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(Research Article)

Evaluation of Anti-inflammatory Activity and Total Flavonoids Content of *Manilkara zapota* (Linn.) Bark

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ABSTRACT

The crude methanolic extract of the bark of Manilkara zapota (Molina) Standley (Family: Cucurbitaceae), was evaluated for its possible anti-inflammatory activity and determination of total flavonoids content growing in Bangladesh. The anti-inflammatory activity was studied using carrageenan and histamine-induced rat paw edema test at different doses (200 and 400 mg/kg body weight) of the methanol extract. At the dose of 400 mg/kg body weight, the extract showed a significant anti-inflammatory activity both in the carrageenan and histamine-induced oedema test models in rats showing 59.72% and 60.0% reduction in the paw volume comparable ($P<0.01$) to that produced by the standard drug indomethacin (62.50% and 65.16%) at 4h respectively. The percentage inhibition of the oedema paw volume by the 400 mg/kg body weight of the extract was also statistically significant ($P<0.05$; $P<0.01$) compared favorably with the indomethacin treated animals at 1, 2 and 3 h in both models. The total flavonoids content were calculated as quite high in methanolic extract (169.37 mg/g of quercetin equivalent). Acute toxicity test showed that the plant might be safe for pharmacological uses. Therefore, the obtained results tend to suggest the acute anti-inflammatory activity as well as total flavonoids content from the methanolic extract of the bark of Manilkara zapota and thus provide the scientific basis for the traditional uses of this plant part as a remedy for pain and inflammations.

Key Words: *Manilkara zapota*, Anti-inflammatory, Carrageenan, Total flavonoids.

INTRODUCTION

Manilkara zapota (L.) (Family: Sapotaceae) commonly known as common names (Creole); sapoti, (English); chickle gum, chicle tree, common naseberry, naseberry, sapodilla, (French); sapotille, sapotilleir, sapotillier commun, sapodilla, (Hindi); chiku; has been collected from sundarban, Bangladesh. *M. zapota* is a species of the lowland rainforest. Trees grow well in a wide range of climatic conditions from wet tropics to dry cool subtropical areas. It is an evergreen, glabrous tree, 8-15 m in height. It is cultivated throughout India, though it is native to Mexico and Central America[1]. The fruit of the *M. zapota* contains cyanogenic glycoside, phenolic compound and terpenoid[2].
Bark is used as tonic and the decoction is given in diarrhea, dysentery and peludism[1,2]. The leaves are used to treat cough, cold, and diarrhoea[3]. The leaves of the plant posses antioxidant [4] and antimicrobial activity [5]. The bark of the *M. zapota* is also traditionally used for the treatment of gastrointestinal disorder, fever and pain [6].

Acute and chronic inflammatory diseases remain one of the world's major health problems[7, 8]. Inflammation is the response of living tissues to injury. It involves a complex array of enzyme activation, mediator release, extravasations of fluid, cell migration, tissue breakdown and repair[9, 10]. Non-steroidal anti-inflammatory drugs (NSAID) are among the most commonly prescribed drugs due to their consistent effectiveness in the treatment of pain, fever, inflammation and rheumatic disorders. However, their use is associated with adverse effects at the level of digestive tract, ranging from dyspeptic symptoms, gastrointestinal erosions and peptic ulcers to more serious complications, such as over bleeding or perforation[11]. Therefore to overcome the toxicity of NSAID, the development of new anti-inflammatory drugs is still necessary and the natural product such as medicinal plants could lead in discovering new anti-inflammatory drugs with less undesirable effects[12]. Now-a-days attention is being focused on the investigation of the efficacy of plant-based drugs used in the traditional medicine because they are cheap, have little side effects and according to WHO,

about 80% of the world population still rely mainly on herbal remedies[13].

Since no literature is currently available to substantiate anti-inflammatory activity as well as flavonoids content from the methanolic extract of the bark of *M. zapota* growing in Bangladesh, the present study was designed to provide scientific evidence for its use as a traditional folk remedy by investigating the anti-inflammatory activity as well as total flavonoids content from the bark of *M. zapota* that also confirm its use as a remedy for pain and inflammations.

MATERIALS AND METHODS

Collection and Identification of Plant Materials

The barks of *M. zapota* were collected from Karamjal, Sundarban, Khulna, Bangladesh. A specimen copy was deposited to Bangladesh National Herbarium for identification & the accession number was DACB-33801.

Preparation of Methanolic Extract

The barks of *M. zapota* were freed from any of the foreign materials. Then the barks were air-dried under shed temperature followed by drying in an electric oven at 40º C. The dried plant materials were then ground into powder. About 500g of powdered material was taken in a clean, flat-bottomed glass container and soaked in 1500 ml of 80% methanol. The container with its contents was sealed and kept for a period of 7 days accompanying occasional shaking and stirring. The whole mixture then underwent a coarse filtration by a piece of clean, white cotton material. Then it was filtered through whatman filter paper (Bibby RE200, Sterilin Ltd., UK) which was concentrated with rotary evaporator at bath temperature not exceeding 40˚ to have gummy concentrate of extract (yield approx. 10.58%).

Test for Different Chemical Groups

The crude mmethanolic extract was tested for its different chemical groups as alkaloids, flavonoids, gums, reducing sugars, saponins, steroids and tannins[14]. In each test 10% (w/v) solution of the extract in methanol was taken.

Experimental Animals and Drug

For the screening of in vivo anti-inflammatory activity male rats of Wister strain weighing 175-202 g were used. The animals were housed under standard Laboratory (at Pharmacology Laboratory of BCSIR, Chittagong) conditions maintained at 25±1°C and under 12/12 h light/dark cycle and feed with Balanced Trusty Chunts and water *ad libitum*. All experimental protocols were in compliance with BCSIR Ethics Committee on Research in Animals as well as internationally accepted principles for laboratory animal use and care.

The standard drug Indomethacin was used for this study and purchased from Square Pharmaceuticals Ltd, Bangladesh.

Chemicals

Quercetin, carrageenan and histamine were obtained from Sigma Chemical Co. (St. Louis, MO, USA). Tween 80, aluminium chloride and potassium acetate were of analytical grade and purchased from Merck (Darmstat, Germany).

Acute Toxicity Test

The acute toxicity of *M. zapota* methanolic extract was determined in rats according to the method of Hilaly *et al* [15] with slight modifications. Rats fasted for 16h were randomly divided into groups of five rats per group. Graded doses of the extract (200, 400, 800, 1600 and 3200 mg/kg p.o.) were separately administered to the rats in each of the groups by means of bulbed steel needle. All the animals were then allowed free access to food and water and observed over a period of 48h for signs of acute toxicity. The number of deaths within this period was recorded.

Anti-inflammatory Activity

Carrageenan-induced oedema test

Carrageenan induced rat hind paw edema was used as the animal model of acute inflammation according to the method of Lanhers *et al* [16,17]. In this experiment, the rats were divided into four groups of five animals each. Group I (control) received 2% Tween 80 in normal saline (2 ml/kg). Group II (Positive control) received 10 mg/kg body wt. of indomethacin orally. Group III and IV received 200 and 400 mg/kg body wt. of the extract orally respectively. Acute inflammation was induced in all the four groups by sub plantar injection of 0.05 ml of its suspension of Carrageenan with 2% Tween 80 in normal saline in the right Paw of the rats 30 minutes after the oral administration of the tested materials. The paw volume was measured with a micrometer screw gause at 1, 2, 3 and 4h after the administration of the drug and the extract. The percentage inhibition of inflammatory effect of the extract was calculated using the following expression:

Percentage inhibition of inflammation = $[(V_c-V_t)/V_c] \times 100$

Where V_c is the average degree of inflammation by the control group and V_t is the average degree of inflammation by the test group (Table-2).

Histamine-Induced Oedema Test

Using the method of Perianayagam *et al* [18], the paw oedema was produced by sub-plantar administration of 0.1% freshly prepared solution of histamine into the right hind paw of the rats. In this experiment, twenty rats were divided into four groups of five animals each. Group I (control) received 2% Tween 80 in normal saline (2 ml/kg). Group II (Positive control) received 10 mg/kg body wt. of indomethacin orally. Group III and IV received 200 and 400 mg/kg body wt. of the extract orally respectively. Acute inflammation was induced in all the four groups by sub plantar injection of 0.1 ml of Histamine with 2% Tween 80 in normal saline in the right hind paw of the rats 1h after the oral administration of the tested materials. The paw volume was measured with a micrometer screw gause at 1, 2, 3 and 4h after the administration of the drug and the extract. The percentage inhibition of inflammatory effect of the extract was calculated using the same formula for carrageenan-induced paw oedema.

Determination of Total Flavonoids Content

Aluminium chloride colorimetric method was used for determination of total flavonoids concentration of the methanol extract[19,20]. The extract (0.5 ml, 1:10 g ml^{-1}) in methanol were separately mixed with 1.5 ml of methanol, 0.1 ml of 10% aluminum chloride, 0.1 ml of 1 M potassium acetate and 2.8 ml of distilled water. It was allowed to stand for 30 min at room temperature and the absorbance of the reaction mixture was measured at 415 nm with a double beam UV/Visible spectrophotometer (Shimadzu). Total flavonoids content was determined as mg of quercetin equivalent per gram using the equation obtained from

quercetin calibration curve y=4.7385x + 0.0355; R^2 = 0.9993.

Statistical Analysis

Data were presented as mean ± Standard deviation (S.D). Statistical analysis for animal experiment was carried out using one-way ANOVA followed by Dunnet's multiple comparisons using SPSS Data Editor for Windows, Version 11.5.0 (SPSS Inc., U.S.A.). The results obtained were compared with the control group. *p* values <0.05 were considered to be statistically significant (*p* denotes probability).

RESULTS

Phytochemical Screening

Results of different chemical tests on the methanolic extract of *M. zapota* bark showed the presence of saponin, gums, reducing sugars, tannins and flavonoids (Table 1).

Acute Toxicity Test

In acute toxicity study, oral administration of graded doses (200, 400, 800, 1600 and 3200 mg/kg p.o.) of the methanol extract of *M. zapota* to rats did not produce any significant changes in behaviour, breathing, cutaneous effects, sensory nervous system responses or gastrointestinal effects during the observation period. No mortality or any toxic reaction was recorded in any group after 48h of administering the extract to the animals. *M. zapota* was safe upto a dose level of 3200 mg/kg of body weight.

Anti-inflammatory Activity

Carrageenan-induced paw oedema

The anti inflammation effect of the methanolic extract of the bark of *M. zapota* using carrageenan induced oedema tests is expressed in (Table-2). In this test, the positive control (Indomethacin) significantly ($p<0.05$; $p<0.01$) decreased the paw edema at 1h to 4h after carrageenan injection compared to saline with inhibition 55.76% to 62.50%. A maximum oedema paw volume of 1.44±0.02 mm was observed in the control rats, 4 h after the carrageenan injection. Rats with the extract at 400 mg/kg body weight significantly decreased ($p<0.05$; $p<0.01$) the carrageenan-induced oedema paw volume from 1h to 4h compared to the standard drug indomethacin at a dose of 10 mg/kg body weight. The inhibition percentage of the oedema paw volume by the 400 mg/kg body weight of the extract was also found statistically significant when it was compared with the indomethacin treated animals at 1, 2, 3 and 4 h. The highest reduction in the paw volume by the 400 mg/kg body weight was 59.72% was comparable to that of the indomethacin (62.50%) at 4 h.

Histamine-induced paw oedema: Table 3 showed the anti-inflammation effect of the methanolic extract of *M. zapota* bark using histamine-induced paw oedema tests. In the histamine-induced oedema test, a maximum oedema paw volume of 1.55 ± 0.07 mm was observed in the control rats, 4 h after the histamine injection. Rats pre-treated with the extract at 400 mg/kg body weight significantly decreased ($p<0.05$; $p<0.01$) the histamine-induced oedema paw volume from 1h to 4 h compared to the standard drug indomethacin at a dose of 10 mg/kg body weight. The percentage inhibition of the oedema paw volume by the 400 mg/kg body weight of the extract was also statistically significant ($p<0.05$; $p<0.01$) compared favorably with the indomethacin treated animals at 1, 2, 3 and 4 h. The maximum reduction in the paw volume by the 400 mg/kg body weight was (60.0%) compared to the indomethacin (65.16%) at 4 h.

Total Flavonoids Content

The total flavonoids content was calculated as significant in methanolic extract of *M. zapota* 169.37 mg/g of quercetin equivalent per gm of dry extract (Table-4).

DISCUSSION

The anti-inflammatory activity was studied using two established method namely carrageenan and histamine-induced rat paw edema test at different doses (200 and 400 mg/kg body weight) of the methanol extract of *M. zapota* bark.

Carrageenan induced oedema involves the synthesis or release of mediators at the injured site. These mediators include prostaglandins, especially the E series, histamine, bradykinins, leucotrienes and serotonin, all of which also cause pain and fever. Inhibitions of these mediators from reaching the injured site or from bringing out their pharmacological effects normally ameliorate the inflammation and other symptoms. Development of oedema induced by carrageenan is commonly correlated with early exudative stage of inflammation [21]. Carrageenan oedema is a multimediated phenomenon that liberates diversity of mediators. It is believed to be biphasic; the first phase (1h) involves the release of serotonin and histamine while the second phase (over 1h) is mediated by prostaglandins, the cyclooxygenase products, and the continuity between the two phases is provided by kinins [17]. Since carrageenan-induced inflammation model is a significant predictive test for anti-inflammatory agents acting by the mediators of acute inflammation [22, 23], the results of this study are an indication that *M. zapota* can be effective in acute inflammatory disorders.

The extract also exhibited pronounced reduction in the oedema produced by histamine. This result tends to suggest that the anti-inflammatory activity of the extract is possibly backed by its anti-histamine activity. The antihistaminic effect of the extract increased with increase in the dose of the extract. Histamine is an important inflammation mediator, potent vasodilator substance and also increases the vascular permeability [24, 25]. Since the extract effectively suppressed the oedema produced by histamine, it showed that the extract exhibited anti-inflammatory actions by inhibiting the synthesis, release or action of inflammatory mediators such as histamine, serotonin and prostaglandins. .

This study has shown that the methanol extract of the bark of *M. zapota* possessed a significant anti-oedematogenic effect ($P<0.01$) on paw oedema induced by carrageenan and histamine compared favorably with the standard drug (indomethacin) in treated rats.

The anti-inflammatory activity of the methanolic extract of *M. zapota* may also be proved due to the presence of flavonoids in a significant amount (169.37 mg quercetin equivalent per g of dry extract). Flavonoids (or bioflavonoids) are naturally occurring compounds, containing in vascular plants. These compounds have been considered to possess anti-inflammatory properties, both in vitro and in vivo [26]. Numerous studies have proposed that flavonoids act through a variety mechanisms to prevent and attenuate inflammatory responses and serve as possible

cardioprotective, neuroprotective and chemopreventive agents [27].

Phytochemically, the barks of *M. zapota* have been also reported to yield tannins. Tannins are important compounds known to be potent cyclooxygenase-1 inhibitors and with anti-phlogistic activity [28]. The mechanisms of anti-inflammatory activity may be related to the anti-phlogistic action of the tannins.

Non-steroidal anti-inflammatory drugs (NSAID) such as indomethacin used in this study are known to inhibit cyclooxygenase enzymes I and II which are implicated in the production of inflammation-mediating agent prostaglandin E_2 (PGE_2) from arachidonic acid [29, 30]. Therefore, the pattern of anti-inflammatory activity exhibited by this extract was similar to that of indomethacin.

CONCLUSION

Since the plant extract reduced significantly the formation of oedema induced by carrageenan and histamine, the bark of *M. zapota* exhibited acute anti-inflammatory activity. The potential of the extract of *M. zapota* as acute anti-inflammatory agent may be due to the presence of phytoconstituents like flavonoids, tannins, phenolics and might be responsible for its activity. Again, no mortality was recorded in the acute toxicity test; it showed that the plant might be safe for use. Therefore, it can be revealed that the methanolic extract of *M. zapota* bark possess acute anti-inflammatory activity and justify its use as a traditional folk remedy for inflammation, pain etc. However, a more extensive study is necessary to determine the exact mechanism(s) of action of the extract and its active compound(s).

Table 1: Results of different group tests of methanolic extract of *M. zapota* bark.

Phytoconstituents	Methanol extract of *M. zapota*
Alkaloid	-
Reducing sugar	+
Tannins	+
Gums	+
Flavonoids	+
Saponin	+
Steroid	-

Table 2: Effect of methanol extract of *M. zapota* bark and indomethacin on carrageenan-induced oedema paw volume in male Wistar rats.

Treatment Groups	Doses (mg/kg body weight)	Right hind paw volume (mm)			
		1 h	2 h	3 h	4 h
Control	2 ml/kg (2% tween 80 in normal saline)	1.04±0.08	1.29±0.05	1.36±0.07	1.44±0.02
Positive Control (Indomethacin)	10	0.46±0.03* (55.76)	0.54±0.04* (58.14)	0.52±0.03** (61.76)	0.54±0.06** (62.50)
Extract	200	0.78±0.06* (24.03)	0.79±0.06** (38.76)	0.80±0.07* (41.18)	0.84±0.04** (41.66)
Extract	400	0.53 ± 0.09** (49.04)	0.59 ± 0.08* (54.26)	0.56 ± 0.09** (58.82)	0.58 ± 0.07** (59.72)

Values in brackets denote percentage inhibition of the oedema paw volume.

*Values are expressed as mean±SD; Values are calculated as compared to control using one way-ANOVA followed by Dunnet's Test; * indicates P < 0.05; ** indicates P < 0.01 vs. control; n = 5.*

Table 3: Effect of methanol extract of *M. zapota* bark and indomethacin (standard drug) on histamine-induced oedema paw volume in male Wistar rats.

Treatment Groups	Doses (mg/kg body weight)	Right hind paw volume (mm)			
		1 h	2 h	3 h	4 h
Control	2 ml/kg (2% tween 80 in normal saline)	1.07±0.05	1.25±0.03	1.36±0.07	1.55±0.09
Positive Control (Indomethacin)	10	0.44±0.07* (58.87)	0.51±0.06** (59.20)	0.53±0.08* (61.03)	0.54±0.04** (65.16)
Extract	200	0.76±0.09** (28.97)	0.84±0.07* (32.80)	0.90±0.04* (33.82)	0.94±0.03* (39.35)
Extract	400	0.50 ± 0.05* (53.28)	0.57 ± 0.06* (54.40)	0.58 ± 0.09** (57.35)	0.63 ± 0.07** (59.35)

Values in brackets denote percentage inhibition of the oedema paw volume.

*Values are expressed as mean±SD; Values are calculated as compared to control using one way-ANOVA followed by Dunnet's Test; * indicates P < 0.05; ** indicates P < 0.01 vs. control; n = 5.*

Table 4: Total flavonoids content of methanol extract of *M. zapota* bark.

Extract	Avg. absorbance at 415 nm	Total flavonoids content
		mg of quercetin equivalent (QE) per gm of dry extract
Methanol extract of *M. zapota* bark	1.04±0.03	169.37±0.07

The values are expressed as mean ± standard deviation (n=3).

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