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Investigation of hypoglycemic and antidiarrheal activity on mice model and *in vitro* anthelmintic study of *Macropanax dispermus* (Blume) Kuntze (Araliaceae): a promising ethnomedicinal plant

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ABSTRACT

Introduction: *Macropanax dispermus* is an ethnomedicinal plant, which has been shown to have pharmacological effects against inflammation. Inflammation is also associated with diabetic-related complications. In addition, the indigenous people used this plant to cure numerous digestive system disorders. These ethnomedicinal uses have inspired the current research to focus on determining the biological potential of the crude methanol extract of its leaves (MDML) and stem barks (MDMS) against morbid diseases such as diarrhea, helminthiasis, and diabetes mellitus related to hyperglycemia. This study also identified the functional groups present in MDML which could correlate the presence of different phytochemicals responsible for biological activities.

Methods: The hypoglycemic activity and antidiarrheal tests were done on Swiss albino mice through an oral glucose tolerance test (OGTT) and castor-oil-induced diarrhea, respectively. The anthelmintic test was done *in vitro* on *Pheretima posthuma*. The functional groups were identified by using Fourier-transform infrared (FTIR) spectroscopy.

Results: Here, MDML at 400 mg/kg exhibited a significant ($P<0.05$) hypoglycemic activity as well as decreased diarrheal drops significantly ($P<0.001$) when compared to the control group. Additionally, MDMS showed a concentration-dependent significant effect as a prospective anthelmintic agent. The FTIR spectra demonstrated the presence of different functional groups, which might contribute to the presence of flavonoids, saponins, terpenoids, and other related compounds.

Conclusion: The present research demonstrated that MDML and MDMS might be effective interventions for treating hyperglycemia, diarrhea, and helminthiasis.

Implication for health policy/practice/research/medical education:
The investigated *Macropanax dispermus* (Blume) Kuntze (Araliaceae) extracts exhibited significant activity against hyperglycemia and castor oil-induced diarrhea and might contribute to the formulation of alternative medicinal agents to treat diabetes and diarrhea. In addition, MDMS was proved to be an effective anthelmintic agent.

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Introduction

Herbal medicines have always been popular among people due to their natural effects in curing diseases more cheaply. In an investigation, it was found that numerous compounds have to be screened, synthesized, and tested to develop a synthetic drug, which is very costly, requiring millions of dollars (1). In contrast, herbal medicines require minimum facilities to prepare with the least expenses and have well-known pharmacological effects in treating many diseases. Additionally, people believe

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that herbal medications offer many remedies for multiple diseases without showing any undesirable side effects at lower expenses (2). Therefore, many people around the world prefer herbal medicines over synthetic drugs for the treatment of several diseases. Thus, considering the expense and effectiveness, herbal medicines have always been chosen over synthetic medicines as reliable means of treating diseases (3).

Diabetes mellitus (DM) is a disorder of the endocrine gland that incorporates decreased or no secretion of insulin, damaged pancreatic β-cells and results in altered carbohydrate, lipid, and protein metabolism along with the complications of a wide range of vascular diseases. Hyperglycemia is an important condition in the progression and subsequent development of the major complications of diabetes mellitus (4). Along with lifestyle modification and dietary control, a variety of oral hypoglycemic agents are effective treatment options to control the progression of DM (5). Despite having a wide range of efficacy, these oral hypoglycemic agents are associated with several side effects like indigestion, obesity, and hypoglycemia, which have necessitated the alternative form of hypoglycemic medicines with fewer side effects (6). Phytotherapy has been proven to be effective in alleviating hyperglycemia and more than 800 plants have been reported to have an excellent antidiabetic potential (7).

Diarrhea is another death-causing disease, which disrupts the regular movement of the bowel, incorporating the increase in the volume of water in the stool along with the recurrence of defecation as well as reduced fluid and electrolyte absorption (8,9). The treatment of diarrhea often adds oral rehydration solution, antisecretory, antimotility as well as zinc supplements to diminish the diarrheal drops and restore regular defecation (9, 10). Despite their efficacy, the World Health Organization (WHO) has recommended plant-based therapy to fight the diarrheal episodes in its diarrhea control program (11).

Helminthiasis is one of the most common infections of the intestine, which breed morbid conditions among people in developing countries. It is mainly caused by the infestation of helminths residing in the human gastrointestinal tract, which gradually attack the surrounding tissues by migrating larvae toward them (12). They secrete toxins that cause blood loss, organ injury, and gastrointestinal obstruction (13). Anthelmintics kill or expel the infesting helminths in the gastrointestinal tract and other infected tissues to treat the disease. Still, they exhibit numerous side effects, including gastrointestinal tract disturbances, nausea, and giddiness, as well as increased resistance to synthetic anthelmintic drugs. It has necessitated the urge to use alternative treatment strategies such as herbal or plant-based medicines effective against resistant and non-resistant helminth species.

Fourier-transform infrared (FTIR) spectroscopy is a sophisticated, high-resolution analytical tool that can predict the functional group and the chemical bonds present in the extracts, hence predicting the presence of structural compounds and chemical constituents. The spectrum of an unknown compound can be recognized by comparing it to the library of known compounds (14,15). Therefore, MDML was studied through FTIR spectroscopic technique to identify its functional groups, which can relate to its previous investigation of qualitative and quantitative phytochemical analysis.

Since immemorial, plants have been used as an effective medicinal agent and are accepted worldwide due to their better cultural acceptability, fewer side effects, reduced toxicity, and effective pharmacological action. Thus, the researchers have been successful in developing various popular plant-derived drugs like paclitaxel, vinblastine, vincristine, quinine, artemisinin, and morphine in the treatment of cancer, malaria, as well as central nervous system-related algesia (16-18). *Macropanax dispermus* is a medicinal plant, possessing a wide variety of ethnomedicinal uses as well as various pharmacological effects, which have already been proved in previous investigations. It is commonly known as "Gu Shing" in Bhutan, "Jawa Tengah" in Indonesia, "Tha-yat-kin" or "Ka-la-kin" in Myanmar, "Charee Pilaa" or "Ninde" in Nepal, "A sa ding" in China, "Deno appo" among tribal people in Rangamati district of Bangladesh (19-23). In Thailand and Myanmar, the indigenous people usually use this plant as an effective treatment option for cough suppression, relief of menopausal and malarial fever, improving digestion and blood flow, elimination of waste matter, and postpartum bathing (24,25). Its crude methanol extracts have exhibited the presence of several phytochemicals by using the β-carotene bleaching method (26). Researchers have also investigated MDMS, MDML, and its different fractions, which have demonstrated the presence of significant amounts of phytochemicals, thrombolytic, cytotoxic, anti-arthritic activity as well as analgesic, antipyretic, and anti-inflammatory effects in the preclinical investigation on Swiss albino mice model (27,28). Several types of research are correlating inflammation, algesia, diarrheal action, insulin resistance, and helminth infections (29-31). Considering all the beneficiaries of plant-based medicines and the abundant pharmacological effects of the different extracts of *M. dispermus*, MDML and MDMS have been investigated for their potential as hypoglycemic, antidiarrheal, and anthelmintic agents. MDML was investigated further to identify its functional groups using FTIR spectroscopic analysis.

Materials and Methods

Chemicals

This research used laboratory-grade solvents and chemicals, including methanol, glucose, castor oil,

tween-80, and others (Merck, Germany).

Collection and identification of the plant

Macropanax dispermus was collected in the matured stage in August 2018 from Rangamati, a district of the Chattogram division, Bangladesh. A prominent local traditional healer aided the collection. Then, Professor Shaikh Bokhtear Uddin, PhD, a botanist and taxonomist at the Department of Botany, University of Chittagong, identified the plant and stored a specimen in the same department (herbarium no.: sr20385).

Preparation of crude extracts

In the Medicinal Chemistry and Pharmacology laboratory of the Department of Pharmacy, University of Chittagong, the plant samples were thoroughly washed, dried, and chopped accordingly. After that, the dried samples (leaves and stem barks) were ground using a mechanical grinder. The ground leaves of 1.36 kg and stem barks of 493 g were soaked in 7.29 L and 2.60 L, methanol, respectively, with occasional shaking for 13 days. After filtration, the filtrate was concentrated by using a rotary evaporator (Stuart, UK). The crude leaves and stem barks weighed 28.50 g and 7.66 g, respectively. The following equation was used to calculate the extract's percentage (%) yield (32).

$$\%\,of\ yield\ of\ extracts = \frac{Weight\ of\ extract}{Weight\ of\ powder} \times 100$$

Experimental animals

The Swiss albino mice, which weighed about 20-30 gm, were used for this study. All of the mice were collected from the animal house of the Department of Pharmacy, Jahangirnagar University, Bangladesh. Then, the mice were kept in the animal house of the Pharmacy Department at the University of Chittagong. They were placed in standard propylene cages and habituated under a controlled temperature of 22±2 °C, a relative humidity of 60%-70% for 14 days. The mice were fed adequate diets and drinking water *ad libitum* nutrients in a well-facilitated cage throughout the whole study. *Pheretima posthuma* was used for the anthelmintic test collected from Chittagong, Bangladesh's locality.

Study design

For the *in vivo* experiments, all the investigated extracts were used at the doses of 200 and 400 mg/kg of body weight of mice for the treatment groups. Here, 1% tween-80 at 10 mL/kg was used as the control group. Metformin (250 mg/kg) and Loperamide (50 mg/kg) served as standards in OGTT and castor oil-induced diarrheal tests, respectively. All the animal researches were conducted by following ARRIVE guideline, version 01. The *in vivo* experiments were approved by the ethical committee of the Department of Pharmacy, University of Chittagong, under approval no.- cc98056.

In vivo hypoglycaemic test

The hypoglycaemic test was assessed by using an oral glucose tolerance test (OGTT) (33). In this method, six groups of overnight fasted normal mice (each group contained five mice) were administered with the following: control (1% tween-80; 10 mL/kg), standard (Metformin; 250 mg/kg), crude leaves (MDML), and stem barks (MDMS) at the doses 200 & 400 mg/kg body weight of mice. After the extract administration, the mice were administered with glucose 2 g/kg of the body weight of mice. The blood glucose level was measured before dosing and then at 30, 60, 90, and 120 minutes after glucose administration using glucose-oxidase-peroxide reactive strips and a digital glucometer.

In vivo antidiarrheal test

This test was performed by using a castor oil-induced diarrheal test where six groups of 18 hour fasted mice (five mice in each group) were used (34). In this research, the mice were administered 1% tween-80 (10 ml/kg), Loperamide (50 mg/kg), MDML, and MDMS at the doses 200 & 400 mg/kg body weight of mice. After one hour of this administration, 0.5 mL of castor oil was given to the mice orally and kept in separate cages to assess the severity of diarrhea for four hours. The percent inhibition of total defecation and that of diarrhea were calculated using the formulas 1 and 2:

In vitro anthelmintic test

The anthelmintic assay was performed by using the previously ascertained method with minor modifications (35). *Pheretima posthuma* was used because of its anatomical and physiological similarity with intestinal roundworm parasites of human beings and for the fact that they belong to the same group of Annelida (36,37). Five groups of earthworms (six earthworms to each group) were treated with the control (distilled water), Albendazole, MDML, and MDMS at different concentrations. The time (in minutes) for its paralysis and death was counted.

Fourier-transform infrared (FTIR) analysis

$$Inhibition\ of\ defcation\,(\%) = \frac{Total\ number\ of\ \ feces\ in\ control - Total\ number\ of\ \ feces\ in\ treated\ mice}{Total\ number\ of\ \ feces\ in\ control} \times 100 \quad (1)$$

$$Inhibition\ of\ diarrhea\,(\%) = \frac{Total\ number\ of\ diarrheal\ \ feces\ in\ control - Total\ number\ of\ diarrheal\ \ feces\ in\ treated\ mice}{Total\ number\ of\ diarrheal\ \ feces\ in\ control} \times 100 \quad (2)$$

About 1 mg of MDML was mixed with 50 mg of FTIR-grade potassium bromide pellet. Then, the sample mixture was placed into the sample holder. The sample was investigated by using FTIR spectroscopy at 750-4000 cm^{-1} afterwards (38).

Statistical analysis

The obtained results were undergone statistical analysis through one-way ANOVA followed by post hoc Dunnett's t-test and expressed as Mean ± SEM (Standard Error of Mean). Statistical Software Statistical Package for Social Science (SPSS, Version 16.0, IBM Corporation, NY) was employed to perform former statistical analysis. Results below $P<0.05$ were considered statistically significant compared to control.

Results

Extraction yield

The percentage of yield of MDML and MDMS were 2.09% and 1.55%, respectively.

In vivo hypoglycaemic test

In the present study, the control in this experiment decreased the blood glucose level slightly 120 minutes after glucose administration. The reference standard decreased the blood glucose level 60 minutes after oral glucose administration. MDML showed a significant ($P<0.05$) decrease in blood glucose levels 90 and 120 minutes after oral administration, respectively, when compared to the control group. MDMS significantly decreased the blood glucose level 120 minutes after oral glucose administration (Table 1).

In vivo antidiarrheal test

In the current study, loperamide used as standard significantly inhibited the defecation and diarrheal drops by 57% and 68.83%, respectively. MDML and MDMS also inhibited defecation by 58% and 59.74%, while inhibited diarrhea by 36% and 51.95% significantly at 400 mg/kg, respectively. Here, Table 2 demonstrates the mean number of feces and the mean number of diarrheal feces. Figure 1 represents the percentages of defecation inhibition and percentages of diarrhea inhibition.

In vitro anthelmintic test

The present research exhibited that the reference standard albendazole caused the paralysis and death of *P. posthuma* in 18.83 ± 1.08 to 95.5 ± 1.36 and 31.17 ± 1.25 to 115.33 ± 1.52 minutes at different concentrations, respectively. MDML took the time for paralysis of the earthworms from 30±1.15 minutes to 121.67 ± 1.45 minutes, while 77.5 ± 0.72 minutes to 176.5 ± 3.49 minutes were required for the death of those earthworms at different concentrations. These were statistically significant in comparison to the

Table 1. Hypoglycemic activity of crude methanol extracts of *Macropanax dispermus* leaves (MDML) and stem barks (MDMS) by using oral glucose tolerance test

Group	Dosage (mg/kg)	Normal blood glucose concentration (0 min) (mg/dL)	Blood glucose concentration (mg/dL) after glucose loading			
			30 min	60 min	90 min	120 min
Control	10	141.60±5.42	166.80±4.60	154.60± 6.65	152.40±11.08	146.20±9.48
Metformin	250	150.80±3.38	169.60±3.04	158.00±1.79	139.00±1.26	122.00±2.53
MDML	200	156.40±5.92	163.00±5.21	151.60±6.11	140.80±5.28	134.20±11.13
	400	161.20±2.15	164.20±3.94	154.40± 4.38	116.2 ± 8.82*	104.00±11.84*
MDMS	200	149.60±2.89	168±80.09	157.40±11.43	151 ± 10.77	124.20±6.51
	400	154.80±3.90	165.80±10.96	164.6±6.96	141.2 ± 9.85	113.60±11.41

Results are expressed as mean ± SEM; *$P < 0.05$ compared to the control group.

Table 2. Screening of antidiarrheal activity of crude methanol extracts of *Macropanax dispermus* leaves (MDML) and stem barks (MDMS) by using castor-oil-induced diarrhea test

Group	Dosage (mg/kg)	Mean no of feces	Mean no of diarrheal feces
Control	10	20 ± 0.55	15.4 ± 0.68
Loperamide	50	8.6 ± 0.87***	4.8 ± 0.49***
MDML	200	12.8 ± 1.16**	10.2 ± 1.24*
	400	8.4 ± 0.98**	6.2 ± 0.73***
MDMS	200	16.4 ± 1.08	13 ± 1.1
	400	12.8 ± 2.75**	7.4 ± 2.18***

Results are expressed as Mean ± SEM; *$P < 0.05$, **$P < 0.01$, and ***$P < 0.001$ compared to the control group.

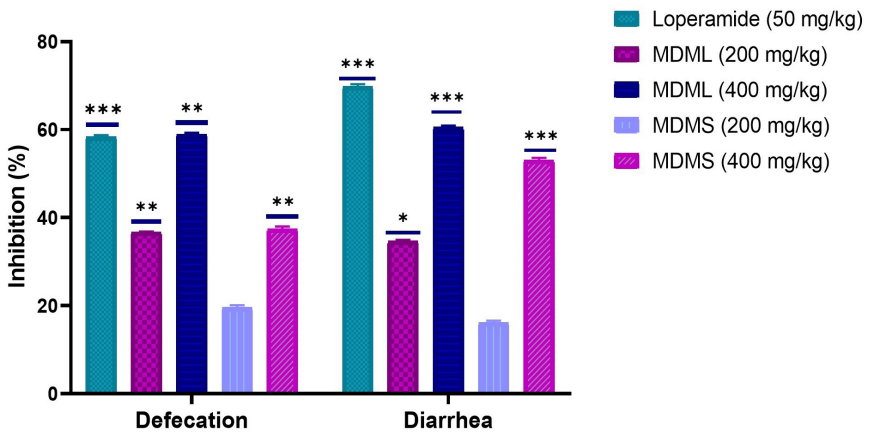

Figure 1. Antidiarrheal activity of crude methanol extracts of *Macropanax dispermus* leaves (MDML) and stem barks (MDMS) by using castor oil-induced diarrhea test. Results are expressed as Mean ± SEM; *$P < 0.05$, **$P < 0.01$, and ***$P < 0.001$ compared to the control group.

standard group. MDMS took time to cause the paralysis and death of *P. posthuma* from 25.83 ± 0.4 minutes to 36.67±0.92 minutes and 133.33 ± 1.65 minutes to 145.67±2.73 minutes, respectively from the highest to lowest concentration. These data are tabulated in Table 3. All the results were statistically significant ($P < 0.001$) except that of the highest concentration compared to standard.

Fourier-transform infrared (FTIR) analysis

The MDML FTIR spectra was screened for the wavenumber range of 750-4000 cm^{-1}. Table 4 represents all the prime peaks with the functional group and vibration mode analysis. Figure 2 represents the MDML FTIR spectra. Here, MDML FTIR spectra demonstrated many known and unknown peaks, confirming aromatic compounds, aldehyde, ester, ether, amide, and hydroxyl groups.

Discussion

In this study, we conducted oral hypoglycemic (OGTT), antidiarrheal, and anthelmintic experimental studies and FTIR spectroscopic analysis on both MDMS and MDML crude extracts. Previous investigations identified that MDML and MDMS contained several phytochemicals like saponins, tannins, phlorotannins, flavonoids, alkaloids, reducing sugars, sterols, and terpenes (28). These phytochemicals have shown diversified effects. Flavonoids enhance peripheral glucose take-up and cell glycolysis, and saponins are used to mimic the pancreatic β-cells and increase insulin in blood (40-42). Also, flavonoids, tannins, saponins, sugars, sterols, and terpenes have been

Table 3. Anthelmintic activity of crude methanol extracts of *Macropanax dispermus* leaves (MDML) and stem barks (MDMS)

Group	Concentration (mg/mL)	Time is taken for paralysis (P) (min)	Time is taken for death (D) (min)
		Pheretima posthuma	
		P	D
Negative control	-	-	-
Albendazole	10	18.83 ± 1.08	31.17 ± 1.25
	5	34.83 ± 1.78	52 ± 1
	2.5	54.17 ± 1.74	85.67 ± 1.15
	1.25	95.5 ± 1.36	115.33 ± 1.52
MDML	10	30 ± 1.15***	77.5 ± 0.72***
	5	42 ± 1.69.	94.17 ± 1.35***
	2.5	95.17 ± 1.4***	150.67 ± 3.49***
	1.25	121.67 ±1.45***	176.5 ± 3.49***
MDMS	10	25.83 ± 0.4	36.67 ± 0.92
	5	62.33 ± 1.71***	77.5 ± 2.43***
	2.5	84 ± 1.71***	127.17 ± 1.97***
	1.25	133.33 ± 1.65***	145.67 ± 2.73***

Results are expressed as mean ± SEM; *$P < 0.05$, **$P < 0.01$, and ***$P < 0.001$ compared to the reference standard of correspondent concentration.

Table 4. FTIR spectral values and functional group of crude methanol extracts of *Macropanax dispermus* leaves

Wavenumber (cm^{-1})	Wavenumber range (cm^{-1}) (39)	Functional group present	Predicted compound
~1050	1000–1300	s; C-O stretching	Ether
1450	1430–1460	s; C-N stretching	Primary amide
1500	1400–1600	m; C=C stretching	Aromatic compound
1700	1690–1710	v; -C=O of aldehyde	Aromatic aldehyde
1750	1725–1750	v; -C=O of ester	Membrane lipid, fatty acid
2900	2800–2900	w; Alkyl C-H stretching	Alkane
3000	3000–3100	Alkenyl C-H stretching	Aromatic and Olefinic compound
3600	3500–3650	v; -OH stretching	Hydroxyl group
3750	3600-3750	-OH stretching	Hydroxyl group
3850-3900	3200–4000	-OH stretching	Organic acid, Phenol

Note. w- weak; m- medium; s- strong; v- variable.

investigated to exert their effects against diarrhea (43,44). They might act by halting the secretory, spasmodic, and motility action of the gastrointestinal tract and improving the absorption of the intestine (45,46). Furthermore, polyphenolic compounds such as flavonoids, tannins, phlobatannins, and alkaloids acted as anthelmintic agents. They might act through uncoupling oxidative phosphorylation, hampering helminth parasites' energy production (47). Considering all these effects of the present phytochemicals in MDML and MDMS and correlating the possible mechanism of action of previous research, these extracts were selected for further investigation for their hypoglycaemic, antidiarrheal, and anthelmintic activities.

Hyperglycemia can occur due to faulty glucose (sugar) metabolism in the body; OGTT measures the ability of the body to metabolize glucose and clear it from the body. Therefore, it has been a widely accepted study on animal models to analyze the hypoglycemic activity of the plant extract.

The current research showed that the control had no contribution to lower the blood glucose level as it reduced the blood glucose level very slightly. It can be disregarded in comparison to other samples. The reference standard Metformin exhibited an increase in blood glucose level 30 minutes after oral glucose administration; After that, it initiated a decremental effect on the blood glucose level gradually up to 2 hours after oral glucose administration. Blood glucose levels dropped off upon administration of MDML and MDMS at lower and higher doses in the same manner as Metformin significantly, where MDML and MDMS (400 mg/kg) acted as a potent hypoglycemic agent. MDML proved to have better and more significant dose-dependent hypoglycemic activity than MDMS. Hyperglycemia is often associated with DM, hence MDML and MDMS might also be used as a potential treatment option for DM. Since Metformin exhibited its hypoglycemic action in OGTT, the possible mechanism of action of the investigated extracts might be comparable with its action. Thus, the extracts could be hypothesized to lower the glucose level through enhanced insulin secretion (48). The existence of flavonoids, sterols, and sugars in the investigated extracts might be associated with their hypoglycemic effects (49).

The castor oil-induced diarrheal model was used to evaluate the aptitude of the plant extracts to restrain the diarrheal drops. Previous research has enlightened the

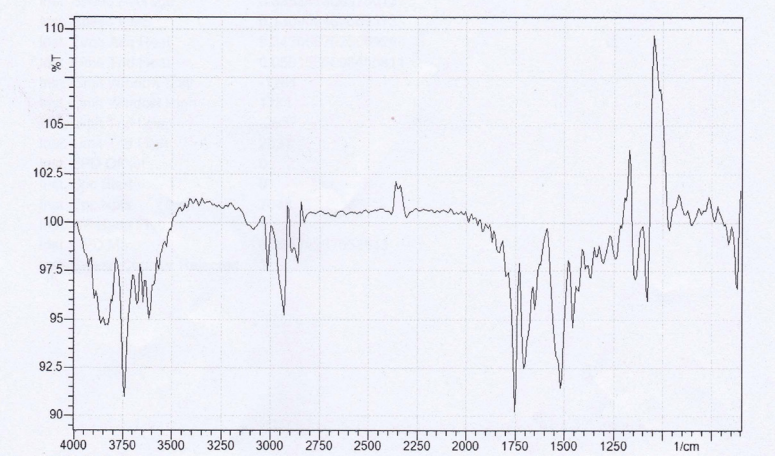

Figure 2. FTIR spectra of crude methanol extract of *Macropanax dispermus* leaves.

probable mechanistic way through which the castor oil might exert its diarrheal effect. It included the adenylate cyclase commencement, Na^+, K^+-ATPase activity inhibition, and/or endogenous prostaglandin synthesis. Castor oil exerted diarrhea and was metabolized into ricinoleic acid while mixing with bile and pancreatic enzymes. Hence, the produced ricinoleate salts advance the prostaglandin or adenylate cyclase release in the epithelial cells of the intestine (50,51). Therefore, castor oil was given orally to induce diarrhea in mice. In the existing research, the control did not reduce the diarrheal drops, whereas the popular antidiarrheal drug, loperamide, showed a significant decrease in defecation and diarrheal drops in the mice. MDML and MDMS also showed a significant antidiarrheal effect at higher doses. However, MDML been proved to be a more effective antidiarrheal agent than MDMS. The presence of tannins, flavonoids, alkaloids, saponins, reducing sugars, sterols, and terpenes might contribute to the antidiarrheal effect of MDML and MDMS (52). A previous investigation identified that flavonoids inhibited the production of autacoids and prostaglandins, which in turn blocked the action of castor oil on mice. Thus, the investigated extracts might act by blocking the adenylyl cyclase activation or prostaglandin production to induce an antidiarrheal effect on castor oil-induced diarrheal mice (53).

An *in vitro* anthelmintic study utilized *P. posthuma* to exercise the direct effect of the plant extracts on it. A maximum period of 120 minutes was determined for the paralysis as well as the death of the worm (54). In the continued study, an extensively used anthelmintic drug, albendazole, caused the paralysis and death of the roundworm within a short period, even at the lowest concentration. In contrast, the control has shown almost no effect. In contrast, MDML took a much longer time to cause the paralysis and death of the earthworm, which depicted its moderate effect at the highest concentration and mild effect at the lower concentration as an anthelmintic agent. In addition, MDMS has illustrated an excellent and significant concentration-dependent anthelmintic effect which can kill the earthworm within the shortest possible time. Albendazole acts by inhibiting microtubule polymerization in the adult and larval forms of the parasite. Since MDMS was comparable with the effect of albendazole, it might exert its anthelmintic effect similarly. The presence of flavonoids, tannins, phlobatannins, and alkaloids might contribute to the excellent anthelmintic effect of MDMS (55).

The FTIR analysis has shown the presence of a vital functional group that can contribute to the synthesis of a wide range of pharmaceutically active phytoconstituents. The FTIR spectrum analysis has depicted the possible presence of ether, primary amide, aromatic compounds, aldehyde, alkane, alkene, membrane lipid, fatty acid, and many other unknown compounds in MDML. The presence of these functional groups could be further analyzed in support of the presence of a wide range of phytochemicals (56). The occurrence of a hydroxyl group may reveal that MDML could contain flavonoids, alcoholic- and phenolic compounds (57). The peak at 3600 cm^{-1} (O-H stretching) and about 1050 cm^{-1} (C-O stretching) might validate the presence of flavonoids. The presence of saponin might be authenticated by the existence of the peak at 1700 cm^{-1}, 1750 cm^{-1} (C=O stretching), and 1050cm^{-1}(C-O stretching). Also, the presence of C-O stretching might depict the presence of terpenoids. It can be further analyzed for the confirmed compound identification by using the nuclear magnetic resonance (NMR) spectroscopic technique. Future investigations may also include isolation and identification of its single compound as well as the pathway for its mechanism of pharmacological action.

Conclusion

Both samples, MDML and MDMS, hold a considerable amount of phytoconstituents, such as flavonoids, sterols, sugars, tannins, alkaloids, saponins, and were excellent hypoglycemic and anti-diarrheal agents. This research work can facilitate natural product researchers to take an attempt to develop a potent herbal formulation, which may curb the incidences of diabetes, diarrhea, and helminthiasis. In the future, we suggest that the NMR study be carried out to isolate and identify the active compounds of MDML and MDMS, which may contribute to the possible reason for its effectiveness.

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Data curation: Syeda Rubaiya Afrin, Mohammad Rashedul Islam.

Formal analysis : Syeda Rubaiya Afrin, Mohammad Rashedul Islam.

Investigation: Syeda Rubaiya Afrin, Mohammad Rashedul Islam, Sayeda Saima Didari.

Methodology: Syeda Rubaiya Afrin, Mohammad Rashedul Islam, Sarah Waddun Jannat.

Project administration: Mohammed Kamrul Hossain.

Resources: Syeda Rubaiya Afrin, Mohammad Rashedul Islam, Sayeda Saima Didari, Sarah Waddun Jannat, Ummah Tasnim Nisat.

Software: Mohammad Rashedul Islam, Ummah Tasnim Nisat.

Supervision: Mohammed Kamrul Hossain.

Validation: Mohammed Kamrul Hossain, Syeda Rubaiya Afrin, Mohammad Rashedul Islam

Visualization: Syeda Rubaiya Afrin, Mohammad Rashedul Islam.
Writing–original draft: All authors.
Writing–review&editing: All authors.

Conflict of interests

All authors declare that they have no competing interests.

Ethics considerations

We declared that the "Principle of Laboratory Animal Care" (NIH publication No. 85-23, revised 1985) and specific national laws were followed. All test protocols have been examined and approved by the ethical committee of the Department of Pharmacy, University of Chittagong, Chittagong-4331, Bangladesh, under approval no.cc98060.

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