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Sub-acute oral toxicity evaluation of aqueous extract of bamboo shoots (*Dendrocalamus hamiltonii*) in Balb/c mice

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ABSTRACT

Probiotics Bamboo shoot (*Dendrocalamus hamiltonii)*, the young tender and immature culm, is being considered as a complete health food due to its high nutritional and bioactive content. Although, freshly harvested bamboo shoots are nutritionally richer; anti-nutritional factors and toxicity in fresh shoots used for consumption are a matter of concern. This study was conducted to evaluate the sub-acute oral toxicity of aqueous extract in shoots of *Dendrocalamus hamiltonii*. The bamboo shoot extract was administered orally to Balb/c mice at doses of 400, 800 and 1600 mg/kg, body weight for 28 days. Results revealed a significant enhancement in the level of reduced glutathione and superoxide dismutase accompanied by a significant reduction in the level of lipid peroxidation. A dose-dependent increase was observed in the activity of glutathione peroxidase and glutathione reductase while, a marked reduction was seen in the activity of enzyme catalase. None of any mortality and behavioral changes was observed. At higher dose (1600 mg/kg, body weight) the level of serum creatinine, serum glutamic pyruvic transaminase and lactate dehydrogenase increased significantly however, the histo-architecture of liver and kidney was normal. Therefore, it is concluded that the medium-term oral administration of the bamboo shoot extract for 28 days does not cause toxicity.

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1. Introduction

Bamboo (*Dendrocalamus hamiltonii)* is a plant with multidimensional uses being used as fuel, food, shelter, rural housing, fencing, agricultural implements and tools. In modern days, it is being used as industrial raw material, construction and engineering materials, food and medicine (1). Each part of the bamboo plant viz. leaf, rhizome, culm, culm sheath, root and shoot are used for various purposes. Extracts from bamboo shoots, leaves and culm have anti-cancer, anti-hyperlipidemic, anti-aging, anti-viral and anti-bacterial functions (2-6).

Bamboo-based products such as bamboo vinegar, bamboo extracts, bamboo salt, and bamboo silica occupy a significant position in the 21st century (7,8).

Bamboo shoots, the young emerging aerial culms have a long history of being used as a source of food and medicine in many Asian countries. The juvenile shoots are delicious, crispy and rich in nutrients and bioactive compounds such as phenols, phytosterols, dietary fiber etc. and gaining worldwide popularity as a health food. They are consumed as vegetables, pickles, salads, and in preparation of different types of dishes in many Asian countries especially in India, China and Japan (9-13). Freshly harvested shoots are generally consumed after processing and long term preservation due to the presence of high content of an anti-nutrient, cyanogenic glycoside and very short shelf life of shoots (14,15).

Natural products from plants are in great demand for developing new drugs as they have several health promoting constituents.

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However, it is important to conduct toxicity studies of the plants before using for the development of functional foods and pharmaceuticals to ensure safety to humans. Despite the increasing number of reports on the therapeutic uses of bamboo shoots, the *in-vivo* toxicological effects of the shoots have yet to be reported. To the best of our knowledge, this is the first report of toxicity evaluation of bamboo shoot extract in animal models for its safe utilization in food and medicinal products. In the present study, sub-acute toxicity test was performed in Balb/c mice to find out the adverse effects of aqueous crude extract of freshly harvested shoots of a popular edible bamboo, *Dendrocalamus hamiltonii* (Nees & Arn Ex Munro) on some observable and biochemical parameters. The results would serve as a very important baseline for further studies in developing functional foods and nutraceuticals from the fresh juvenile shoots of *D. hamiltonii*.

2. Materials and Methods

2.1. Collection of bamboo shoots

Two weeks old shoots of *D. hamiltonii* were collected during the month of July from Shillong, Meghalaya, India. After harvesting, the shoots were extracted softly and the soil was leveled. Thereafter, the shoots were packed properly and transported from Shillong to Botany Department, Panjab University, Chandigarh, India by air.

2.2. Preparation of bamboo shoots

In the laboratory, shoots were washed properly, the hard basal portion was discarded, culm sheaths were removed and weight of the shoots was noted. The shoots were then cut into thin slices, dried at 60^{o}C for 48 h and pulverized to fine powder using mortar and pestle.

2.3. Preparation of bamboo shoot extract (BSE)

For this, 10 g of dried bamboo shoot powder was taken in a conical flask and soaked in 100 ml of distilled water. The conical flask was plugged with cotton wool and then kept on a rotary shaker at 120 rpm for 24 h. The extract was then filtered and dried using a hot air oven at low temperature. The dried crude extract was weighed and stored at 4^{o}C in air tight bottles for further experiment.

2.4. Qualitative Phytochemical Analysis

Preliminary phytochemical analysis of crude aqueous extract was carried out to identify different phytochemicals present in the extract using the established laboratory methods.

2.5. Experimental design

Sub-acute oral toxicity study was conducted on the shoots of *D. hamiltonii* according to OECD (Organization for Economic Co-operation and Development, 1998) (16) Guidelines 407, adopted on 3rd October, 2008-Repeated Dose 28-Day Oral Toxicity Study in Rodents. The experimental protocols were approved by the Institutional Ethics Committee (Panjab University, Chandigarh, India) and conducted according to the Indian National Science Academy Guidelines for the use and care of experimental animals. The animals (male Balb/c mice weighing 28-40 g each) were obtained from Central Animal House, Panjab University, Chandigarh, India, kept in the cages bedded with sterilized rice husk and maintained at Department of Biophysics, Panjab University, Chandigarh, India in a 12 h light/dark cycle at 25±2 ^{o}C. All animals had free access to standard animal pellet diet (Ashirwad Industries Ltd., Ropar, Panjab) and clean tap water all the time.

For the experiment, mice were randomly assigned into four groups (N=5). Group-1 served as control group. To other groups, BSE was administered at concentration 400, 800 and 1600 mg/kg, body weight in the dose volume of 1 ml/kg, body weight as aqueous suspensions for 28 days. The doses were selected on the basis of signs of toxicity. High dose produced significant changes in the biochemical parameters, low dose caused no/non-significant changes in biochemical parameters while; the medium dose fixed midway between the high and low dose. The control group was given tap water and feed *ad libitum*. The animals were closely observed daily in the morning for overt signs of toxicity and mortality. The body weight of the mice was measured once per week by using digital balance. After completion of the treatment period, the mice were kept on fasting overnight and blood was collected from the retro-orbital plexus of the eye. 500 µl of blood was withdrawn in micro centrifuge tubes and incubated in an upright position at 37^{o}C for 3 h. Thereafter, the samples were centrifuged at 3000 rpm for 10 min and the serum was carefully aspirated for biochemical analysis. The animals were then sacrificed by cervical dislocation under chloroform general anesthesia; the liver and kidney tissues were excised out and analyzed for biochemical and histoarchitecture alterations.

2.6. Biochemical estimations

The serum sample was used to determine the level of alkaline phosphatase (ALP), serum glutamic pyruvic transaminase (SGPT), serum glutamate oxaloacetate transaminases (SGOT), the total bilirubin, albumin, lactate dehydrogenase (LDH), creatinine, urea, blood urea nitrogen (BUN), glucose, total cholesterol (TC), high-density lipoproteins (HDL), low-density lipoproteins (LDL), triglyceride (TG) by using commercially available standard kits and total proteins by using Lowry's method (Lowry et al.) (17).

2.7. Assessment of oxidative stress

The quantitative measurement of lipid peroxidation (LPO) in liver was performed according to the method of Trush et al., (18) reduced glutathione (GSH) level in the liver homogenate was estimated according to the method of Moron et al. (19) and the activity of glutathione reductase (GR), glutathione peroxidase (GPx), catalase (CAT) and superoxide dismutase (SOD) was assayed according to the methods of Williams and Arscott (20), Paglia and Valentine (21), Luck (22) and Kono (23) respectively.

2.8. Histopathological studies

For histopathology, liver and kidney tissues removed aseptically from the animals, were cut into small pieces and fixed in 10% buffered formalin to preserve the cellular structure of the tissue. After fixation, the water was removed from the tissue block using isopropyl alcohol in a slow, step-wise manner by passing the tissue block through a series of solutions of increasing isopropyl alcohol concentration. Thereafter, the tissue blocks were infiltrated with paraffin and 5µm thick section was cut and mounted on individual microscope slides. The extra paraffin was removed before staining using benzene and the slides were stained using hematoxylin and eosin stains to investigate histopathological changes.

2.9. Statistical analysis

Data were reported as mean±SD (standard deviation), analyzed through analysis of variance (ANOVA) using PASW Statistics (version 18.0) to determine the level of significance. The separation of means or significant difference contrasts was done by post-hoc test. The numerical consequence was well-defined as $F < 0.05$.

3. Results

3.1. Phytochemical screening of bamboo shoot extract

The preliminary qualitative phytochemical examination of aqueous bamboo shoot extract revealed the presence of nutrients like proteins, amino acids, carbohydrates and secondary metabolites such as phenols, flavonoids, saponins, triterpenes etc. (Table 1).

Table 1. Phytochemical analysis of bamboo shoot extract

Test	Phytochemical	Observation
Wagner's reagent	Alkaloids	-
Molisch test	Carbohydrates	+
Picrate paper	Cyanogenic glycosides	+
Frothing test	Saponins	+
Conc. sulphuric acid	Triterpenes	+
Ferric chloride	Phenols	+
Liebermann-Burchard reaction	Phytosterols	-
Ferric chloride	Tannins	-
Alkaline reagent	Flavonoids	+
Ninhydrin reagent	Amino acid	+
Ninhydrin reagent	Proteins	+

(+) Present, (-) Absent

3.2. General behavior and mortality

There was not any dose-related change in the general behavior, color of skin, fur and eye observed among the groups of mice during the whole study period. Daily oral administration of BSE for 28 consecutive days did not induce any obvious symptoms of toxicity in any of the dosage groups. No lethality was recorded during the observation days following bamboo shoots extract administration.

3.3. Body and organ weight

The alterations in the body and organs weight were observed with all the doses. Mean body weight gain was calculated for each group. All treated mice in each of the dosage groups continued to gain weight normally throughout the study period except the group treated with lower dose (400 mg/kg, body weight), where a slight decrease in weight was observed. The highest increase in the body weight during experimental period was observed in the control group (Figure. 1). The relative weight of liver increased significantly with all the doses when compared with normal control group. But the effect of BSE was reverse on the weight of kidney. The relative

weight of kidney decreased with all the doses but a significant decrease was seen at the dose level 800 mg/kg, body weight as compared to the control group and other doses (Figure. 2).

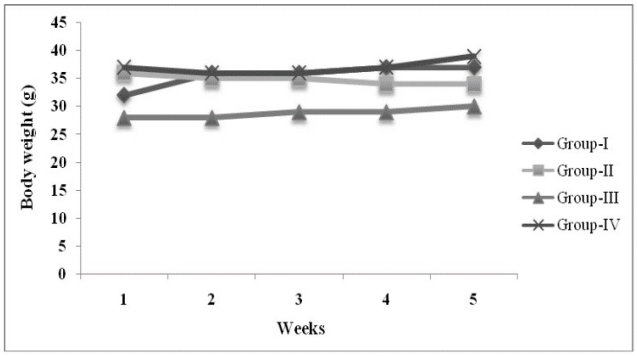

Figure 1. Change in body weight (g) of Balb/c mice during sub-acute toxicological studies. Group I = Control, Group II = BSE-400, Group III = BSE-800, Group IV = BSE-1600 mg/kg, body weight.

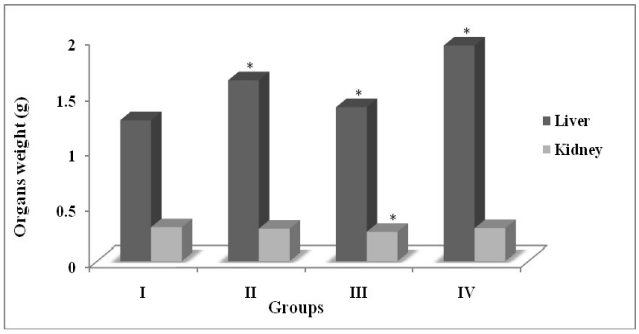

Figure 2. Effect of bamboo shoot extract on relative weight of liver and kidney. Group I = Control, Group II = BSE-400, Group III = BSE-800, Group IV = BSE-1600 mg/kg, body weight.
*p < 0.05 significant as compared to control group.

3.4. Lipid profile and blood glucose level

The serum biochemical parameters revealed a concentration-dependent increase in fasting glucose level. The higher dose treated group (1600 mg/kg, body weight) had significantly higher glucose level while, the group treated with lowest dose (400 mg/kg, body weight) had lowered serum glucose level (Table 2). Regarding lipid profile, bamboo shoot treated groups had significantly ($p < 0.05$) lowered TG levels compared with the normal control group. The levels of TC and LDL also got reduced in the treatment groups but the alterations were non-significant compared with the control group. On the other hand, a non-significant increase was observed in serum HDL level upon administration of BSE (400 and 800 mg/kg, body weight), but at the higher concentration (1600 mg/kg, body weight) HDL level decreased significantly ($p <0.05$) compared with the control group (Table 2).

Table 2. Effect of bamboo shoot extract on the levels of glucose and lipid profile

Parameter (mg/dL)	BSE (mg/kg, body weight) treated group			
	Control	400	800	1600
Glucose	65 ± 2.92	72 ± 1.60*	75 ± 2.35*	92 ± 3.80*
Total Cholesterol	120 ± 3.67	112 ± 1.11*	90 ± 4.25*	98 ± 1.31*
HDL-Cholesterol	90 ± 0.94	94 ± 1.33	92 ± 0.53	82 ± 1.54*
LDL-Cholesterol	19 ± 3.44	17 ± 1.66	15 ± 1.52	15 ± 0.97
Triglycerides	231 ± 0.94	123 ± 1.32*	150 ± 1.35*	203 ± 0.90*

Values are expressed as mean ± standard deviation (SD) (N = 5).
*p < 0.05 significant with respect to control group.

3.5. Liver function

Liver function in all the mice was monitored by analyzing the levels of SGPT, SGOT, total bilirubin, ALP, total proteins, albumin, globulin and LDH to determine liver health (Table 3). BSE did not alter the level of total bilirubin but ALP level increased significantly ($p<0.05$) in all the groups when compared with the normal control group. A marked reduction was observed in total protein and globulin levels at the dose level 400 and 800 mg/kg, body weight, but no significant change were seen in the albumin content of the animals. The level of SGOT got reduced in all the treatment groups but a significant decrease was seen at the dose 400 and 800 mg/kg, body weight. Likewise, SGPT level also decreased significantly ($p < 0.05$) at the dose level 400 and 800 mg/kg, body weight, but at high dose (1600 mg/kg, body weight) a significant ($p < 0.05$) increase was observed. Regarding LDH, a slight decrease was observed at the dose level 400 and 800 mg/kg, body weight, but at high dose the activity increased significantly ($p < 0.05$) compared to the control group.

3.6. Kidney function

The concentration of creatinine increased ($p < 0.05$) in all the groups treated with BSE. Blood urea and BUN levels also increased but significant ($p < 0.05$) increase was seen in the group treated with high dose (1600 mg/kg, body weight) (Table 4).

Table 3. Effect of bamboo shoot extract on the liver function

Parameter	BSE (mg/kg, body weight) treated group			
	Control	400	800	1600
Billirubin (mg/dL)	0.27 ± 0.05	0.27±0.04	0.27±0.04	0.27 ± 0.03
Proteins (mg/dL)	78 ± 3.15	66± 2.30*	69± 1.43*	76 ± 2.24
Albumin (mg/dL)	16 ± 1.34	16 ± 0.48	16 ± 1.18	17 ± 0.99
Globulin (mg/dL)	63 ± 0.96	50± 0.56*	52± 1.12*	57 ± 1.00
Alkaline phosphatase (U/L)	51 ± 4.25	86± 4.62*	83± 7.30*	65 ± 5.61*
SGOT (U/L)	113 ± 3.81	93± 4.39*	94± 4.40*	109 ± 7.97
SGPT (U/L)	58 ± 3.88	57 ± 5.33	46± 2.82*	187 ± 8.12*
LDH (U/L)	984 ± 20.4	967± 24.4	971± 23.5	1353 ± 33.6*

Values are expressed as mean ± standard deviation (SD) (N = 5).
*p < 0.05 significant with respect to control group.

Table 4. Effect of bamboo shoot extract on the kidney function

Parameter (mg/dL)	BSE (mg/kg, body weight) treated group			
	Control	400	800	1600
Creatinine	0.33 ± 0.02	0.38±0.05	0.38 ± 0.03	0.41± 0.03*
Blood urea	51 ± 0.25	55 ± 0.71	58 ± 0.54*	60 ± 0.23*
BUN	23 ± 0.11	25 ± 0.37	26 ± 0.27	28 ± 0.38

Values are expressed as mean ± standard deviation (SD) (N = 5).
*p < 0.05 significant with respect to control group.

3.7. Antioxidative potential of bamboo shoot extract

The antioxidative potential of the BSE was estimated by measuring MDA levels, GSH content and the activity of enzymes GR, GPx, CAT and SOD (Table 5). BSE administration caused a significant ($p < 0.05$) reduction in the levels of hepatic LPO; decrease was dose-dependent up to the concentration 800 mg/kg, body weight, whereas when dose concentration increased MDA content also increased but it was significantly lower than that of the control group. The levels of GSH also increased up to the concentration 800 mg/kg, body weight, while at higher concentration, a marked ($p < 0.05$) reduction was seen in the levels of GSH. The activity of hepatic GR and GPx decreased at the dose 400 and 800 mg/kg, body weight ($p < 0.05$), but at higher dose activity increased significantly compared to the control group, when compared among the treated groups, enzyme level increased in a concentration-dependent manner. The level of CAT in control mice was 1.42 ± 0.22 (µmoles H_2O_2 reduced/min/mg proteins). Upon BSE administration, a significant reduction was observed in the activity of CAT. When compared among the groups, the group treated with concentration 800 mg/kg, body weight had the highest activity while the groups received concentration 400 and 1600 mg/kg, body weight manifested lowest activity. In contrast, SOD level increased ($p < 0.05$) upon BSE administration as compared to the control group. When compared among the treated groups, SOD activity declined in a concentration-dependent manner.

3.8. Histopathological studies

Histopathological examination of liver from control and BSE treated mice revealed normal histoarchitecture. The lobular structure of the liver was preserved. Portal tracts were of normal size, without increase of collagen fibers and without inflammatory infiltrates. The structure of the cytoplasm was also preserved in all hepatocytes (Figure. 3). Similarly, no changes were observed at any dose of BSE in the structure of the renal tissue. All tested groups had normal glomeruli and tubules, without any pathological change as compared to the control mice (Figure. 4).

Table 5. Effect of bamboo shoot extract on antioxidant defense system

Parameter	BSE (mg/kg, body weight) treated group			
	Control	400	800	1600
MDA (nmoles/min/mg protein)	2.95± 0.21	0.96 ± 0.03*	0.87 ± 0.07*	0.88 ± 0.09*
GSH (nmole/mg protein)	0.84± 0.09	1.01 ± 0.08*	1.32 ± 0.07 *	0.69 ± 0.07*
GR (nmoles of NADPH/ consumed/min/mg protein)	20.21± 4.23	13.80 ± 4.62*	18.60 ± 3.84*	22.47 ± 4.12
GPx (nmoles of NADPH/ oxidized/min/mg protein)	15.50± 3.54	11.97 ± 2.88*	14.15 ± 2.93	26.15 ± 4.74*
CAT (µmoles H_2O_2 reduced/ min/mg proteins)	1.42± 0.22	0.38 ± 0.08*	0.88 ± 0.09*	0.38 ± 0.08*
SOD (IU/mg protein)	2.67± 1.77	5.70 ± 2.31*	5.62 ± 2.42*	5.22 ± 3.25*

Values are expressed as mean ± standard deviation (SD) (N = 5).
*p < 0.05 significant with respect to control group.

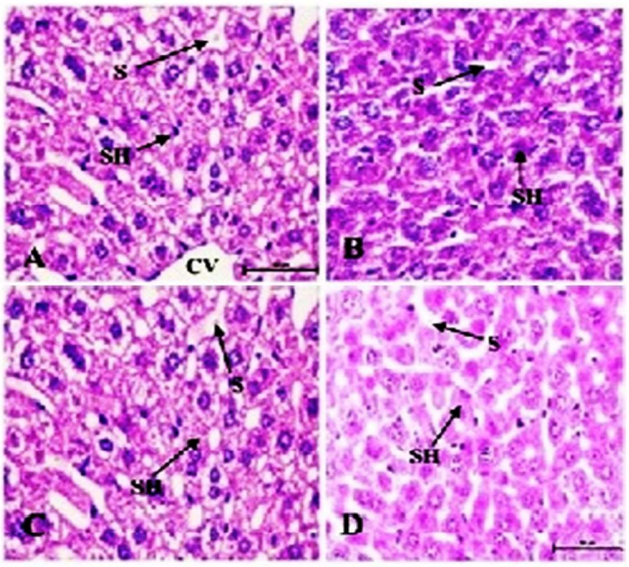

Figure 3. Histomicrographs of liver tissue showing a regular hepatic architecture, a central vein with radially arranged normal hepatocytes and sinusoids. (A) Control group; (B) BSE-400; (C) BSE-800; (D) BSE-1600 mg/kg, body weight treated groups, (400X). CV = central vein, S = sinusoids, SH = sheets of hepatocytes.

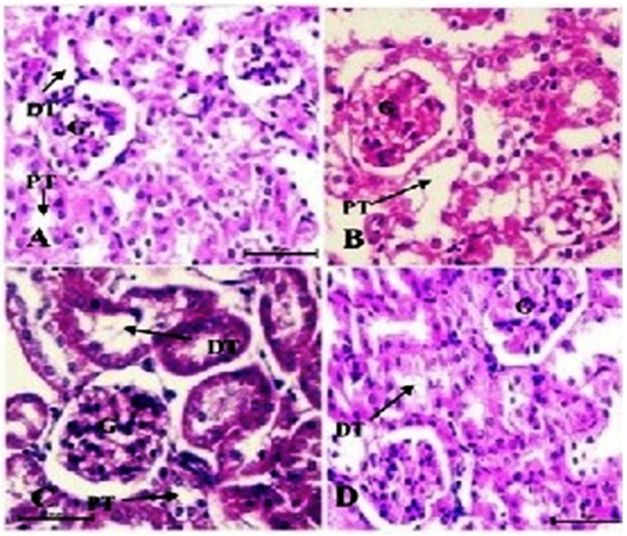

Figure 4. Histomicrographs of renal tissue showing normal glomerulus and tubules. (A) Control group; (B) BSE-400; (C) BSE-800; (D) BSE-1600 mg/kg, body weight treated groups, (400X). G = Glomerulus, DT = Distal convoluted tubules, PT = Proximal convoluted tubules.

4. Discussion

Natural plant products have been used as therapeutics since ancient times and are now the main source of compounds used in the discovery and development of new drugs. The top most marketed drugs from the last century have been developed from natural plant products (24). Bamboo shoots have been used as food and medicine in China, India and South-East Asia since ancient times. In the past few years, research has indicated the antimicrobial, antioxidant, anticancer, anti-apoptotic, anti-fatigue and cholesterol lowering properties of bamboo (25-28). Many bamboo-based functional food items and pharmaceutical products are being developed and consumed. In fact in the 21st century, bamboo shoots have come in a totally new avatar like health and functional food or nutraceuticals (29). But the anti-nutritional factors and probably toxic influences associated with bamboo shoots are a matter of concern. Hence, it is essential to ensure safety and to standardize the dose of bamboo shoot extract to be taken for possible medicinal effects.

The phytochemical investigation of extract of *D. hamiltonii* shoots showed the presence of phytochemicals such as proteins, amino acids, carbohydrates, phenols, flavonoids, saponins and triterpenes. The varied biological activities exhibited by bamboo shoots may be attributed to the synergistic action of all these phytochemicals. In sub-acute toxicity study, BSE did not cause any significant

change in the general behavior and body weight of mice except, the group treated with low dose (400 mg/kg, body weight), where a significant decrease in the body weight was observed as compared to control and other groups. The glucose level increased to a significant level with all the three doses (400, 800 and 1600 mg/kg, body weight) of BSE as compared to the normal control group. However, in all the groups the level of glucose was not more than 100 mg/dl. The animals having fasting blood glucose levels more than 200 (mg/dl) are considered as diabetic animals (30). The rise in blood sugar level in mice after administration of BSE as compared to control mice which were receiving normal animal diet might be due to high fiber content present in bamboo shoots. Haber et al. (31) studied the effects of fiber-rich and fiber-free diet on the satiety, rate of ingestion and serum-insulin level and found that, the removal of fiber from food, can result in faster and easier ingestion, decreased satiety, and disturbed glucose homeostasis. These effects favor over nutrition and, if often repeated, might lead to diabetes mellitus. This is based on the findings, when ten normal subjects provided with three kinds of apple based diet (fiber-free apple juice, apple puree, and intact apples), plasma-glucose rose to similar levels. But there was a striking rebound fall in blood sugar level after apple juice and to a lesser extent after puree, but was not seen after consuming intact apples because serum-insulin rose to higher levels after juice and puree than after apples. It has also been proved that juice could be consumed eleven times faster than intact apples and four times faster than fiber-disrupted puree. Bamboo shoots are not only rich in dietary fiber but also a good source of phenols and phytosterols, and regular consumption of shoots reportedly decreased serum TC, LDL, and increased fecal volume and bowel movement (32,33). Our results are in agreement with these results, as when mice were administered with aqueous extract of *D. hamiltonii* shoots, a significant decrease was observed in the level of TC and LDL while increase in the level of HDL in all the groups. It has been reported that cholesterol-lowering effects of bamboo shoots have been attributed to inhibition of cholesterol absorption and increase of cholesterol excretion (34).

Liver function in all the mice was observed by analyzing the levels of serum bilirubin, total proteins, albumin, globulin, alkaline phosphatase, SGOT and SGPT, which are commonly measured as a part of a diagnostic evaluation of hepatocellular injury to determine liver health. Bilirubin is an endogenous anion derived from hemoglobin degradation from the RBC. When the liver function tests are abnormal and the serum bilirubin levels more than 17µmol/L, it suggests underlying liver disease (35). In the present study, bilirubin content decreased slightly at high dose (1600 mg/kg, body weight), but no change was observed at the concentration 400 and 800 mg/kg, body weight as compared to the control group. The measurement of proteins is another useful indicator of hepatic functions because liver is the major source of most of the serum proteins. Upon BSE administration, protein level decreased with all the doses but a marked reduction was seen at the dose 400 and 800 mg/kg, body weight. Similar reduction pattern was seen in the case of globulin, but no significant change was observed in the albumin content of the mice. Contrarily, ALP level increased in all the groups but a significant increase was seen at the concentration 400 and 800 mg/kg, body weight. SGPT and SGOT are the most widely used liver enzymes that are sensitive to abnormalities in the liver. In the present study, SGOT level decreased in all the treatment groups but a significant decrease was observed at the level 400 and 800 mg/kg, body weight. SGPT level also decreased at the dose level 400 and 800 mg/kg, body weight, while, increased significantly at high dose as compared to the control group and other doses. Significant alterations in the level of LDH were also observed in all the treatment groups as our body also responds to the cell injury by releasing an enzyme, LDH into the bloodstream. LDH level decreased slightly at the dose level 400 and 800 mg/kg, body weight, but increased to a significant level at higher dose (1600 mg/kg, body weight). It was also observed that increase in the level of LDH was concentration-dependant. Similarly, alterations were observed in the levels of serum creatinine, blood urea and BUN. The creatinine level increased significantly in all the groups with highest increase in the group treated with high dose. Increase in blood urea and BUN level was also observed but found to be statistically non-significant. The increase in creatinine, urea, and BUN level might be due to the presence of high protein content in fresh juvenile shoots of *D. hamiltonii*. It has been reported that diet rich in proteins is associated with increased glomerular filtration rate (GFR), urea, serum creatinine, and serum concentrations of uric acid (36).

The MDA content which is an important indicator of lipid peroxidation and indirectly reflects the extent of cellular injury in living beings (37,38) decreased in all

the BSE administered animals. The results also showed a positive correlation between the level of GSH and LPO. GSH level increased in a dose-dependent manner up to the level 800 mg/kg, body weight. It has been reported that bamboo shoots are rich in phenolic compounds and important minerals and play an important role in controlling lipid peroxidation which is associated with its antioxidant activity (39,40). The antioxidant enzymes (SOD, CAT, GR, GPx) respond differently to the juvenile shoots of *D. hamiltonii*. Results showed a significant increase in the activity of hepatic SOD compared to the control group. But when compared among the groups, the activity of SOD decline in dose-dependent manner. In contrast, the activity of enzyme catalase decreased in all the treated groups Similarly, GR and GPx activity also decreased at the dose level 400 and 800 mg/kg, body weight, but at high dose (1600 mg/kg body weight) activity of both the enzymes increased significantly as compared to the control group. The histopathological studies showed a normal structure of liver and kidney. The portal tracts of liver were intact and the structure of the cytoplasm was also preserved in all the hepatocytes. Similarly, glomeruli and tubules of kidney were also normal in all the bamboo shoot treated mice.

5. Conclusion

It was observed that the bamboo shoots had no mortality and observable toxic effect during the entire period in Balb/c mice dosed up to 1600 mg/kg, body weight. Although, at higher dose the level of serum creatinine, serum glutamic pyruvic transaminase and lactate dehydrogenase increased significantly however, the histoarchitecture of liver and kidney was normal. Further experimental investigation is recommended to examine the long-term efficacy and safety of shoots of *Dendrocalamus hamiltonii* and other bamboo species.

Conflict of interest

The authors declare that there are no conflicts of interest.

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