  = highly significant when compared with obese control (group II)



**Fig. 5** Effects of *D. latifolia* bark extract (DLBE) on triglyceride in albino SD rats after 60 days of treatment. All values are expressed as mean  $\pm$  S.E.M. values ( $n=6$ ). *ns* non significant, when compared with obese control (group II).  $**p < 0.01$  = highly significant when compared with normal control (group I).  $\#p < 0.05$  = significant when compared with obese control (group II).  $\#\#p < 0.01$  = highly significant when compared with obese control (group II)



a non-significant levels the AST and ALT levels when compared with HFD group II animals (Fig. 6).

Upon justification of kidney function test, we used creatinine and serum blood urea nitrogen as a biomarker the result of all the groups are mentioned in Fig. 7 that reveals that BUN and creatinine levels were elevated in group II treated animals as compared to group I rats. The results of group III animals showed that the BUN and creatinine levels are significantly reduces ( $p < 0.01$ ) when compared with group II SD rats. The DLBE treated group V and VI reveals that

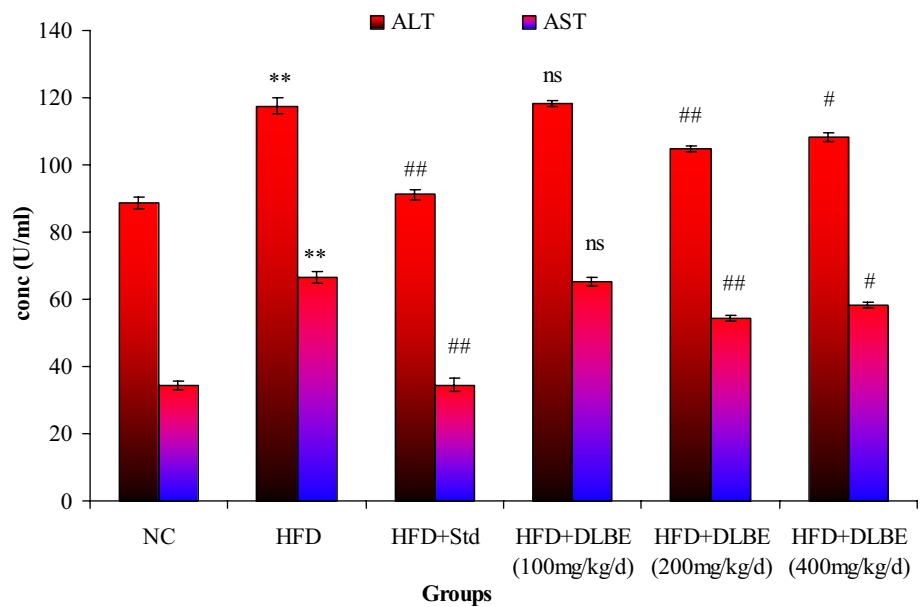
the BUN and creatinine levels were significantly reduced ( $p < 0.01$ ,  $p < 0.05$ ) when compared with group II animals. Although the DLBE treated group IV shows that the level of BUN and creatinine are non-significant while compared with group II animals.

## Histopathology

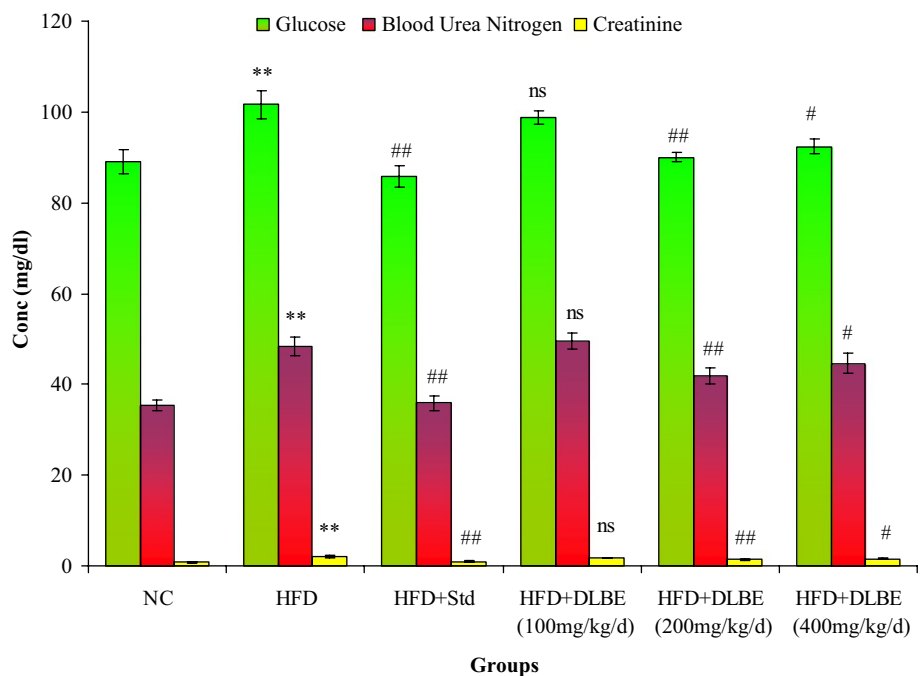
The stained liver section showed that the group I (normal) animals revealed normal architectures. The HFD treated



**Fig. 6** Effects of *Dalbergia latifolia* bark extract (DLBE) on AST and ALT levels in SD rats after 60 days of treatment. All values are expressed as mean  $\pm$  S.E.M. values ( $n=6$ ). \* $p < 0.01$  compared with respective normal control group I. # $p < 0.05$ , ## $p < 0.01$  compared with respective HFD group II. ns non significant compared with respective HFD group II



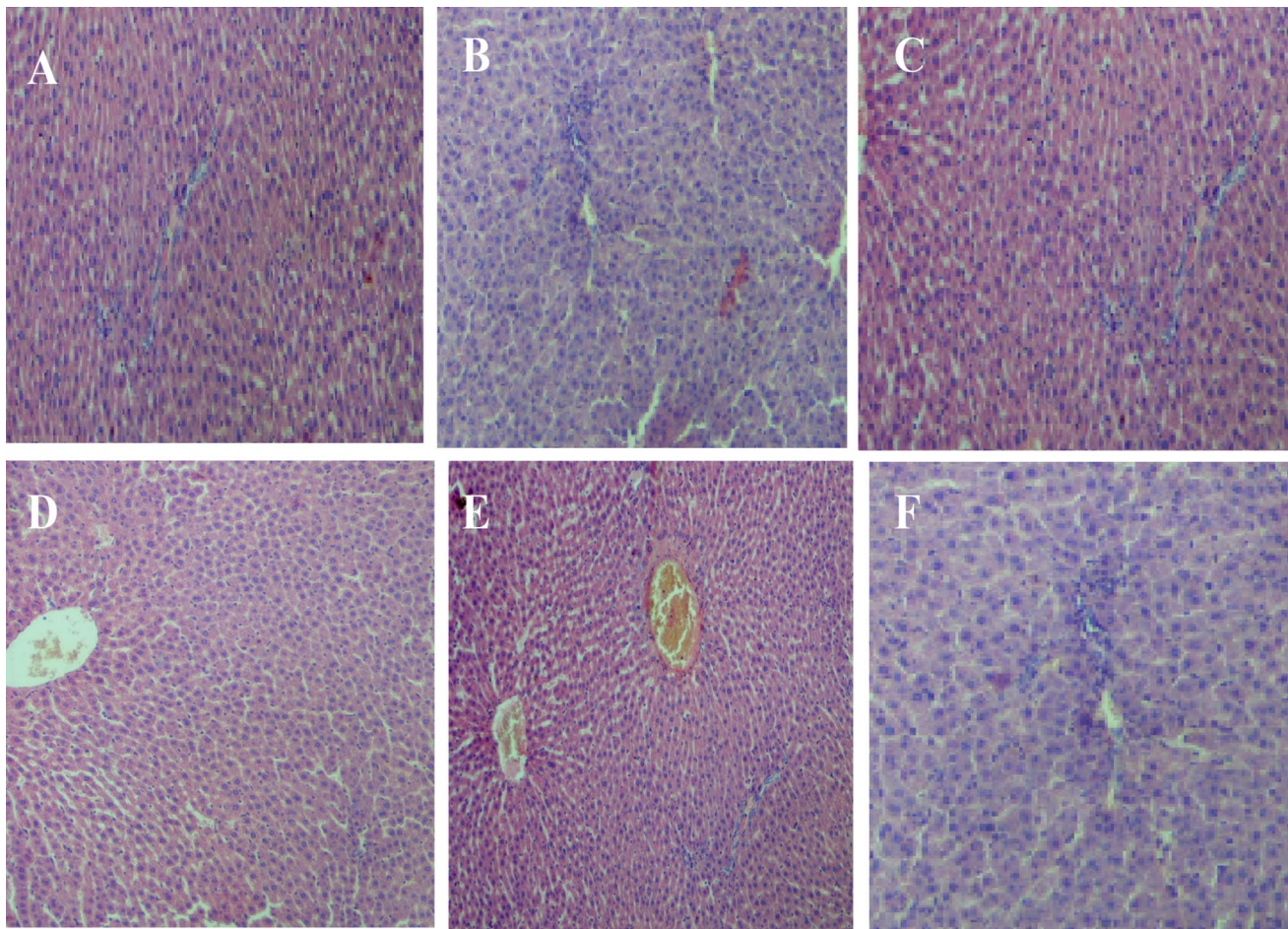
**Fig. 7** Effects of *D. latifolia* bark extract (DLBE) on BUN and creatinine levels in SD rats after 60 days of treatment. All values are expressed as mean  $\pm$  S.E.M. values ( $n=6$ ). \* $p < 0.01$  compared with respective normal group I. # $p < 0.05$ , ## $p < 0.01$  compared with respective HFD group II. ns non significant compared with respective HFD group II



group II induced toxicity showed rupture of nucleus. Group III that was treated group with 5 mg/kg sibutramine showed normal structure. Group IV treated at a dose of 100 mg/kg DLBE along with HFD the cells was ruptured. The treated group with DLBE at a dose of 200 and 400 mg/kg the cells were showing normal architecture (Fig. 8).

The kidney section of group I (normal) animal's revealed normal architectures. HFD group II-induced toxicity showed rupture of the nucleus. Group III rats treated with 5 mg/kg sibutramine showed the normal structure of the kidney section. Group IV treated at a dose of 100 mg/kg of DLBE along with HFD the cells was ruptured. The animals that





**Fig. 8** Hematoxylin and eosin-stained sections of rat liver ( $\times 10$ ) in experimental groups of animals. **a** Group I: normal group animals revealed normal architectures. **b** HFD group II-induced toxicity showing rupture of nucleus. **c** Group III administration of 5 mg/kg

sibutramine showing normal structure. **d** Group IV treated at a dose of 100 mg/kg DLBE along with HFD the cells was ruptured. **e, f** Treated with DLBE at a dose of 200 and 400 mg/kg the cells were showed normal architecture

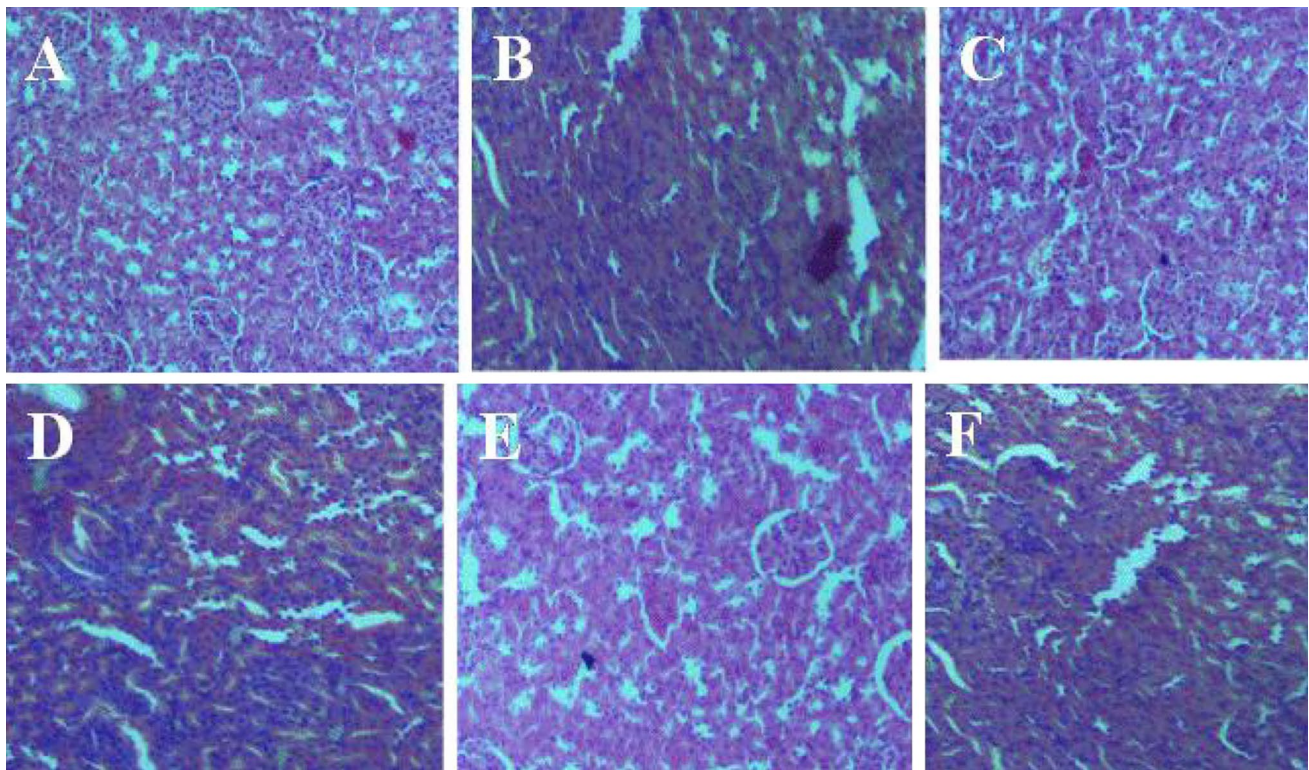
were treated with DLBE at a dose of 200 and 400 mg/kg the cells showed normal architecture (Fig. 9).

## Discussion

$\beta$ -sitosterol is the major compound found in *D. latifolia* that is structurally similar to the dietary fat which does corporal competition in the gastric tract and thus reduces the absorption of fat in the gastric antrum and act as anti-obesity agent (Chidrawar et al. 2011). From the HPTLC data it was recorded that DLBE consist of  $\beta$ -sitosterol in the majority. Thus we can say that the antiobesity activity of DLBE may be due to the presence of  $\beta$ -sitosterol. To balance the fat is precarious in the etiology of disease related to obesity. The animals are served with HFD and simultaneously they are treated with drug this is considered as an important factor in the obesity studies (Kusunoli et al. 2000). After

treating the animals for 60 days with HFD the body weight elevates and this is also proven by our study. The results of our study show that in HFD group animals the body weights increases in a percentage approximately 133.34% which is significantly higher ( $p < 0.01$ ) than the normal control group animals. While treatment with the standard drug sibutramine which commonly used for the purpose to reduce the weights of overweight adults (Al-Tahami et al. 2017). The animal group that is treated with sibutramine at a dose of 5 mg/kg (group III) showed a reduction in the weight of body approximately 71.14% while compared with high-fat diet group animals. The recent study demonstrates that the HFD group displayed enhanced gain in body weight ratio as compared with the normal diet and this seems to be a hallmark of the obesity (Meriga et al. 2017). The body weight of the animals treated with DLBE along with HFD groups at a dose of 200 and 400 mg/kg respectively significantly diminishes it ( $p < 0.01/58.61$  and  $p < 0.05/53.42\%$ ) when compared with





**Fig. 9** Hematoxylin and eosin-stained sections of rat kidney ( $\times 10$ ) in experimental groups of animals. **a** Group I: normal group animals revealed normal architectures. **b** HFD group II-induced toxicity showing rupture of nucleus. **c** Group III administration of 5 mg/kg

sibutramine showing normal structure. **d** Group IV treated at a dose of 100 mg/kg of DLBE along with HFD the cells was ruptured. **e, f** Treated with DLBE at a dose of 200 and 400 mg/kg the cells were showing normal architecture

high-fat diet-induced group animals. Above all; the bark extract shows a non-significant effect on the body weight when it is taken in a small doses such as 100 mg/kg. Thus we can conclude that overall DLBE had the capability to moderate the body weight gain that could be owing due to its collective possessions on different pathways such as metabolic and serotonin (Asgar et al. 2006). The plant extract having the property to inhibit the metabolism of carbohydrate and fatty acids, thus these changes send signals to the brain that causes a reduction in the appetite (Sullivan et al. 1974).

Fat pad comprises the adipose tissue and is surrounded in the nearby areas of the gastrointestinal tract (Chen et al. 2012). The comparative weight of visceral fat pad depots was expressively increased ( $p < 0.01$ ) in high-fat diet treated group as compared with the normal group. The plant extract treated group (V and VI) supplemented with HFD shows a significant decline ( $p < 0.01$ ) in the weight of organs (heart, kidney, liver, spleen and uterine fat-pad weight) while compared with group II animals. Treatment of rats with DLBE (200 mg/kg) was capable to moderate the body weight ( $p < 0.01$ ) due to metabolic effects and modification in 5-hydroxytryptamine pathways. The preferment of lipolysis in adipocytes is major mechanisms for the prevention of fat accretion (Bairras et al. 2007). Furthermore, numerous

reports disclosed the provincial differences in adipose metabolism that includes the receptiveness to nutritional treatments/workout and hormones that promotes lipolysis (Doucet et al. 2002). Management of HFD treated animals by administrating them with DLBE (200 mg/kg) was capable to decrease the fat pad weight due to lipolysis of adipose tissue.

A condition in which there is an alteration of lipoprotein metabolism that is possibly due to the metabolism of lipoprotein. Hence in this situation there will be a noticeable elevation in the serum level of total cholesterol, LDL and TG whereas the level of HDL remains decline (Ahmad et al. 1998). Usually, the lipids get absorbed into the gastrointestinal tract through a form of chylomicrons, TG, phospholipids and cholesterol (Guyton and Hall 1996). The bark extract of *D. latifolia* showed a significant decrease ( $p < 0.01$  and  $p < 0.05$ ) in the level of TC, VLDL, TG and LDL, in a graded dosing manner ((200 and 400 mg/kg respectively). However, after treating the animals for 60 days at a dose below 100 mg/kg of DLBE; it does not show any significant role. This may be possible due to the structural similarity of the phytoconstituent  $\beta$ -sitosterol to that of cholesterol. That may act as a possible target to diminish the plasma cholesterol level in a significant pattern (Hirunpanich et al. 2006).

The level of liver marker enzyme (AST and ALT) are found to be normal in a standard circumstance nevertheless a condition in which patient having hepatic complications such as necrosis or membrane damage these enzymes get elevated and get transferred into the systemic circulation. These elevated level of liver biomarkers shows that there is a deformity in the liver that results in an elevated level of AST and ALT (Hussain et al. 2012). Among all the biomarkers ALT is a specific hepatoenzyme principally found in the cytoplasm (Nyblom et al. 2006). Treatment of the animals with DLBE (200 and 400 mg/kg) showed a protective effect on the hepatic biomarkers and resulted in the reduce level ( $p < 0.01$ ,  $p < 0.05$ ) of AST and ALT. the same thing was observed in the kidney function test that the markers BUN and creatinine were significantly increased ( $p < 0.01$ ) in HFD treated group alone as compared with normal treated animals. The bark extract of *D. latifolia* showed a significant reduction ( $p < 0.01$ ,  $p < 0.05$ ) in serum blood urea nitrogen and creatinine level while compared with the animals treated solely with high-fat diet.

A wide number of metabolic disorders are due to the accumulation of fat in visceral organs such as liver and kidney that results in a normal human being into an obese. Thus leads to change in the microscopical structure of tissues which shows drastic changes into the architecture of different organs of the body. Predominantly it causes disarrangement of glomeruli with inflammation in kidney and also generation of fat in the liver and other parts of the body. The bark extract of the plant *D. latifolia* at a dose of 200 and 400 mg/kg showed a defensive action on the liver and kidney and act in the management of obesity and related diseases. While it does not show any protective effect when given in a specific low dose i.e. 100 mg/kg. Hence from this study, we came on the result that the *D. latifolia* bark extract shoes a protective action in HFD induce obesity in a dose depended manner and can use a possible agent for target drug delivery.

## Conclusion

*D. latifolia* used traditionally or locally as an antiobese. Many traditional preparations are available constituted *D. latifolia*. An attempt was taken to explore the scientific anti-obesity activity of *D. latifolia* in rodents. Hydroalcoholic extract of *D. latifolia* at a dose of 200 mg/kg and 400 mg/kg significantly showed more slim and non-corpulent effects ( $p < 0.01$ ,  $p < 0.05$ ) during animal studies. This can be proven by its controlled weight gain mechanism, progressed lipid profile, biochemical parameters and histopathology findings. The bark of *D. latifolia* is enriched with flavonoids, and phenolic acid compounds and it could be a new therapeutic antioxidant and mast cells stabilizing effects. Overall constituents present in the extract may play an important role

in targeting obesity. Thus, further studies can be performed to explore more molecular mechanism so that it can be used as an encouraging anti-obesity agent.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest associated with this manuscript.

## References

- Abdelaal M, Roux CW, Docherty NG (2017) Morbidity and mortality associated with obesity. *Ann Transl Med* 5:161
- Ahmed SM, Clasen ME, Donnelly JF (1998) Management of dyslipidemia in adults. *Am Fam Phys* 57:2192–2204
- Al-Tahami BAM, Ab AASI, Sanip Z, Yusoff Z, Shihabudin TMT, Singh TSP, Rasool AHG (2017) Metabolic and inflammatory changes with orlistat and sibutramine treatment in obese Malaysian subjects. *J Nippon Med Sch* 84:125–132
- Anonymous (1972) Wealth of Indian raw materials. Publication and information directorate, CSIR, New Delhi, pp 214–230
- Asghar M, Zeyssig R, Monjok E, Kouamou G, Ohia SE, Lokhandwala MF, Bagchi D (2006) Hydroxycitric acid (HCA-SX) decreases oxidative stress and insulin resistance and increases brain serotonin levels in obese Zucker rats. *Exp Biol Meet* 20:655
- Bairras C, Mauriege P, Bukowiecki L, Atgie C (2007) Regulation of lipolysis in white adipose tissues of lean and obese Zucker rats. *J Physiol Biochem* 63:287–296
- Bluher M (2019) Obesity: global epidemiology and pathogenesis. *Nat Rev Endocrinol* 15:288–298
- Chandrasekaran CV, Vijayalakshmi MA, Prakash K, Bansal VS, Meenakshi J, Amit A (2012) Review article: herbal approach for obesity management. *Am J Plant Sci* 3:1003–1014
- Chen J, Wang R, Li XF, Wang RL (2012) Bifidobacterium adolescentis supplementation ameliorates visceral fat accumulation and insulin sensitivity in an experimental model of the metabolic syndrome. *Br J Nutr* 107:1429–1434
- Chidrawar VR, Patel KN, Sheth NR, Shiromwar SS, Trivedi P (2011) Antiobesity effect of *Stellaria media* against drug induced obesity in Swiss albino mice. *Ayu* 32(4):576
- Chooi YC, Ding C, Magkos F (2018) The epidemiology of obesity. *Metabolism* 92:6–10
- Chopra RN, Nyer, SL, Chopra IC (1980) Supplement to the glossary of Indian medicinal plants. CSIR, New Delhi, p 90
- Dewangan P, Acharya V (2017) Ethnomedicinal importance of some plants of Family Leguminosae. *Indian J Appl Pure Biol* 32(2):155–161
- Doucet E, St-Pierre S, Almeras N, Imbeault P, Mauriege P, Pascot A, Despres JP, Tremblay A (2002) Reduction of visceral adipose tissue during weight loss. *Eur J Clin Nutr* 56:297–304
- El-shiekh RA, Al-Mahdy DA, Mounier SM, Hifnawy MS, Abdel-Sattar EA (2019) Anti-obesity effect of argel (*Solenostemma argel*) on obese rats fed a high fat diet. *J Ethnopharmacol* 238:111893. <https://doi.org/10.1016/j.jep.2019.111893>
- Friedewald WT, Levy RI, Fredrickson DS (1972) Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem* 18:499–502
- Guyton AC, Hall JE (1996) In: Guyton AC (ed) Textbook of medial physiology, 9th edn. W. B. Saunders, Philadelphia, PA, pp 869–899

- Hirunpanich V, Utaipat A, Morales NP, Bunyapraphatsara N, Sato H, Herunsale A, Suthisisang C (2006) Hypocholesterolemic and antioxidant effects of aqueous extracts from the dried calyx of *Hibiscus sabdariffa* L. in hypercholesterolemic rats. *J Ethnopharmacol* 103:252–260
- Hussain T, Gupta RK, Sweetey K, Khan MS, Hussain MS, Arif M, Hussain A, Faiyazuddin M, Rao CV (2012) Evaluation of antihepatotoxic potential of *Solanum xanthocarpum* fruit extract against antitubercular drugs induced hepatopathy in experimental rodents. *Asian Pac J Trop Biomed* 2:454–460
- Kalluri SN, Bhupathi ES, Ganji V (2018) Correlation of baseline and Isometric exercise-induced blood pressure with total body fat percentage and body mass index in female medical students. *Int J Clin Exp Physiol* 5:81–86
- Kang JG, Park CY (2012) Anti-obesity drugs: a review about their effects and safety. *Diabetes Metab J* 36:13–25
- Kaur G, Kulkarni SK (2000) Antiobesity effect of a polyherbal formulation, ob-200g in female rats fed on cafeteria and atherogenic diets. *Indian J Pharmacol* 32:294–299
- Khalid M, Akhtar J, Badruddeen AM, Singh K (2015) Pharmacognostical investigation and total phenolic content of *Dalbergia latifolia* (Roxb.) bark. *Int J Pharmacogn* 2:248–253
- Kusunoli M, Hara T, Tsutsumi K, Nakamura T, Miyata T, Sakakibara F, Sakamoto S, Ogawa H, Nakaya Y, Storlien LH (2000) The lipoprotein lipase activator, No-1886, suppresses fat accumulation and insulin resistance in rats fed a high fat diet. *Diabetol* 43:875–880
- Lee HI, Kim MS, Lee KM, Park SK, Seo K, Kim HJ, Kim MJ, Choi MS, Lee K (2011) Anti-visceral obesity and antioxidant effects of powdered sea buckthorn (*Hippophae rhamnoides* L.) leaf tea in diet-induced obese mice. *Food Chem Toxicol* 49:2370–2376
- Li MF, Cheung BM (2011) Rise and fall of anti-obesity drugs. *World J Diabetes* 2:9–23
- Maffetone PB, Rivera-Dominguez I, Laursen PB (2017) Over fat and under fat: new terms and definitions long overdue. *Front Public Health* 4:279
- Meriga B, Parim B, Chunduri VR, Naik RR, Nemani H, Suresh P, Uddand Rao VS (2017) Antiobesity potential of Piperonal: promising modulation of body composition, lipid profiles and obesogenic marker expression in HFD-induced obese rats. *Nutr Metab* 14:72
- Mujumdar AM, Misar AV, Upadhye AS (2005) Antidiarrhoeal activity of ethanol extract of the bark of *Dalbergia lanceolaria*. *J Ethnopharmacol* 102(2):213–216
- Nadkarni KM (1954) Indian materia medica. Popular book depot, Bombay, p 432
- Nyblom H, Bjornsson E, Simren M, Aldenborg F, Almer S, Olsson R (2006) The AST/ALT ratio as an indicator of cirrhosis in patients with PBC. *Liver Int* 26:840–845
- O. E. C. D. (2001) Acute oral toxicity-Acute oral toxic class method. Guideline 423. adopted 23/06/1996) Eleventh Addendum to the OECD guidelines for the testing of chemicals, Organization for Economic Co-operation and Development, Paris, 2001
- Park YH, An M, Kim JK, Lim YH (2020) Antiobesity effect of ethanolic extract of *Ramulus mori* in differentiated 3T3-L1 adipocytes and high-fat diet-induced obese mice. *J Ethnopharmacol* 251:112542
- Parrotta JA (2001) Healing plants of peninsular India. CABI publishing, Puerto Rico, USA, p 387
- Reitman S, Frankel S (1957) A colorimetric method for the determination of serum glutamic oxalacetic and glutamic pyruvic transaminases. *Am J Clin Pathol* 28:56–63
- Savini I, Catani MV, Evangelista D, Gasperi V, Avigliano L (2013) Obesity-associated oxidative stress: strategies finalized to improve redox state. *Int J Mol Sci* 14(5):10497–10538
- Shoab A, Salem Bekhit MM, Siddiqui HH, Dixit RK, Bayomi M, Khalid M, Shakeel F (2020) Antidiabetic activity of standardized dried tubers extract of *Aconitum napellus* in streptozotocin-induced diabetic rats. *3 Biotech* 10(2):56
- Singh T, Singh K, Sharma PL (2010) Ameliorative potential of angiotensin1-7/Mas receptor axis in streptozotocin-induced diabetic nephropathy in rats. *Method Find Exp Clin* 32:19–25
- Sullivan AC, Triscari J, Hamilton JG, Miller ON, Wheatley VR (1974) Effect of (-)-hydroxycitrate upon the accumulation of lipid in the rat. *Lipogenesis Lipids* 9:121–128
- Valsamakis G, Konstantakou P, Mastorakos G (2017) New targets for drug treatment of obesity. *Annu Rev Pharmacol* 57:585–605
- Warnick GR, Nguyen T, Albers AA (1985) Comparison of improved precipitation methods for quantification of high-density lipoprotein cholesterol. *Clin Chem* 31:217–222
- Wybenga DR, Pileggi VJ, Dirstine PH, Giorgio JD (1970) Direct manual determination of serum total cholesterol with a single stable reagent. *Clin Chem* 16:980–984