International Journal of Scientific Research in Dental and Medical Sciences

www.ijsrdms.com

Cocos Nucifera Endocarp Extract Exhibits Anti-diabetic and Antilipidemic Activities in Diabetic Rat Model

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ARTICLE INFO

Article history:
Received 09 December 2021
Received in revised form 22 January 2022
Accepted 05 February 2022
Available online 14 February 2022

Keywords:
Cocos
Hypoglycemic agents
Hypolipidemic agents
Oxidative stress

ABSTRACT

Background and aim: The fruits of Cocos nucifera have long been used in traditional medicine as anti-inflammatory, antimicrobial, antiparasitic, anticancer, and cardiotonic. This study aimed to evaluate the anti-diabetic and antilipidemic activities in the diabetic rat model.

Material and methods: Cocos nucifera endocarp was extracted with Methanol and then fractionated with different solvents, namely h-hexane, Chloroform, and ethyl acetate. A total of 30 Streptozotocin-induced diabetic rats were used in six experimental groups. All the animals were treated for 14 days period. The measured outcomes were fasting blood sugar (FBS), lipid profiles, acute hypoglycaemic effects, and changes in body weights. Antioxidative studies and phytochemical screening were also performed.

Results: A significant hypoglycemic effect was found in the group treated with ethyl acetate fractions (6.33 ± 0.32 mmol/L, $p<0.05$) when compared to placebo (7.85±0.38 mmol/L). After a glucose load, the same fraction also showed a significant antihyperglycemic effect within 75 minutes of treatment. Both ethyl acetate and chloroform fractions reduced the baseline serum cholesterol and triglyceride levels. However, no significant change in body weight was reported in any treatment groups. In the DPPH free radical scavenging assay, the methanolic fraction and ethyl acetate fractions showed notable free radical scavenging activity with IC50 value 32.31 µg/ml and 27.55 respectively, compared to standard Tert-Butyl-1-hydroxytolune (23.92 µg/ml), indicating potential antioxidative properties.

Conclusions: Cocos nucifera endocarp showed promising anti-diabetic and antilipidemic properties. The ethyl acetate soluble fraction might be further explored to isolate active medicinal compounds in drug discovery.

1. Introduction

Natural products have a long history of alleviating numerous diseases.[1] In particular, medicinal plant extracts were very popular before the dawn of synthetic medicine. Currently, extensive efforts are seen in the scientific community to validate the folklore use of medicinal plants as well as the discovery of new therapeutics. Research on medicinal plants can lead to discovering safer alternatives for treating acute and chronic diseases. Although computerized and automated technologies are now being used to generate libraries of numerous synthetic compounds, becoming a therapeutic drug from them has been declined in recent years.[2] Drug discovery based on ethnobotanical knowledge is now gaining popularity due to its fewer side effects than synthetic medicine. Identifying novel drug leads from medicinal plants is now an important pool in new drug discovery. The phytochemical profiles of herbal remedies can give clues to structuring, screening, and creating novel multi-target therapeutics.[3] A recent survey states that 537 million adults worldwide live with diabetes, and 6.7 million deaths due to diabetes in 2021 have been reported.[4] Diabetes is associated with acute metabolic decomposition leading to functional and structural changes in different body cells that are often permanent and irreversible, affecting the nervous system, kidneys, eyes, reproductive organs. Type II Diabetes Mellitus (T2DM) is predominant in over 90 percent of diabetic people. The onset of T2DM is usually at the middle age due to reduced insulin production or resistance to insulin action. Synthetic hypoglycemic drugs and insulin use are the main medication for diabetes management. However, these

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http://doi.org/10.30485/IJSRDMS.2022.320342.1228

medications show many side effects and cannot prevent diabetic complications. Thus, the discovery of antidiabetic drugs from alternative sources, particularly from natural sources, plays an imperative role in current drug discovery programs. It has been reported that plants containing polyphenols, saponins, flavonoids, alkaloids possess antidiabetic properties.[5] Cocos nucifera Linn (Arecaceae) is a popular coconut tree, extensively grown in tropical and subtropical areas worldwide.[6] The folklore use of coconut was reported in ancient ayurvedic medicine thousand years ago. Many pharmacological activities like antineoplastic, antiparasitic, antimicrobial, insecticidal activities have been reported in the literature. However, most research was done using water, oil, kernel, or husk fibers. Very limited works are done using endocarp. Singla and Dubey[7] reported that ethanolic extract could significantly inhibit the α-amylase activities. They also reported high alkaloids, saponins, tannins, triterpenes, flavonoids, glycosides, quinones, carbohydrates, lactones, and terpenoids in the ethanolic extract the endocarp. Nuciferoic acid, a novel keto fatty acid, was identified by Singla et al. (2018). The component showed hyaluronidase inhibitory activity, which indicated potential anti-inflammatory action.[8] The endocarp extracts showed vasorelaxant and antihypertensive effects in the rat model.[9] This study aims to investigate the pharmacological responses of the methanolic extract and different solvent-fractions Cocos nucifera Linn endocarp in a diabetic rat model. Phytochemical screening for major chemical groups and antioxidant activities were also explored.

2. Material and methods

Ethics approval

All animal procedures were approved by the Animal Care and Utilization Committee of University of Dhaka. All animal experiments were approved and performed following the guidelines of the Ethics Committee of the University of Dhaka of Bangladesh. All surgical procedures were performed under anesthesia, and every effort was made to minimize suffering. Rats were anesthetized by intraperitoneal injection of sodium pentobarbital.

Collection and extraction of cocos nucifera endocarp

The endocarp of unripe Cocos nucifera fruit aging 2-3 months were collected from various locations of Bangladesh during the month of March-April. The endocarp was prepared by washing with distilled water without squeezing and afterward cut into small pieces. The thoroughly air-dried endocarps were then grinded with a mechanical grinder. About 950 g of the powdered sample was soaked in 4 liters of Methanol sealed with a cotton plug and covered with aluminum foil for 15 days with shaking and occasionally stirring for better extraction. Whatman No.1 filter paper was used as a filtering medium to filter the mixture. The final crude methanolic extract (CME) was obtained by concentrating the filtrate with a Heidolph rotary evaporator at 40 ℃. The extract was then fractionated into three portions using n-hexane, Chloroform, and ethyl acetate following a modified Kupchan partition method.[10] These fractions were named as n-hexane fraction (NHFCN), chloroform fraction (CFCN), and ethyl acetate fraction (EAFCN) of Cocos nucifera. Then, the fractions were dried and preserved in the refrigerator at 4 ℃, covered with aluminum foil to prevent fungal or microbial contamination.

Experimental design

A total of 30 diabetic rats were used, divided into six groups containing five rats in each group for this experiment. All the animals were treated for 14 days period. Group I served as a placebo where deionized water (10 ml/kg body weight) was used, denoted as the water control (WC) group. Group II received Glibenclamide at a dose of 5 mg/10 ml/kg body weight and was assigned as Glibenclamide treated (GT) group. Group III-VI were assigned as CME or crude methanolic extract group (III), NHFCN or n-hexane fraction group (IV), CFCN or Chloroform fraction group (V), and EAFCN or Ethyl acetate fraction group (VI) and therefore receiving these extracts at a dose of 200mg/10ml/kg body weight respectively.

During the investigation of chronic hypoglycemic activity, studies were performed by evaluating the effects on body weight, levels of serum glucose during fasting condition, and serum lipids for 14 days. Bodyweight was observed weekly to detect if any changes occurred in body weights. The acute hypoglycemic effect of Cocos Nucifera extracts on type II diabetic rats was also performed after an oral glucose load at 0-, 30- and 75-min. A blood sample was collected from the tail tip by amputation under pentobarbital anesthesia, and then at 2500 rpm, the blood was centrifuged for 15 minutes to separate the serum. Several methodologies were used to investigate (a) serum glucose levels by Glucose Oxidase method utilizing a microplate reader;[11] (b) serum level of total cholesterol and triglyceride (TG) utilizing the enzymatic method in an Auto Analyzer;[12] (c) serum level of high-density lipoprotein (HDL) enzymatically using a micro-plate reader; (d) serum level of Low-Density Lipoprotein (LDL) by Friedewald method;[13] (e) serum level of insulin by enzyme-linked immunosorbent assay (ELISA) method;[14] (f) liver glycogen level[15] after 14 days of chronic treatment with different fractions of crude extract of endocarp of Cocos Nucifera. Bodyweight and blood samples were taken from different groups of rats on days 0, 7, and 14 for biochemical investigations.

Hypoglycemic activity study

Experimental animals

Long-Evans rats were used to investigate antidiabetic activities. Rats (150-170 g) of all females, bred at the animal house of the Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM) in Dhaka, Bangladesh. The animals were kept in a laboratory, maintaining the room temperature at 20±5 ºC with 40-70% humidity. The day-night cycle was maintained as 12:12 hours for all the animals during the study period. A standard laboratory pellet diet was given, and water was provided ad libitum. The animals were let fasted overnight with only allowing free access to water. All rats were then weighed before doing the experiments. All experiments were done at 8.30 a.m. to avoid the influence of circadian rhythms.

Induction of type II diabetes

Intraperitoneal injection of streptozotocin (STZ) at a dose of 90 mg/kg body weight in Citrate Buffer (10 mL) was used following standard procedures as described elsewhere to induce type II diabetes in rats.[16] Three months after STZ giving an injection, a fasting blood glucose level of 8-12 mmol/L was selected as a diabetic rat model for our experiments.

Administration of endocarp extracts

The NHFCN, CFCN, and EAFCN fractions were orally administrated at a dose of 200 mg/kg body weight to the diabetic rats for 14 days to evaluate the antidiabetic activity[16] The oral dose for the standard drug Glibenclamide was 5 mg/10 ml/kg body weight. For the water control group, 10 ml/kg body weight deionized water was administrated.

Phytochemical analysis

Qualitative phytochemical screening was performed on the methanolic crude extract to detect major chemical groups like alkaloids, flavonoids, tannins, saponins, carbohydrates, quinones, glycosides through the established methods.[17] In brief, the presence of alkaloids was tested with Mayer's, Wagner's, Dragendorff's and Hager's test. Concentrated HCl and 0.1% ferric chloride were used to detect the presence of flavonoids and tannins. Molish reagents and concentrated sulfuric acid were used for carbohydrates. The ability to produce suds was used as a marker of the identification of saponins. All the tests were performed three times to confirm the detection.

Antioxidant activity study

Antioxidant activity is one of the desired pharmacological activities of a plant. This study used the stable radical 2, 2- diphenylpicrylhydrazyl (DPPH) as a reagent.[18] Tert-butyl-1-hydroxytolune (BHT) (BHT) was used as a standard To evaluate the free radical scavenging activity. DPPH dissolved in methanol solvent produces a purple-colored solution. Breaching of this color by crude methanolic extract and its corresponding fractions was measured by UV-Vis spectrophotometric method to calculate the antioxidant potentiality. The concentration of DPPH was 20 µg/ml. 4 mg of DPPH was taken and dissolved in methanol solvent to get this concentration. 1000 µg/ml of different fractions was also prepared by dissolving a calculated number of different fractions in methanol. Serial dilution of the initial solution was done to make the solutions of concentration 500 µg/ml up to 0.977 µg/ml. Each sample was dissolved in methanol, and 2.0 ml of each solution was mixed with 3.0 ml of DPPH methanol solution (20 µg/ ml). The final solution was kept in the dark place at room temperature for 30 minutes to complete the reaction. After 30 minutes, absorbance was measured for the samples (A sample) at 517 nm by UV spectrophotometer against methanol as blank (A blank). Antioxidant activity was measured by calculating the inhibition percentage (I %) by the following equation:

$$(I\ \%) = (1- A_{sample} / A_{blank}) \times 100$$

Here, Asample is the absorbance of the sample, and blank is the absorbance of the blank. We plotted the value of percent inhibition in the graph against the sample concentration. From the graph, the concentration of the sample which provided 50% inhibition (IC50) was calculated.

Statistical analysis

All data present represent the mean ± SD of at least three independent experiments. Data analysis and curve fitting was carried out using the GraphPad Prism software package v9.0.0 (GraphPad Software, La Jolla, CA).

3. Results

Chronic hypoglycemic effect

The fasting serum glucose levels at baseline were almost similar in all treatment groups. However, after 14 days of treatment, all groups except the placebo (negative control; water control (WC) showed a reduction of fasting blood sugar (Fig. 1). Compared to placebo, the reduction was significant in positive control Glibenclamide (5.97±0.42, $p<0.01$) and EAFCN (6.33±0.32, $p<0.05$) groups.

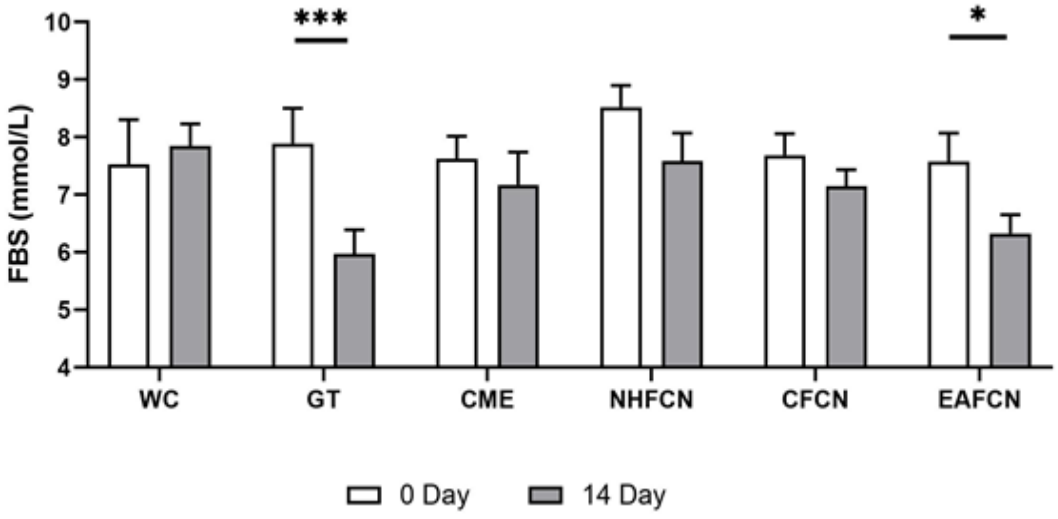

Fig. 1. Chronic hypoglycemic effects of cocos nucifera extracts. Serum blood glucose was measured at 0 day and after treatment for 14 days. Results are expressed as mean ± SD. WC, Water control; GT, Glibenclamide treatment; CME, crude methanolic extract; NHFCN, n-hexane fraction; CFCN, Chloroform fraction; EAFCN, Ethyl acetate fraction. Analysis was performed within groups using paired 't-tests (*p<0.05, ***p<0.001).

Acute hypoglycemic effect

The acute hypoglycemic effect of Cocos Nucifera extract on type II diabetic rats was noted after oral glucose load at 0, 30 min, and 75 min. The effect of the extract in lowering serum glucose was significant in the standard drug (Glibenclamide), and Ethyl acetate fraction fed group compared to WC treated group (Fig. 2).

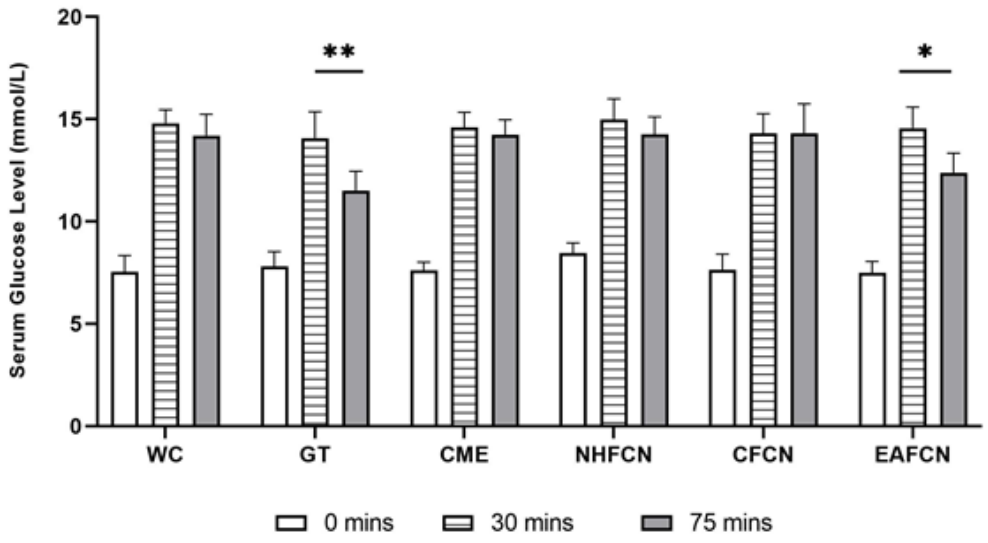

Fig. 2. Acute effects of cocos nucifera extracts on serum glucose level of type II diabetic rats with a simultaneous glucose load. Glucose levels were measured at 0 min, 30 mins, and 75 mins intervals in different treatment groups. Results are expressed as Mean ± SD. WC: Water control group; GT: Glibenclamide group; CME: crude methanolic extract; NHFCN: n-hexane fraction; CFCN: chloroform fraction and EAFCN: ethyl acetate fraction of cocos nucifera. P <0.05 compared to 30 mins level.

Effects on fasting serum insulin level

The sub-chronic effect of the fractions on insulinemic status was observed for 14 days on type II diabetic model rats. On 0-day, water control, Glibenclamide, and type II extract-treated groups showed a similar serum insulin level. After 14 days study period, the water control and n-hexane group showed a reduction in serum insulin level (Table 1). A significant elevation level of serum insulin level was observed in the standard Glibenclamide treated group when compared with 0 days (baseline). A small increase in insulin was seen in the FAFCN group; however, the change was not statistically significant (p=0.207). The other group did not show any significant change in serum insulin level.

Table 1. Effects of Cocos Nucifera extracts on fasting serum insulin level of type II diabetic rats.

Treatment Groups	Serum Insulin (ng/ml)	
	0 Day	14 Day
WC	0.28 ± 0.08	0.30 ± 0.07
GT	0.30 ± 0.07	0.46 ± 0.05*
CME	0.28 ± 0.08	0.38 ± 0.04
NHFCN	0.30 ± 0.07	0.26 ± 0.08
CFCN	0.33 ± 0.04	0.34 ± 0.05
EAFCN	0.31 ± 0.07	0.41 ± 0.05

Results are expressed as mean ± SD. WC: Placebo group fed only water; GT: Positive control Glibenclamide group; CME: Crude methanolic extract; NHFCN: N-hexane fraction; CFCN: Chloroform fraction and EAFCN: Ethyl acetate fraction of Cocos Nucifera. Analysis was performed within groups using paired 't-tests (*p<0.05).

Effects on serum cholesterol and triglyceride levels

Sub-chronic effects of fractions on serum cholesterol levels were also observed to find the beneficial effects of the extracts (Table 2). There was a 3% reduction in the Ethyl acetate treated group of total cholesterol levels on the 14th day. No effect was found regarding serum cholesterol levels among the other groups. Serum triglyceride (TG) level was also reduced; there was an 11% reduction in the Chloroform treated group and a 6% reduction in the ethyl acetate treated group after 14 days. An increase in serum HDL level was also observed. HDL-cholesterol level was increased by 11% and 7% in the Chloroform fraction and ethyl acetate fraction treated group, respectively, and decreased in the n-hexane treated group after 14 days study period. Other groups showed no significant change. Chloroform and ethyl acetate groups showed decreased LDL-cholesterol levels but were not significant.

Table 2. Effects of Cocos Nucifera extracts on fasting serum insulin, total serum cholesterol, triglyceride, HDL, and an LDL level of type II diabetic rats.

Group		WC	GT	CME	NHFCN	CFCN	EAFCN
Cholesterol (mg/dl)	0 Day	59.05 ± 7.11	63.64 ± 5.43	66.57 ± 2.19	57.82 ± 4.31	63.88 ± 8.76	68.46 ± 12.25
	14 Day	59.50 ± 8.56	61.16 ± 5.53**	64.23 ± 3.43	61.06 ± 5.39	63.51 ± 12.22	66.38 ± 10.36*
TG (mg/dl)	0 Day	73.83 ± 21.98	74.50 ± 12.25	78.92 ± 12.58	49.50 ± 5.73	83.50 ± 23.56	79.52 ± 33.46
	14 Day	67.12 ± 10.43	67.64 ± 9.92**	76.44 ± 3.86	57.20 ± 11.62	74.04 ±19.45**	74.46 ± 8.68*
HDL-C (mg/dl)	0 Day	36.60 ± 6.20	39.30 ± 5.48	30.96 ± 3.68	39.12 ± 3.39	29.90 ± 5.47	32.28 ± 5.30
	14 Day	36.28 ± 5.15	39.98 ± 3.26	32.65 ± 5.34	37.88 ± 5.32	33.18 ± 4.24	34.54 ± 3.50
LDL-C (mg/dl)	0 Day	9.28 ± 7.13	9.18 ± 4.26	10.51 ± 0.65	8.05 ± 5.02	17.31 ± 8.22	20.02 ± 15.08
	14 Day	9.11 ± 5.22	10.19 ± 3.34	10.34 ± 1.12	13.55 ± 6.11**	16.28 ± 9.55	19.87 ± 9.12

Results are expressed as mean ± SD. WC: Placebo group fed only water; GT: Positive control Glibenclamide group; CME: Crude methanolic extract; NHFCN: N-hexane fraction; CFCN: Chloroform fraction and EAFCN: Ethyl acetate fraction of Cocos Nucifera. Analysis was performed within groups using paired 't-tests (*p<0.05).

Effect on body weight

The effect of different fractions on the body weight in STZ-induced diabetic rats was investigated through this study. Five rats in each group were allocated for the experiment. These rats were observed for 14 days to detect any change in body weight. Reading was taken once a week. No significant change in body weight was observed in any group after chronic administration of extracts or drugs (Table 3).

Table 3. Effects on body weights of Cocos Nucifera extracts on type II diabetic rats.

Group	Body Weight (g)		
	0 day	7 days	14 days
WC	162 ± 17	164 ± 25	167 ± 25
GT	167 ± 20	170 ± 15	177 ± 24
CME	150 ± 7	152 ± 10	157 ± 8
NHFCN	158 ± 8	156 ± 11	158 ± 13
CFCN	152 ± 4	150 ± 10	154 ± 9
EAFCN	156 ± 9	160 ± 14	162 ± 13

Results are expressed as mean ± SD. WC: Placebo group fed only water; GT: Positive control Glibenclamide group; CME: Crude methanolic extract; NHFCN: N-hexane fraction; CFCN: Chloroform fraction and EAFCN: Ethyl acetate fraction of Cocos Nucifera. Analysis was performed within groups using paired 't-tests (*p<0.05).

Antioxidant screening

DPPH radical scavenging method has been extensively used for screening in vitro antioxidant activity. Tert-butyl-1-hydroxytolune (BHT) was used as a standard to evaluate the free radical scavenging activity. The ethaylacetate fraction showed the lowest IC50 value (Table 4).

Table 4. Antioxidative potentials of different fractions of Cocos Nucifera extracts.

Group	IC50 (µg/ml)
BHT	23.92 ± 5.41
CME	35.55 ± 5.20
NHFCN	79.11 ± 8.04
CFCN	32.31 ± 5.18
EAFCN	27.55 ± 6.79*

Results are expressed as mean ± SD. BHT: Tert-butyl-1-hydroxytolune; CME: Crude methanolic extract; NHFCN: N-hexane fraction; CFCN: Chloroform fraction and EAFCN: Ethyl acetate fraction of Cocos Nucifera. p<0.05 was taken as significant.

The final crude methanolic extract (CME) was obtained by concentrating the filtrate at 40℃ using a Heidolph rotary evaporator. The extract was then fractionated into three portions using n-hexane, Chloroform, and ethyl acetate following a modified Kupchan partition method.[10] These fractions were named as n-hexane fraction (NHFCN), chloroform fraction (CFCN), and ethyl acetate fraction (EAFCN) of Cocos Nucifera. Among all the samples, ethyl acetate fraction showed significant antioxidant activity compared to standard.

Phytochemical screening

Primary qualitative analysis indicated that the crude methanolic extract of Cocos Nucifera fruit endocarp is abundant in alkaloids, flavonoids, tannins, saponins, and carbohydrates (Table 5).

Table 5. Results of preliminary phytochemical analysis of endocarp of Cocos Nucifera.

Compounds	Specific tests	Observation	Inference
Alkaloids	Mayer's test	+	Presence of Alkaloids
	Wagner's test	+	
	Dragondorff's test	+	
	Hager's test	+	
Flavonoids	H_2SO_4 test	+	Presence of Flavonoids
Polyphenols (Tannins)	$FeCl_3$ test	+	Presence of Tannins
Saponins	Foam test	+	Presence of Saponins
Carbohydrates	Molisch's test	+	Presence of Carbohydrates
Quinones	HCl test	---	Absence of Quinones
Glycosides	NaOH test	---	Absence of Glycosides

(+) denotes presence, and (-) denotes absence of phytochemicals.

4. Discussion

The streptozotocin-induced diabetic rat model is mainly used to evaluate the antidiabetic potential of natural products. STZ causes degeneration of pancreatic islets of Langerhans and thus induces diabetes in experimental animals.[19] Diabetes is a metabolic disorder where impaired insulin secretion or insulin resistance results in elevated blood glucose levels. Although several antidiabetic medications are currently available, plant-based therapeutics are also gaining attention in the scientific community due to their cost-effectiveness and minimal side effects.[20] Our study demonstrated that ethyl acetate fraction of Cocos Nucifera endocarp could induce a significant reduction of fasting blood glucose level in STZ induced diabetic rat model compared with the untreated diabetic control rats (Fig. 1).

Moreover, acute antihyperglycemic activity was noted after a glucose load within 75 minutes of extract treatment (Fig. 2). However, serum insulin secretion was not significant in any extract treatment groups for a total of 14 days of treatment (Table1). The antidiabetic effects from medication are commonly attributed to insulin secretion by pancreatic beta-cells, increasing insulin sensitivity, cellular utilization of glucose, deposition of glucose in muscle and liver cells, modification of carbohydrate digestion process, and modification gut-enzyme activity.[21] The antidiabetic effect in our experiment might involve any of these pathways. However, Singla and Dubey (2019)

reported that crude extract of Cocos Nucifera endocarp could inhibit the α-amylase enzyme activities.[7] The docking studies in their report showed that probable molecules in the extracts had more affinity to the enzyme active sites than that of standard acarbose drug.[7] This enzyme plays a role in carbohydrate digestion. So, the antidiabetic activity in our experiment might also be due to the inhibition of this enzyme. Many scientific reports reveal that inflammation of the pancreatic Langerhans beta-cell islets might lead to the development of diabetes.[22] Singla et al. (2018) reported that Cocos Nucifera endocarp contained nuciferoic acid, which showed hyaluronidase inhibitory activity.[8] Hyaluronidase inhibitors are potent agents that maintain hyaluronic acid homeostasis and may serve as anti-inflammatory agents.[23] So, the anti-inflammatory potential of Cocos Nucifera endocarp extract might play a protective role on the pancreas and help in glucose homeostasis. Moreover, oxidative stress has a great role in developing diabetes.[24] Hyperglycemia associated with diabetes induces the generation of free radicals in the body. Free radicals can alter cellular functions by damaging lipids, proteins, DNA, and cellular components. Many chemically-induced diabetic animal model studies suggest that neutralizing free radicals might effectively treat diabetes.[25] All crude fractions showed potential antioxidative activities compared to standard BHT (Table 4). So, the antidiabetic effect in our animal model experiment might be due to the content of antioxidative materials in the endocarp extracts. Padumadasa et al. (2016) reported rich content of phenolic compounds using ethyl acetate fractions of this fruit.[26] High phenolic contents in Cocos Nucifera endocarp extract were reported by Singla and Dubey (2019),[7] and we also found polyphenols in our extract (Table 5). Several reports suggest that dietary polyphenols show antidiabetic properties in animal studies.[27] In our experiment, the antidiabetic effects might be due to high phenolic contents in this fraction. Our experiment also reported the presence of various phytochemical constituents, including alkaloids, flavonoids, and tannins (Table 4). These constituents have been reported to show direct or indirect effects on diabetes prevention.[28] Hence, we could state that flavonoids and polyphenols or other phytochemicals play a vital role in the observed antidiabetic activity in diabetic rat models. So, diverse mechanisms might be involved in Cocos Nucifera endocarp extract antidiabetic activities. Dyslipidemia is common in diabetic conditions. It is now considered the most important risk factor in diabetic complications, including neuropathy, retinopathy, nephropathy, and cardiovascular complications.[29] Rapid urbanization, a sedentary occupation, and a high intake of lipid diets contribute to dyslipidemia development. Statins and fibrates are the mainstays of the treatment of dyslipidemia. However, their long-term use has adverse effects, and some are contraindicated in some diabetic complications.[30] So, there is always a need to develop new medications with fewer side effects. Plant-based therapeutics have fewer toxicities than synthetic medications. In our experiments, ethyl acetate and chloroform fractions show antilipidemic activities. However, negative effects were noticed with n-hexane fractions (Table 2). Plants rich in alkaloids and polyphenol compounds have improved lipid metabolism.[31] These phytochemicals promote the inhibition of anabolic metabolism while increasing the catabolic metabolism of lipids, ultimately reducing the availability of fatty acids in the body. The lipid-lowering activity by most of our fractions might be related to the flavonoid-rich contents in the endocarp of Cocos Nucifera. Taken together, the antidiabetic and antilipidemic activities extracts of Cocos Nucifera endocarp might be a promising candidate for future drug development. Nevertheless, more phytochemical and animal studies are still needed to elucidate these ethnopharmacological activities further.

5. Conclusions

Based on the findings in our present experiment, Cocos Nucifera endocarp extracts exhibited promising antidiabetic and hypoglycaemic activities in Streptozotocin-induced diabetic rats. Cocos Nucifera endocarp extracts also showed moderate antilipidemic effects. Phytochemical screening showed potential antioxidant activities. These findings indicated the biological, toxicological, and pharmacological importance of Cocos Nucifera endocarp. Further investigation on the isolation of pure compounds and pre-clinical studies in animal models might help discover new drug candidates with chemically interesting and biologically important properties. More studies are also needed to understand better these medicinally important fruit plants' antidiabetic and antilipidemic mechanisms. Further studies on this aspect are underway.

Conflict of Interest

The authors declared that there is no conflict of interest.

Acknowledgements

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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How to Cite this Article: Akter F, Bhuiya NM, Hasan N, Rokeya B, Raihan SZ, Al Mahmud Z. Cocos Nucifera Endocarp Extract Exhibits Anti-diabetic and Antilipidemic Activities in Diabetic Rat Model. International Journal of Scientific Research in Dental and Medical Sciences, 2022;4(1):8-15.
http://doi.org/10.30485/IJSRDMS.2022.320342.1228.