Journal of
Biomedical and Pharmaceutical Sciences

Research Article Open Access

Aqueous Extract of *Bombax ceiba* Young Roots Prolongs Glucose, Sucrose and Starch Absorption from Intestine of Normal Rats

Maruf-ul-Islam[1], Md Hasibul Hasan Joarder[1], Koushik Ahamed[1], Md Ben Yameen[1], Rokshana Sharmin[1], AHM Khurshid Alam[2] and Ariful Islam[2]*

[1]*Department of Pharmacy, Jessore University of Science and Technology, Jessore, Bangladesh*
[2]*Department of Pharmacy, University of Rajshahi, Bangladesh*

Abstract

The aim of the study to investigate the effect of Aqueous Extract of *B. ceiba* Young Roots (AEBCYR) on the absorption of carbohydrates (mono-, di-, and poly-saccharide) from the intestine in healthy rats. Eighty healthy Long Evans rats were randomly assigned into eight groups (n=10 per group). The systemic absorption of carbohydrates was examined after loading a mixture of carbohydrates separately with AEBCYR in the ratio of 3:2 by using a glucometer. Furthermore, the sGPT and sGOT levels were determined by a semi bio-analyzer. Evaluations were based on a significance level of $p<0.05$. Aqueous extract of *B. ceiba* young roots (G-AEBCYR) solution inhibited glucose absorption up to 90 min and the glucose level was found to be 3.2 ± 0.22 mmol/L. Similarly, Suc- AEBCYR and Sta- AEBCYR solutions inhibited sucrose and starch absorption up to 120 and 180 min, and the reduction of glucose level was 39.22% and 56.37%, respectively, when compared with the standard CMC solution. On the other hand, the CMC mixed glucose (G-CMC), sucrose (Suc-CMC), and starch (Sta-CMC) solutions inhibited the maximum glucose absorption up to 60, 90, 120 min. Also, the AEBCYR reduced the hepatotoxicity by detecting the decreased levels of sGPT and sGOT compared to the CMC. Phytochemical analysis revealed the presence of fibers, alkaloid. Our results indicate that the AEBCYR delays carbohydrate absorption from the intestine of normal rats. It also showed a remarkable decrease of sGPT and sGOT levels, which indicates hepatoprotective activity.

Keywords: *Bombax ceiba*; Diabetes; Monosaccharide; Disaccharide; Polysaccharide; sGPT; sGOT

Abbreviation

B. ceiba: Bombax ceiba; G-AEBCYR: Glucose mixture with Aqueous Extract of *B. Ceiba* Young Root; Suc-AEBCYR: Sucrose mixture with Aqueous Extract of *B. ceiba* Young Root; Sta-AEBCYR: Starch mixture with Aqueous Extract of *B. ceiba* Young Root; G-CMC: Glucose mixture with CMC; Suc-CMC: Sucrose mixture with CMC; Sta-CMC: Starch mixture with CMC; sGPT: serum Glutamate Pyruvate Transaminase; sGOT: Serum Glutamic Oxalate Transaminase; CMC: Carboxy Methyl Cellulose

Introduction

Diabetes Mellitus (DM) is likely one of the most widely known metabolic disorder known to people [1]. It was initially recognized in the Egyptian populations around 3000 years ago [2]. Since 1965, the World Health Organization (WHO) established for the classification, diagnosis and management of diabetes [3]. In 2012, an unexpected 1.5 million losses were due to diabetes and another 2.2 million deaths were because of high blood glucose level. WHO forecasted diabetes would be the seventh leading cause of death globally by 2030 [4,5]. In 2010, around 344 million people affected in diabetes with impaired glucose tolerance and the number of adult patients with diabetes will rise to 472 million by 2030 [6]. It has been reported that people with diabetes are at higher risk of vascular complications, including cardio-, peripheral, and cerebrovascular diseases; retinopathy and nephropathy [7]. Ershang et al. reported that diabetic patients are sensitive to the state of dyslipidemia and mortality [8]. Diet control and use of lipid lowering agents can lessen serum lipid levels and lower the possibility of cardiovascular events [9]. Recently, approximately 3 million people in Bangladesh have been suffering from diabetes and the figure will be reached to 11 million by 2030. The economic burden of diabetes in developed and developing countries is a major problem [10]. Importantly, the medical cost of a diabetic patient is 2 to 3 fold higher than a non-diabetic healthy people [11]. Moreover, the living cost is 2 to 5 fold higher than a non-diabetic healthy people. Therefore, management of diabetes is a great challenge for researchers [12]. However, drugs derive from natural sources are less toxic and have fewer side effects than synthetic drugs. The use of natural products is amplified than synthetic drugs in the treatment of several diseases, including diabetes [13].

Diabetes is known as metabolic disorders that are characterized by high blood sugar level (hyperglycemia) and high levels of glucose in urine (glycosuria) [14]. Carbohydrates are the main sources of energy obtain from the diets, which contain starch, vegetables, fruits, dairy products, and sugars. Carbohydrates have direct vital effect on increasing blood glucose level, on the contrary proteins and fats have little or no effect [15,16]. Dietary carbohydrates specially starch are hydrolyzed in the small intestine with the action of pancreatic amylase and Brush-Border Membrane (BBM) and converted into disaccharides. These disaccharides (sucrose, lactose) are converted to monosaccharides (glucose, galactose, and fructose), which are transported from the lumen of the intestine by Na^+/glucose cotransporter 1 (sGLT1) [17]. Prevention of intestinal absorption of carbohydrates would help to maintain glucose levels in the blood and decreases complications [18]. Hence, the direct prevention of GIT glucose absorption could state a novel mechanism for an anti-diabetic drug [19].

***Corresponding author:** Ariful Islam, Associate Professor, Department of Pharmacy, University of Rajshahi, Bangladesh, Tel: +88-0721711110; E-mail: arifulislam@ru.ac.bd

Received: April 18, 2019; **Accepted:** May 15, 2019; **Published:** May 22, 2019

Citation: Maruf-ul-Islam, Joarder MHH, Ahamed K, Yameen MB, Sharmin R, et al. (2019) Aqueous Extract of *Bombax ceiba* Young Roots Prolongs Glucose, Sucrose and Starch Absorption from Intestine of Normal Rats. J Biomed Pharm Sci 2: 125.

Bombax ceiba (*B. ceiba*), a member of the Bombacaceae family, is popularly known as silk-cotton tree [20,21] distributed in temperate and tropical Asia, Africa and Australia. The plant has been used in traditional medical systems such as Ayurveda, Siddha and Unani. An inclusive literature survey shows that different parts (root, stem bark, leaf, fruit, flower heartwood and seed) of the plant are reported to have therapeutic potentials to treat different diseases such as diabetes, asthenia, polyurea and glycosuria [22,23]. Bhavsar et al. reported that the bark of *B. ceiba* possessed anti-diabetic activity [24]. The cardioprotective effect of *B. ceiba* flowers has been reported by Patel et al. [25]. Rehman et al. and Phulan et al. reported that the stem bark of *B. ceiba* showed potential antibacterial and antioxidant activity [26,27]. The hepatoprotective activity of *B. ceiba* flowers has been reported by Ravi et al. [22]. The leaves of *B. ceiba* have anti-pyritic activity [28]. The aqueous extract of *B. ceiba* has *in vitro* anti-inflammatory [29], cytotoxic [30], and *in vivo* hypoglycemic [31], and hypolipidemic activities [32]. Pharmacognostical, phytochemical and biological evaluations of the stem bark of *B. ceiba* were carried out by Ansari et al. [33]. The stem bark of *B. ceiba* has anti-obesity potential in high fat diet-induced experimental rats [34]. These reported *in vitro* cell free and *in vivo* animal studies suggest that the plant, *B. ceiba*, has enormous therapeutic potential against several diseases, which influenced us to evaluate how the Aqueous Extract of *B. ceiba* Young Roots (AEBCYR) inhibits the absorption of carbohydrates (mono-, di-, and poly-saccharide) from the intestine in healthy rats, which might relevant to the treatment and management of diabetes and obesity [35].

Materials and Methods

Plant materials

The fresh *B. ceiba* Young Roots (BCYR) were collected from rural area of Kushtia and Jessore district in Bangladesh. The species was identified by an expert taxonomist of Bangladesh National Herbarium, Dhaka where a voucher specimen (no.41877) has been deposited for future use. After collection, the fresh roots were thoroughly washed with distilled water and kept apart barking layer from the roots and sliced into small pieces. The sliced roots were then sun dried under shade and kept in the store for future use.

Preparation of the aqueous extract

The sliced BCYR (40 g) were submerged into distilled water (100 mL) in a beaker and stirred gently for 10 to 15 min with a glass rod. Following 12 hours, the mixture was filtered by silk cloth and the viscous water soluble fraction was collected.

Ethical permission

The protocol used in this study for the use of rat as an animal model for diabetes research was approved by the Jessore University of Science and Technology Animal Ethical committee (license number ERC/FBS/JUST/2018-12) Bangladesh.

Selection of animal

To perform the experiment, 80 healthy Long Evans male rats (age 6 weeks, weighing about 100–150 g) were collected from the Ethnopharmacology Laboratory of Jahangirnagar University, Bangladesh. The animals were housed in propylene cages in a controlled environment (temperature 25 ± 2°C and 12 h dark and light cycle) and received feed formulated by ICDDR, B and water *ad libitum*. The animals were acclimatized to laboratory conditions for 10 days prior to initiation of experiments. To keep the hydration rate constant water supply was continued while foods were stopped 12 hours before the experiments.

Chemicals and drug collection

A saline solution was collected from Beximco Infusion Ltd. sGPT and sGOT kits were purchased from Siemens Healthcare Diagnostics Ltd, UK. Oral Gavage was purchased from Jahangirnagar University, Bangladesh. All the chemicals used were of analytical grade.

Preparation of different dosing mixtures

Glucose, sucrose and starch solution: Each solution was prepared separately by dissolving glucose, sucrose and starch in distilled water in such a way that each 0.3 mL of solution contains 1200 mg/kg Body Weight (BW) of each sample.

Glucose, sucrose and starch were mixed with aqueous extract of *B. ceiba* young roots (AEBCYR): Each glucose, sucrose and starch (1200 mg/kg, BW) solution was mixed separately with aqueous extract of AEBCYR (800 mg/kg) to form G-AEBCYR, Suc-AEBCYR and sta-AEBCYR, respectively.

Glucose, sucrose and starch were mixed with standard carboxyl methyl cellulose (CMC): Three standard solutions were prepared separately by mixing with each carbohydrate solution (1200 mg/kg) with CMC (800 mg/kg) to form G-CMC, Suc-CMC, and sta-CMC, respectively.

Grouping of experimental rats

80 healthy Long Evans rats were randomly assigned into groups (n=10 per group). Rats of all groups were deprived of diet but water for 12 hours to eliminate the relevant gastrointestinal factors. Group-1 rats were received normal diet. Group-2 rats were received a normal diet with CMC. Group-3 (G-AEBCYR), Group-4 (Suc-AEBCYR), and Group-5 (Sta-AEBCYR) rats were treated with a mixture of AEBCYR (800 mg/kg) and glucose (1200 mg/kg), sucrose (1200 mg/kg), and starch (1200 mg/kg) in a ratio of 2:3. Group-6 (G-CMC), Group-7 (Suc-CMC), and Group-8 (Sta-CMC) rats were treated with a mixture of CMC (800 mg/kg) and glucose (1200 mg/kg), sucrose (1200 mg/kg) and starch (1200 mg/kg) in a ratio of 2:3.

Administration of doses

The gastric feeding tube was used to administer doses to the respective groups of rats.

Determination of blood glucose level

Blood samples were collected by cutting the tail-tip of each rat at every 30 min after loading the doses up to 180 min and blood glucose levels were determined by glucometer.

Hepatoprotective test

Collection of blood serum: Blood sample was collected from animals following AVMA 2013 guidelines. According to the method described by Allen-Worthington et al. 70% (v/v) ethanol in 0.9% sterile saline was applied in the ventral chest region for getting deep anesthesia and is considered a non-survival procedure. Immediately the needle was inserted at the base of the sternum, bevel up, into the thoracic cavity at a 15-20° angle directed just to the left of the midline. It was done very slowly to avoid collapsing of heart. Then blood was centrifuged to collect serum at 4000 rpm for 10 min.

sGPT test: The collected serum was used for testing the sGPT

(serum Glutamic Pyruvic Transaminases). This test was carried out by taking calorimetric absorbance and diagnostic kits ALTI FlexRreagent cartridge, cat. No.DF143.

sGOT test: sGOT is known as Aspartate Aminotransferase (AST), which was analyzed by taking absorbance through calorimetric determination using wet reagent diagnostic kits purchased from the AST FlexRreagent cartridge, cat. no. DF41A.

Statistical analysis

Data were expressed as mean ± Standard Error of Mean (SEM). Statistical comparisons were performed by Two-way Analysis of Variance (ANOVA) for blood glucose analysis and Two–way ANOVA analysis. The results were considered to be significant when p values were less than 0.05 ($p<0.05$). Statistical calculations and graphs were prepared using Graph Pad Prism Version 6.00 for Windows (Graph Pad Software, San Diego, CA, USA).

Results

Inhibitory effect of aqueous extract of *B. ceiba* young roots on glucose absorption in normal rats at different time intervals

The sample (G-AEBCYR) and the standard (G-CMC) solutions were administered orally by gastric tube into the Group-3 and Group-6 rats, respectively. The blood glucose levels were measured at every 30 min after loading both the solutions up to 180 min by glucometer. The G-AEBCYR solution gradually reduced the glucose level in blood and the maximum reduction was found to be 4.3 ± 0.27 mmol/L at 90 min, whereas the standard G-CMC solution decreased the maximum blood glucose level to 3.1 ± 0.42 mmol/L at 60 min Table 1. The G-AEBCYR reduced the blood glucose level of 37.26% and 13.73% at 90 and 180 min, respectively, when compared to 0 min, whereas the standard G-CMC reduced the blood glucose level of 44.65% and 3.58% at 60 and 180 min when compared to 0 min Figure 1. Each experiment was carried out thrice and results are presented as mean ± SEM (n=3).

Inhibitory effect of aqueous extract of *B. ceiba* young roots on sucrose absorption in normal rats at different time intervals

The Suc-AEBCYR and Suc-CMC solutions were ingested into Group-4 and Group-7 rats, respectively and blood glucose levels were measured at every 30 min after loading both the sample and standard up to 180 min. The Suc-AEBCYR solution reduced the blood glucose level of 5.3 ± 0.28 to 3.1 ± 0.17 mmol/L at 0 to 120 min, respectively. On the other hand, the Suc-CMC solution decreased the blood glucose level of 5.6 ± 0.28 to 4.2 ± 0.22 mmol/L at 0 min to 90 min, respectively Table 2. The Suc-AEBCYR showed 41.51% and 22.65% reduction of blood glucose level at 120 and 180 min, respectively, when compared to 0 min Figure 2. Each experiment was carried out thrice and results are presented as mean ± SEM (n=3).

Inhibitory effect of aqueous extract of *B. ceiba* young roots on starch absorption in normal rats at different time intervals

In case of starch, blood glucose levels were measured at every 30 min after loading both the Sta-EBCYR and Sta-CMC solutions in Group-5 and Group-8 rats up to 180 min. The Sta-AEBCYR solution reduced the maximum blood glucose to 3. 2.4 ± 0.11 mmol/L from 0 min to 180 min. On the other hand, the Sta-CMC solution decreased the maximum blood glucose level to 3.6 ± 0.41 mmol/L at 120 min Table 3. The percentage of reduction was found to be 38.99 and 6.78 with Sta-CMC at 120 and 180 min, respectively, when compared to 0 min. Interestingly, 56.37% reduction was observed by the Sta-AEBCYR at 180 min when compared to 0 min Figure 3. Each experiment was carried out thrice and results are presented as mean ± SEM (n=3).

Blood glucose level (mmol/L)		
Time	Treatment Groups	
	G-CMC	G-AEBCYR
0 min	5.6 ± 0.45[1]	5.1 ± 0.44
30 min	4.7 ± 0.39	4.2 ± 0.21
60 min	3.1 ± 0.42	3.8 ± 0.24
90 min	4.6 ± 0.39	3.2 ± 0.22
120 min	5.4 ± 0.20	3.7 ± 0.32
150 min	5.4 ± 0.29	4.2 ± 0.37
180 min	5.4 ± 0.29	4.4 ± 0.39

[1]Each value is expressed as mean ± SEM (n=3). G-AEBCYR and G-CMC represent a mixture of glucose with aqueous extract of *B. ceiba* young roots and carboxyl methyl cellulose, respectively in a ratio of 3:2.

Table 1: Blood glucose level after loading the G-AEBCYR and G-CMC solutions in normal rats.

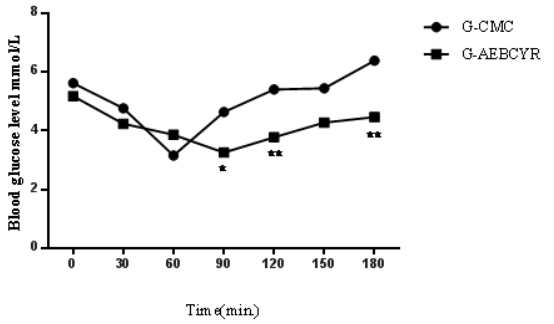

Figure 1: Effect of AEBCYR on intestinal glucose absorption in normal rats. A significant difference ($p<0.05$ to $p<0.01$) was observed from 90 min to 180 min by comparing G-AEBCYR group with G-CMC group. Data were analyzed by ANOVA followed by Scheffe's post-hoc tests. Results are presented as mean ± SEM (n=3).

Blood glucose level (mmol/L)		
Time	Treatment Group	
	Suc-CMC	Suc-AEBCYR
0 min	5.6 ± 0.28[1]	5.3 ± 0.28
30 min	5.0 ± 0.20	4.6 ± 0.31
60 min	4.5 ± 0.18	4.0 ± 0.22
90 min	4.2 ± 0.22	3.6 ± 0.19
120 min	5.1 ± 0.32	3.1 ± 0.17
150 min	5.6 ± 0.40	3.5 ± 0.37
180 min	6.1 ± 0.36	4.1 ± 0.29

[1]Each value is expressed as mean ± SEM (n=3). Suc-AEBCYR and Suc-CMC represent a mixture of sucrose with an aqueous extract of *B. ceiba* young roots and carboxyl methyl cellulose, respectively in a ratio of 3:2.

Table 2: Blood glucose level after loading the Suc-AEBCYR and Suc-CMC solutions in normal rats.

Effects of aqueous extract of *B. ceiba* young roots on sGPT level in normal rats

The measurement of sGPT level among Groups (Group-1 to Group-5) was done and the data are presented in Table 4. The extract reduced the sGPT level for all types of carbohydrates. On the other hand, the standard CMC increased the sGPT level Table 4. The maximum reduction of the sGPT level by Suc-AEBCYR was found to

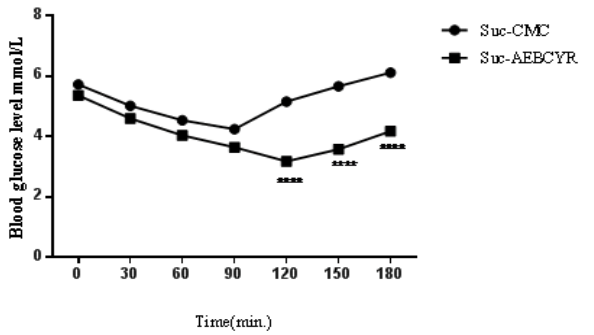

Figure 2: Effect of AEBCYR on intestinal sucrose absorption in normal rats. A difference was significant (p<0.0001) from 120 min to 180 min by comparing Suc-AEBCYR group with Suc-CMC group. Data were analyzed by ANOVA followed by Scheffe's post-hoc tests. Results are presented as mean ± SEM (n=3).

Blood glucose level (mmol/L)		
Time	Treatment Group	
	Sta-CMC	Sta-AEBCYR
0 min	5.9 ± 0.19[1]	5.5 ± 0.10
30 min	5.1 ± 0.18	4.6 ± 0.21
60 min	4.7 ± 0.27	4.2 ± 0.17
90 min	4.3 ± 0.39	4.0 ± 0.25
120 min	3.6 ± 0.41	3.2 ± 0.28
150 min	4.7 ± 0.30	2.8 ± 0.16
180 min	5.5 ± 0.18	2.4 ± 0.11

[1]Each value is expressed as mean ± SEM (n=3). Sta-AEBCYR and Sta-CMC represent a mixture of starch with an aqueous extract of *B. ceiba* young roots and carboxyl methyl cellulose, respectively in a ratio of 3:2.

Table 3: Blood glucose level after loading the Sta-AEBCYR and Sta-CMC solutions in normal rats.

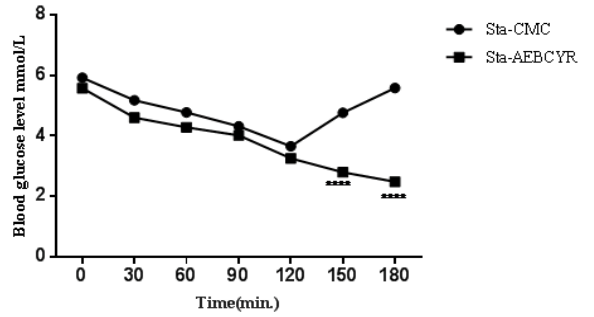

Figure 3: Effect of AEBCYR on intestinal starch absorption in normal rats. A significant difference (p<0.0001) was observed from 150 min to 180 min by comparing Sta-AEBCYR group with Sta-CMC group. Data were analyzed by ANOVA followed by Scheffe's post-hoc tests. Results are presented as mean ± SEM (n=3).

be 87.27% when compared to CMC group Figure 4. Each experiment was carried out thrice and results are presented as mean ± SEM (n=3).

Effects of aqueous extract of *B. ceiba* young roots on sGOT level in normal rats

The comparison of sGOT level between experimental rats (Group-3 to Group-5) and the standard rats (CMC group) is shown in Table 5. The glucose, sucrose and starch mixed AEBCYR reduced the sGOT level of 13.2 ±1.5, 10.3 ±1.3 and 11.0 ±1.1 IU/L, respectively; whereas the CMC increased the sGOT level when compared to the experimental rats Table 5. The Suc-AEBCYR solution reduced the sGOT level of 62.55% when compared to CMC group Figure 5. Each experiment was carried out three times and results are presented as mean ± SEM (n=3).

Phytochemical analysis

Qualitative phytochemical analysis revealed the presence of fibers, alkaloid, cardiac glycosides, amino acids, phytosterol, steroid, carbohydrate, phenolic compound, tannin, saponin and flavonoids in aqueous extract of *B. ceiba* young root. This analysis also showed the presence of high concentration of soluble fibers in aqueous extract of *B. ceiba* young roots Table 6.

Discussion

The present study was geared towards exploring the potential ability of *B. ceiba* to inhibit key steps of carbohydrate digestion. The reduction of postprandial glycemia is always considered beneficial in any treatment from the point of view of cardiometabolic risk.

Groups	sGPT (U/L)
Normal	37.6 ± 4.0[1]
CMC	54.2 ± 2.8
G-AEBCYR	12.0 ± 0.93
Suc-AEBCYR	6.9 ± 0.84
Sta-AEBCYR	10.2 ± 0.98

[1]Each value is expressed as mean ± SEM (n=3). G-AEBCYR, Suc- AEBCYR and Sta-CMC represent a mixture of glucose, sucrose, and starch with an aqueous extract of *B. ceiba* young roots in a ratio of 3:2. CMC represents carboxyl methyl cellulose.

Table 4: sGPT level in normal, standard and carbohydrates mixed AEBCYR rats.

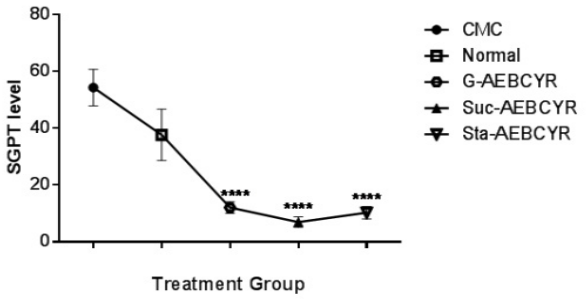

Figure 4: Effect of AEBCYR on sGPT level in normal rats. A significant difference (p<0.0001) was observed by comparing AEBCYR mixed carbohydrates (G-AEBCYR, Suc-AEBCYR, and Sta-AEBCYR) with the CMC for 24 hour treatment. CMC group shows the less significant value (p<0.05) compared with normal group. Data were analyzed by ANOVA followed by Scheffe's post-hoc tests. Results are presented as mean ± SEM (n=3).

Groups	sGOT (U/L)
Normal	36.8 ± 3.0[1]
CMC	27.5 ± 1.7
G-AEBCYR	13.2 ± 1.5
Suc-AEBCYR	10.3 ± 1.3
Sta-AEBCYR	11.0 ± 1.1

[1]Each value is expressed as mean ± SEM (n=3). G-AEBCYR, Suc-AEBCYR, and Sta-CMC represent a mixture of glucose, sucrose, and starch with an aqueous extract of *B. ceiba* young roots in a ratio of 3:2. CMC represents carboxyl methyl cellulose.

Table 5: sGOT level in normal, standard and carbohydrates mixed AEBCYR rats.

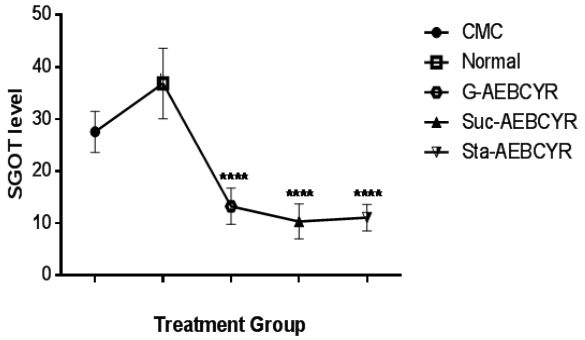

Figure 5: Effect of AEBCYR on sGOT level in normal rats. A significant difference ($p<0.0001$) was found by comparing AEBCYR mixed carbohydrates (G-AEBCYR, Suc-AEBCYR, and Sta-AEBCYR) with the CMC group for 24 hour treatment. CMC group shows the less significant value ($p<0.05$) compared with normal group. Data were analyzed by ANOVA followed by Scheffe's post-hoc tests. Results are presented as mean ± SEM (n=3).

No. of Tests	Name of the phytochemicals	Name of Tests	AEBCYR
1	Carbohydrate	Benedicts test	++
2	Saponin	Foam test	-
3	Flavonoids	Ferric chloride test	+
4	Phenolic compound & tannin	Ferric chloride test	+
5	Fiber	Solubility test	+++
6	Steroid	Spot test	+
7	Phytosterol	Salkowski's test	++
8	Amino acids	Ninhydrin test	+
9	Fixed oils & fatty acid	Spot test	-
10	Cardiac glycosides	Keller-Killani test	++
11	Alkaloid	Wagners test	+
+ve & -ve represent the presence & absence of phytochemicals in AEBCYR (aqueous extract of *B. ceiba* young roots).			

Table 6: Phytochemical constituents of aqueous extract of AEBCYR.

The present study demonstrated the effect of aqueous extract of *B. ceiba* young roots on different forms of carbohydrate absorption. Data obtained from this experiment showed that the absorption of all carbohydrates was reduced by the extract. The monosaccharide (glucose) absorption was reduced to 69.56% by G-AEBCYR compared to G-CMC at 90 min Figure 1. Similarly, disaccharide (sucrose) and polysaccharide (starch) absorption were reduced potentially to 60.78% and 43.63% at 120 min and 180 min, respectively Figures 2 and 3. The aqueous extract containing soluble fibers formed viscous gel in the intestinal water. They bypass the digestion of the small intestine and are very easily fermented by the microflora of the large intestine [36]. On the other hand, viscous fibers of this extract enhanced the viscosity of lumen as well as might protect the starch from enzymatic attack. Dietary carbohydrates contain polysaccharides, monosaccharide and basic sugars such as glucose, fructose, galactose are straight forwardly taken up by intestinal epithelial cells [37].

Glucose adsorption is the physical phenomenon where glucose particles get adsorbed onto the fiber's surface. The adsorption of glucose blocks glucose uptake into the blood [38]. Several studies reported that the flavonoids, tannins, and alkaloids present in the medicinal plants strongly inhibit the alpha amylase [39]. Phytochemical analysis of this plant Table 6 showed the presence of flavonoids, tannins and alkaloids. sGPT level of CMC group was increased Figure 4 than all other groups. For G-AEBCYR, Suc-AEBCYR and Sta-AEBCYR group, the sGPT level were decreased to 77.85%, 87.26%, 81.18%, respectively compared to CMC group Figure 4. In case of sGOT level, the G-AEBCYR, Suc-AEBCYR and Sta-AEBCYR solutions reduced the glucose level of 52%, 62% and 60%, respectively compared to CMC solution Figure 4. It has been reported that water soluble tannin might be bound or separately stay with aqueous fibers [40]. Moreover, flavonoids are present in aqueous extract because it is soluble in polar solvent [41]. This aqueous extract of *B. ceiba* roots contains flavonoids and tannins which are natural antioxidants and scavenge off free radicals. Moreover, Patel et al. reported that flavonoids of *B. ceiba* showed cardioprotective activity [34]. The aqueous extract of *B. ceiba* young roots acts as cardioprotective by detecting the reduced levels of sGPT and sGOT. Our results are consistent with the previously published data [34,41].

Conclusion

The study shows the inhibition of carbohydrate absorption by aqueous extract from the intestine of normal rats after ingestion of G-AEBCYR, Suc-AEBCYR and Sta-AEBCYR solutions. The starch absorbed slowly through the normal rat intestine after ingestion of Sta-AEBCYR solution. The root extracts also showed a remarkable decrease of sGPT and sGOT levels, which indicates hepatoprotective activity on normal rat. These hypoglycemic and hepatoprotective activities were due to presence of phytochemical constituents (alkaloid, glycoside, saponin, flavonoid and soluble fibers). So, *B. ceiba* young roots may take with dietary meal to prevent glucose absorption from the small intestine into blood, which may provide a new approach to prevent glucose absorption and manage type 2 diabetes mellitus and obesity. Further studies are warranted to isolate and characterize the active polyphenol compound that may be used as a candidate drug in diabetes.

Declarations

Ethical permission

The protocol used in this study for the use of rat as an animal model for diabetes research was approved by the Jessore University of Science and Technology Animal Ethical committee. This research work was approved by the Ethical Review Committee of Research Cell of Jessore University of Science and Technology, Bangladesh.

Consent to participate

Not applicable.

Availability of data and materials

The data and materials are available in public library of Jessore University of Science and Technology in a form of graduate student thesis.

Competing interests

All the authors read the manuscript and declare that they have no competing interests.

Funding

This project was partially supported by research fund of Jessore University of Science and Technology, Jessore-7408, Bangladesh.

Authors' contributions

RS conceived, designed and conducted experiments, acquired,

analyzed and interpreted data. MHHJ, MI, KA and BY supervised the study. RS and MI drafted the manuscript. AHMKA supervised the study and AI involved in preparation of manuscript and proofreading. All authors read and approved the final manuscript.

Acknowledgement

The authors would like to express their sincere gratitude to the Department of Pharmacy, Jessore University of Science and Technology and the Professor of the Ethno-Pharmacology Lab of Jahangirnagar for providing necessary facilities to carry out this research work.

References

1. Olokoba AB, Obateru OA, Olokoba LB (2012) Type2 diabetes mellitus: A review of current trends. Oman Med J 27: 269-273.
2. Lakhtakia R (2013) The history of diabetes mellitus: Sultan Qaboos Uni Med J 13: 368-370.
3. Jette N, Quan H, Hemmelgarn B, Drosler S, Maass C, et al. (2010) The development, evolution, and modifications of ICD-10: challenges to the international comparability of morbidity data. Med Care 48: 1105-1110.
4. Global report on diabetes. World Health Organization, Geneva (2016).
5. Mathers CD, Loncar D (2006) Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 3: e442.
6. Hu FB (2011) Globalization of diabetes the role of diet, lifestyle, and genes. Diabetes Care 34: 1249-57.
7. Fowler MJ (2008) Microvascular and macrovascular complications of diabetes. Clin Diabetes 26: 77-82
8. Mooradian AD (2009) Dyslipidemia in type 2 diabetes mellitus. Nat Clin Pract Endocrinol Metab 5: 150-159.
9. Pan SY, Yu Q, Zhang Y, Wang XY, Sun N, et al. (2012) Dietary Fructus Schisandrae extracts and fenofibrate regulate the serum/hepatic lipid-profile in normal and hypercholesterolemic mice, with attention to hepatotoxicity. Lipids Health Dis 11: 120.
10. Barcelo A, Aedo C, Rajpathak S, Robles S (2003) The cost of diabetes in Latin America and the Caribbean. Bull World Health Organ 81: 19-27.
11. Hogan P, Dall T, Nikolov P (2003) American Diabetes Association Economic costs of diabetes in the U.S. in 2002. Diabetes Care 26: 917-932.
12. Alim A, Sharmin R, Hossain MS, Ray DN, Khan MRI, et al. (2012) Evaluation of hypoglycemic effect of compound(s) from petroleum ether fraction of ethanol extract of Mangifera indica red leaves. IOSR J Phar 2: 14-19
13. Sharmin R, Joarder MHH, Islam MU, Ali M, Uddin MJ, et al. (2016) Mixed extract of Azadirachta indica and Piper nigrum showed better hypoglycemic and hepatoprotective effects than individual extract in diabetic mice. Indo Am J Phar Res 6: 5762-5771.
14. Wild S, Roglic G, Green A, Sicree R, King H (2004) Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care 27: 1047-1053.
15. Riaz S (2015) Study of protein biomarkers of diabetes mellitus type 2 and therapy with vitamin B1. J Diabetes Res.
16. Sheard NF, Clark NG, Brand-Miller JC, Franz MJ, Pi-Sunyer X, et al. (2004) Dietary carbohydrate (Amount and Type) in the prevention and management of diabetes. Diabetes Care 27: 2266-2271.
17. Chen L, Tuo B, Dong H (2016) Regulation of intestinal glucose absorption by ion channels and transporters. Nutrients 8: 43.
18. Franz MJ, Bantle JP, Beebe CA, Brunzell JD, Chiasson JL, et al. (2004) American Diabetes Association Nutrition Principles and Recommendations in Diabetes. Diabetes Care 27: s36-s46.
19. Dyer J, Wood IS, Palejeala A, Ellis A, Shirazi-Beechey SP (2002) Expression of monosaccharide transporters in intestine of diabetic humans. Am J Physiol Gastrointest Liver Physiol 282: 241-248.
20. Nistor BLA, Martineau LC, Benhaddou-Andaloussi A, Arnason JT, Levy E, et al. (2010) Inhibition of intestinal glucose absorption by anti-diabetic medicinal plants derived from the James Bay Cree traditional pharmacopeia. J Ethnopharmacol 132: 473-482
21. Shashi C, Abhishek S, Kumari C, Shivani C (2016) A review on Ethanobotanical and pharmacology uses of B. ceiba. Asian Pac J Pharm Appl Sci 1: 24-36.
22. Ravi V, Patel SS, Verma NK, Dutta D, Saleem TSM (2010) Hepatoprotective activity of Bombax ceiba Linn against isoniazid and rifampicin-induced toxicity in experimental rats. Int J Appl Res Nat Prod 3: 19-26.
23. Ravikumar BR, Mohan D, Bhagwat, VG (2009) Efficacy study of Styplon Vet Bolus as supportive therapy in management of hemorrhagic conditions of ruminants. Vet World 2: 470-471.
24. Bhavsar CJ, Talele GS (2013) Potential anti-diabetic activity of Bombax ceiba. Bangladesh J Pharmacol 8:102-106.
25. Patel SS, Verma NK, Rathore B, Nayak G, Singhai AK, et al. (2011) Cardioprotective effect of Bombax ceiba flowers against acute adriamycin-induced myocardial infarction in rats. Braz J Farmacogn 2: 704-709.
26. Rehman M, Akhtar N, Mustafa R (2017) Antibacterial and antioxidant potential of stem bark extract of Bombax ceiba collected locally from South Punjab area of Pakistan. Afr J Tradit Complement Altern Med 14: 9-15.
27. Phulan R, Khullar N (2004) Antimicrobial evaluation of some medicinal plants for their anti -entericpotential against multi -drug resistant Salmonella typhi. Phytother Res 18: 670-673.
28. Hossain E, Mandal SC, Gupta JK (2011) Phytochemical screening and in vivo antipyretic activity of the methanol leaf extract of Bombax Malabaricum DC (Bombacaceae). Trop J Pharm Res 10: 55-60.
29. Ananda RK (2013) In-vitro Anti-inflammatory evaluation of crude Bombax ceiba extracts. Euro J Med Plants 3: 99-104.
30. Alluri VK, Tayi VNR, Dodda S, Mulabagal V, Hsin-Sheng T, et al. (2005) Assessment of bioactivity of Indian plants using brine shrimp (Artemia salina) lethality assay. Int J Appl Sci Eng 3:125-134.
31. Bhavsar CJ, Talele GS (2013) Potential anti-diabetic activity of Bombax ceiba. Bang J Pharmacol 8: 102-106.
32. Rubeena S, Mohammad A, Hussain SA, Qazi AM, Ahmad SI, et al. (1999) Hypotensive, Hypoglycaemic and Toxicological Studies on the Flavonol C-Glycoside Shamimin from Bombax ceiba. Planta Medica 65: 331-334.
33. Gupta P, Goyal R, Chauhan Y, Sharma PL (2013) Possible modulation of FAS and PTP-1B signaling in ameliorative potential of Bombax ceiba against high fat diet induced obesity. BMC Complement Alt Med 13: 281.
34. Ansari MM, Ahmad J, Ahmad A, Ansari SH (2007) Pharmacognostical, phytochemical and biological evaluations of the stem bark of Bombax ceiba Linn. (Semul). Hamdard Med 50: 119-33.
35. Allen-Worthington KH, Brice AK, Marx JO, Hankenson FC (2015) Intraperitoneal Injection of Ethanol for the Euthanasia of Laboratory Mice (Mus musculus) and Rats (Rattus norvegicus). J Am Assoc Lab Anim Sci 54: 769-778.
36. Latime JH, Haub MD (2010) Effect of diatery fiber and its components on metabolic health. Nutrients 2: 1266-1289.
37. Sun SZ, Empie MW (2012) Fructose metabolism in humans-what isotopic tracer studies tell us. Nutr Metab 9: 89.
38. Gallagher AM, Flatt PR, Duffy G, Abdel-Wahab YHA (2003) The effects of traditional antidiabetic plants on *in vitro* glucose diffusion. Nutr Res 23: 413-42.
39. Pare D, Hilou A, Ouedraogo N, Guenne S (2016) Ethnobotanical study of medicinal plants used as anti-obesity remedies in the nomad and hunter communities of Burkina Faso. Medicines 3: 1-24.
40. Zanchi D, Vernhet A, Legrand CP, Cartalade D, Tribet C, et al. (2007) Colloidal dispersions of Tannins in water−ethanol solutions. Langmuir 23: 9949-9959.
41. Dai Y, Spronsen JV, Witkamp GJ, Verpoorte R, Choi YH (2013) Ionic liquids and deep eutectic solvent natural products research: Mixtures of solids as extraction solvents. J Nat prod 76: 2162-2173.