Research Article

Antiulcer activity of ethanolic extract of *Sesamum indicum* on experimental animal models

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Abstract

Objective: Gastroprotective effect of 70% ethanolic extract of *Sesamum indicum* L. (Black sesame) *(Pedaliaceae)* seeds and aerial parts have been assessed in different acute and chronic gastric ulcer models in rats. **Material and Methods:** Extract was administered orally (100, 200 and 400 mg/kg body weight rats), twice daily for 5 days for prevention from ethanol and 10 days for prevention of acetic acid induced ulcers. EESI showed dose dependent inhibition of ulcer index in ethanol and acetic- acid induced ulcers. EESI prevents the oxidative damage of gastric mucosa by blocking lipid peroxidation and by significant decrease in superoxide dismutase, and increase in catalase activity. **Results:** Extract showed dose dependent inhibition of ulcer index in ethanol and acetic acid – induced ulcers. Extract prevents the oxidative damage of gastric mucosa by blocking lipid peroxidation and by significant decrease in superoxide dismutase, and increase in catalase activity. **Conclusions:** Results showed that *Sesamum indicum* possesses significant gastroprotective activity which might be due to gastric defence factors.

Keywords: *Sesamum indicum* L; Anti-ulcer; Antioxidant; Gastroprotective; Lipid peroxidation

Introduction

Black sesame seed *(Sesamum indicum* L.) is a member of Pedaliaceae family. It is an annual shrub. It is oldest oil seed plant known to world, commonly called as Til. Seeds are rich in oil (50%) and protein (18-20%) (Versha et al., 2017). A number of lipid souble antioxidants have been isolated from sesame seeds, including sesamin, sesaminol and sesamolinol (Fukuda et al., 1996). Aqueous and organic (Ethanol/Methanol) extracts are prepared from sesame plant parts. The results reveal that methanol extract is having antioxidant activity enhancing power. Sesame plant is having phenolic compounds. Phenolic compounds have the ability to scavenge free radicals by hydrogen donation or electron donation and against oxidative damages (Versha et al., 2017).

Gastric ulcer is an illness that affects a considerable number of people worldwide (Crawford et at., 2003). It is among the most serious diseases in the world. A localized loss of gastric as well as duodenal mucosa leads to the formation of peptic ulcer. It arises when the normal mucosal defensive factors such as mucus, mucosal blood flow, formation of bicarbonate ions and prostaglandin E2 are impaired or over powered. Also by the aggressive factor includes acid, pepsin, NSAIDs and Helicobacter pylori (Srinivas and Celestin, 2011).

Hence the present study was planned to evaluate antiulcer & antioxidant activity of alcoholic extracts of seeds and aerial parts of *Sesamum indicum* Linn. in ulcer model in experimental animals. Literature review reveals that few work have been done on seeds of *Sesamum indicum* Linn. but no work has been done on leaves and aerial part of *Sesamum indicum* Linn. as antiulcer activity. In view of this, the present study is taken up to evaluate the possible antiulcer and antioxidant activity of *Sesamum indicum* Linn. seeds & and aerial parts. So the study is essential and justifiable.

Material and methods

Plant material collection and extraction

Preparation of SIE (*Sesamum indicum* extract): *Sesamum*

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indicum seed & leaves were purchased from commercial sources and were dried in the shade for 1 week. An extract was prepared by powdering both leaves and seeds and then extract with 70% ethanol for 24hrs. Following filtration and evaporation, the solution was evaporated under vacuum to provide SI extract.

Animals

Sprague–Dawley rats (140–180g) were procured from the animal house of Central Drug Research Institute, Lucknow. They were kept in the departmental animal house at 26±2 °C and relative humidity 44–56%, light and dark cycles of 10 and 14 hrs, respectively for 1 week before and during the experiments. Animals were provided with standard rodent pellet diet (Amrut, India) and the food was withdrawn 18–24 hrs before the experiment though water was allowed ad libitum. All experiments were performed in the morning according to current guidelines for the care of laboratory animals and the ethical guidelines for investigations of experimental pain in conscious animals.

Phytochemical screening

Preliminary qualitative phytochemical screening of leaves of *Sesamum indicum* L. gave the positive test for Lamalbid (I1), sesamoside (I2), shanzhiside methyl ester (I3), pedaliin (P4), and acteoside (P5) were major compounds in all young sesame leaves used in this study (Yushiro et al., 2018), Sesame seeds contain 50-60 % oil and 19-25 % protein with antioxidants lignans such as sesamolin and sesamin. The lignin contents have useful physiological effects in human and animal health (Ashakumary et al., 1999). They contain lignans, including unique content of sesamin, which are phytoestrogens with antioxidant and anti-cancer properties (Bedigian, 2004).

Toxicity studies

Acute toxicity study was evaluated as per described guidelines (Ecobichon, 1997), in which the rats were fasted overnight and treated with the extracts of *Sesamum indicum* at doses of 100-2000 mg/ kg p.o. It was observed that the rats were not mortal even at 2000 mg kg-1 dose of EESI (Ethanolic Extract of *Sesamum indicum*). Hence, 1/5th (400 mg/kg), 1/10th (200 mg/kg) and 1/20th (100mg/kg) of EESI were selected as high dose, standard and low dose, respectively for this study. All the animals remained alive and there were no significant behavioural and body weight changes during the observations period in which the animals were monitored on regular basis.

In LD_{50} studies, it was found that the animals were safe up to a maximum dose of 2000 mg/kg body weight. The biological evaluation was carried out at doses of 100, 200 and 400mg/kg body weight.

Antiulcer activity

EESI, suspended in 1% carboxy methyl cellulose (CMC) in distilled water in doses of 100, 200 and 400mg/kg and Omeprazole, the reference drug, in the dose of 50mg/kg were administered orally twice daily at 10:00 and 16:00 h, respectively, for 5 days for ulcer protective studies. Further the effective dose of EESI 100mg/kg, b.d for 5 days was used for secretion and mucosal studies, and up to 10 days for ulcer healing study. Control group of animals received suspension of 1% CMC in distilled water.

Ethanol (EtOH)-induced ulcers

The gastric ulcers were induced in rats by administering EtOH (1 ml/200 g, 1 h) (Hollander et al., 1984) and the animals were sacrificed by cervical dislocation and stomach was incised along the greater curvature and examined for ulcers. The ulcer index was scored by a person unaware of the experimental protocol, based upon the product of length and width of the ulcers present in the glandular portion of the stomach (mm2/ rat). Statistical analysis of data was done by using unpaired Student's t -test.

Cold-restraint stress (CRS)-induced ulcers

On day 6 to 18 h fasted rats, cold restraint stress was given by strapping the rats on a wooden plank and keeping them for 2 h at 4- 6 °C. The animals were then sacrificed by cervical dislocation and ulcers were scored on the dissected stomachs (Gupta et al., 1985). as described above.

Acetic acid-induced ulcers

The rats were anaesthetized with pentobarbitone (35 mg/kg, i.p.). The abdomen was opened and the stomach was visualized. A cylindrical glass tube of 6 mm in diameter was tightly placed upon the anterior serosal surface of the glandular portion of stomach 1 cm away from the pyloric end. A total of 50% acetic acid (0.06 ml/ animal) was instilled into the tube and allowed to remain 60 s on the gastric wall. After removal of the acid solution, the abdomen was closed in two layers and animals were caged and fed normally. EESI was given in the dose of 200 mg/kg on day 1, orally, twice daily, 4 h after the application of acetic acid and continued either up to 5 or 10 days after induction of the ulcer. The animals were then sacrificed after 18 h of the last dose of drug either on day 6 or day 11 of experiment to assess

the ulcer size and healing. Ulcer index was calculated based upon the product of length and width (mm2/rat) of ulcers (Goel and Maiti, 1992). Statistical significance was calculated using unpaired Student's t -test.

Pylorus-ligation (PL)-induced ulcers

Drugs were administered for a period of 5 days as described above. On day 6 after the last dose, the rats were kept for 18 h fasting and care was taken to avoid coprophagy. Animals were anaesthetized using pentobarbitone (35 mg/kg, i.p.),

the abdomen was opened and pylorus ligation was done without causing any damage to its blood supply. The stomach was replaced carefully and the abdomen wall was closed in two layers with interrupted sutures. The animals were deprived of water during the post-operative period (Sanyal et al., 1971). After 4 h, stomachs were dissected out and contents were collected into tubes for estimation of biochemical parameters.

Determination of gastric wall mucus

Gastric wall mucus was determined according to the method of (Corne et al., 1974). The glandular segments from stomachs were removed, weighed and incubated in tubes containing 1% Alcian blue solution (0.16M sucrose in 0.05M sodium acetate, pH 5.8) for 2 h. The alcian blue binding extract was centrifuged at 3000 rpm for 10 min and the absorbency of supernatant was measured at 498 nm. The quantity of alcian blue extracted (gm per gm of glandular tissue) was then calculated.

Assessment of antioxidant level

Lipid peroxidase (LPO) activity

LPO product malondialdehyde (MDA) was estimated using 1,1,3,3-tetraethoxypropane as the standard and is expressed as nmol/mg protein (Okhawa et al., 1979).

Superoxide dismutase (SOD) activity

SOD was estimated by following the procedure of (Kakkar and Das, 1984). The inhibition of reduction of nitro blue tetrazolium (NBT) to blue colored formozanin presence of phenazine metha sulphate (PMS) and NADH was measured at 560 nm using n-butanol as blank. One unit (U) of enzyme activity was defined as the amount of enzyme that inhibits rate of reaction by 50% in 1 min under the defined assay conditions and the results observed.

Catalase (CAT) activity

Decomposition of H_2O_2 in presence of catalase was followed at 240 nm (Beer and Sizer, 1952). One unit of (U) CAT was defined as the amount of enzyme required to decompose 1 mmol of H2O2/min, at 25 °C and pH 7.0. Results are expressed as U of CAT activity/mg protein.

Statistical analysis

Values were represented as mean±S.E.M. for six rats. Analysis of variance (ANOVA) test was followed by individual comparison by Newmann Keuls test for the determination oflevel of significance.

Results

Antiulcer and ulcer healing effects

Ethanolic extract of *Sesamum indicum* 100–400mg/kg, given orally, twice daily for 5 days showed dose-dependent protective effect against gastric ulcers induced by ethanol & decrease in ulcer index by 43.40%, 54.90% & 73.27% as compared with omeprazole 75.27% (Table-1) and acetic acid-induced chronic ulcers after 5 days of treatment 13.36%, 29.74% & 45.68% compared with omeprazole 42.24% and after 10 days of treatment 16.41%, 35.07% & 82.83% compared with omeprazole 84.32% (Table-3). A total of 50% acetic acid when applied to the serosal surface of rat gastric mucosa in the fundal region near to the pyloric end produced chronic gastric ulcers. EESI 400 mg/kg significantly healed ulcers induced by 50% acetic acid after 10 days of treatment.

Effect on mucin secretion and mucosal glycoproteins

EESI 100-400 mg/kg tended to increase the concentration of individual carbohydrates and total carbohydrates (TC) in the alcoholic precipitate of gastric juice with significant decrease in protein (P) content leading to significant increase in TC:P ratio. EESI showed again similar effect on mucosal glycoproteins content of the mucosa as observed

Table 1. Effect of *Sesamum indicum* Linn. extract (twice daily for five days) on ethanol-induced, CRS and pyloric ligation gastric ulcer

Treatment	Ethanol Induced model		CRS model		Pyloric ligation (PL)	
	Ulcer index (mm^2/rat)	Percent protection	Ulcer index (mm^2/rat)	Percent protection	Ulcer index (mm^2/rat)	Percent protection
Ethanol	18.4 ± 0.53	0	21.18 ± 0.84	0	26.17 ± 0.84	0
Sesamum indicum Linn. Extract 100 (mg/kg)	12.45 ± 0.48	32.34%	12.97 ± 0.48	38.76%	18.97 ± 0.47	27.51%
Sesamum indicum Linn. Extract 200(mg/kg)	8.4 ± 0.96[a]	54.34%	7.9 ± 0.65[a]	62.70%	14.9 ± 0.64[a]	43.06%
Sesamum indicum Linn. Extract 400(mg/kg)	5.1 ± 0.80[b]	72.28%	4.4 ± 0.48[b]	79.22%	9.4 ± 0.48[b]	64.06%
Omeprazole 50(mg/kg)	3.7 ± 0.53[b]	79.62%	4.01 ± 0.47[b]	81.06%	8.06 ± 0.47[b]	69.43%

Values are mean ± SEM for 6 rats. [a]P< 0.05 compared to respective EtOH group. [b]P <0.01 compared to respective EtOH group.

Table 2. Effect of *Sesamum indicum* Linn. extract (twice daily for five days) on gastric juice volume, Acid, Pepsin and DNA in in 4 h PL rats

Treatment	Volume	Acid		Pepsin		DNA
	(ml/100g)	Conc.	Output	Conc.	Output	(µg/ml)
		(µEq/ml)	(µEq/4 h)	(µmol/ml)	(µmol/4 h)	
Control	1.92±0.02	139.2±1.7	244.5±2.6	449.3±4.86	834.5±3.19	234.17±1.87
EESI 100 (mg/kg)	1.81±0.39	125.8±2.0	227.5±1.98	400.33±3.88	796.16±4.26	205.83±2.23
EESI 200 (mg/kg)	1.79±0.03	110.5±0.8	209.67±1.80	382.16±3.4	684.83±4.26	201.67±2.33
EESI 400 (mg/kg)	1.77±0.02	106.2±0.50	196.67±3.0	350±3.24	411.16±2.89	169.17±1.74[y]
Omeprazole 50 mg/kg	1.75±0.24	105.2±1.1	185±1.63	346±5	417.5±4.33[x]	167.33±1.45[x]

Values are mean ± SEM for 6 rats. [x]P< 0.001 compared to respective control group. [y]P <0.001 compared to respective control group.

Table 3. Effect of *Sesamum indicum* Linn. extract (twice daily for five days) on acetic acid-induced gastric ulcer

Treatment and Dose (mg/kg)	5 days treated Ulcer index	% incident of perforation	10 days treated Ulcer index	% incident of perforation
Control	22.28 ± 0.45	0	16.01 ± 0.45	0
Sesamum indicum Linn. Extract 100 (mg/kg)	17.52 ± 0.68	21.36%	11.88 ± 0.85	25.79%
Sesamum indicum Linn. Extract 200 (mg/kg)	16.48 ± 0.82	26.03%	7.03 ± 0.87	56.09%
Sesamum indicum Linn. Extract 400 (mg/kg)	12.13 ± 0.94[a]	45.56%	3.93 ± 0.55[b]	75.45%
Omeorazole 50(mg/kg)	11.68 ± 0.59	47.57%	2.18 ± 0.25	86.38%

Values are mean ± SEM for 6 rats. [a]P< 0.01 compared to respective control group. [b]P <0.001 compared to respective control group.

by an increase in TC:P ratio. However, it increased the defensive mucin secretion.

Antioxidant effect

Antioxidant activity was determined by determining glutathione peroxidase, superoxide dismutase, catalase and myeloperoxidase enzyme activities and the amounts of malondialdehyde and glutathione in stomach tissues. *Sesamum indicum* L extract contains chemicals such as sesamin, sesaminol, and sesamolinol, Lamalbid, sesamoside , shanzhiside methyl ester, pedaliin, and acteoside. They contain lignans, including unique content of sesamin, which are phytoestrogens with antioxidant and anti-cancer properties (Bedigian 2004). When the animals were treated with EESI 200 mg/kg was significant reduced the LPO, SOD and CAT level by 0.55±0.01, 105±4.9 & 26.2±0.8 (P < 0.001) in ethanol induced model and 0.58±0.01, 111±4.6 & 28.2±0.8 (P < 0.001) as compared to elevated level in CRS 0.50±0.01. LPO, SOD and CAT levels near to the normal values when compared to the stress group (UI 4.09/1.2, PB/0.001; LPO 0.189/0.01, PB/0.001; SOD 106.89/1.1, PB/0.001 and CAT 29.49/1.2, P < 0.001).

Secretion of mucus and bicarbonate by surface epithelial constitute a mucus–bicarbonate barrier, which is regarded as first line of defence against potential ulcerogens. The gastric wall mucus was significantly (P< 0.001) enhanced by EESI and is regarded as a first line of defence against EtOH-induced gastric ulcers. After 10 days of treatment, the rats treated with acetic acid showed loss of gland architecture with erosion of the epithelial layer and evident oedema and infiltration by inflammatory cell. EESI (200mg/kg) treated rats showed no ulceration but intactness of gastric epithelium was not completely restored. Minimal oedema and infiltration was seen in the lower half of the

Table 4. Effect of *Sesamum indicum* Linn. extract (twice daily for five days) on lipid peroxidation (LPO), superoxide dismutase (SOD), and catalase (CAT) in CRS-induced gastric ulcer

Treatment	Dose (mg/kg)	LPO	SOD	CAT
Control	-	0.49 ± 0.02	112 ± 3.7	33.2 ± 2.4
Acetic acid	-	0.57 ± 0.03[y]	135 ± 6.2[x]	17.3 ± 0.9[y]
Sesamum indicum Linn. Extract	100	0.63 ± 0.01	124 ± 4.8	26.5 ±3.6
Sesamum indicum Linn. extract	200	0.58 ± 0.01	111 ± 4.6	28.2 ± 0.8
Sesamum indicum Linn. Extract	400	0.49 ± 0.01	106 ± 3.3	26.2 ± 2.0

Values are mean ± SEM for 6 rats. [x]P< 0.001 compared to respective control group. [y]P <0.001 compared to respective control group.

mucosa. Omeprazole treated groups showed no ulceration in gastric mucosa, glands were regular and no inflammation.

Ethanol-induced gastric ulcers have been widely used for the evaluation of gastro protective activity. Ethanol is metabolised in the body and releases superoxide anion and hydroperoxy free radicals. It has been found that oxygen-derived free radicals are implicated in the mechanism of acute and chronic ulceration in the gastric mucosa (Pihan et al., 1987) and scavenging these free radicals can play an appreciable role in healing these ulcers (Halliwell 2001). Acetic acid-induced chronic ulcer model was chosen because it produces gastric lesion, which is similar to human chronic ulcers. In this model, acetic acid produced mucosal injury, which was confined to the glandular stomach (Dharmani et al., 2005). The ulcer produced by acetic acid is due to the release of histamine, which increases the capillary permeability and back diffusion of HCl (Takagi et al., 1969). Treatment with EESI for 10 days afforded complete regeneration of mucosal glandular structure, which was evidenced through histopathological studies of the stomach.

The results of our study prove that the extract of *seasmum indicum* possess antiulcer activity against experimentally induced acute and chronic gastric ulcer. Hence, it can be suggested that the antiulcer activity of the extract may be attributed to its antisecretory and antioxidant activities.

Effects of test drugs on ulcer healing

Oral treatment with Omeprazole (Twice daily) 50 mg/kg for 10 days markedly accelerated the healing of gastric ulcers, and decreased the ulcer index by 67%, compared to respective control and decreased the defective area in the ulcerated region rats.

Discussion

The aim of the present study was to assess the role of various mucosal offensive acid-pepsin and defensive mucosal factors. Attempts were made on the necessity of nontoxic, antiulcer compounds preferably from traditional medicinal plants such as *Sesamum indicum* Linn. The current study deal with the ethanolic extract of *Sesamum indicum* Linn. on gastric ulcers in rats.

The EESI showed significant ulcer protective and healing effects in acute ulcers induced by ethanol and chronic ulcers induced by acetic acid. Ulcers caused by ethanol are due to superficial damage to mucosal cells (Miller and Henagan, 1984). Mucosal blood flow has been attributed to be an important factor in the damage caused by alcohol and is modulated by prostaglandins (Hollander et al., 1985). The incidence of ethanol-induced ulcers is predominant in the glandular part of stomach was reported to stimulate the formation of leukotriene C4 (LTC4), mast cell secretary products (Oates and Hakkinen, 1988) and reactive oxygen oxygen species resulting in the damage of rat gastric mucosa (Peskar et al., 1986). Ethanol-induced depletion of gastric wall mucus has been significantly prevented by EESI, A copious amount of gastric mucus is secreted during superficial mucosal damage and provides a favorable microenvironment in repair by restitution. Therefore, it is conceivable that the observed gastric ulcer protection of EESI provides a general evidence for the close relationship between these factors. Gastric ulcer is often a chronic disease and it may persist for 10–20 years characterized by repeated episodes of healing and re-exacerbations. The action of the ethanolic extract of EESI in accelerating wound healing has been explained by several mechanisms, such as stimulating the contraction of the wound and increasing the formation of epithelisation.

The gastric ulcers induced by acetic acid in rats are known to resemble the human peptic ulcer both grossly and histologically. Chronic ulcers by acetic acid are due to increase in volume of acid output leading to subsequent pyloric obstruction and mucosal necrosis (Okabe and Pfeiffer 1972). Even though the causative factors for ulcerogenesis may be different, the net imbalance in offensive and defensive factors brought about by them is thought to be the cause for ulcerogenesis (Goel and Bhattacharya 1991). The understanding of the mechanism leading to the chronic evolution of gastric ulcer is poor and little information is

available on the role of inflammation and oxygen-derived free radicals in the development and healing of this type of lesion. It is well established that superficial injury is promptly healed through migration from underlying cells of the gastric pit. In the evolution of the experimental ulceration process, a fully developed inflammatory response that leads to cellular infiltration, extracellular matrix proliferation and establishment of a new microvascular supply could be necessary. EESI also healed chronic gastric ulcers produced by 50% acetic acid. Acetic acid is reported to produce ulcers by gastric obstruction leading to increase in acidic gastric juice (Okabe and Pfeiffer, 1972). Perhaps increase in defensive mucosal factors may have a beneficial role in protecting ulcers induced by acetic acid. This shows that EESI induces turnover of glycoprotein in the mucosal cells, thus increasing the quantity of cellular mucous.

SOD plays a significant role in the prevention of gastric damage by converting superoxide, a highly reactive radical, into the less reactive hydrogen peroxide (H_2O_2), which can be broken down by CAT.

Mucus is secreted by the mucus neck cells and covers the gastric mucosa thereby preventing physical damage and back diffusion of hydrogen ions (Williams and Turnberg, 1981). EESI in the dose of 200 mg/kg significantly increased mucus secretion as observed from the increase in TC:P ratio, due to increase in the individual mucopolysaccharides like sialic acid and total hexoses leading to significant increase in total carbohydrates. Increase in glycoprotein content of gastric mucosa is evidenced from increase in TC: P ratio of the mucosal cells, due to increase in mucopolysaccharides, the major constituent of mucus. Hence increase in synthesis of mucus may be one of the important contributing factors for ulcer protective role of EESI. This was consistent with our preliminary study where we observed significant ulcer protective effect in different acute gastric ulcer models with significant decrease in offensive acid-pepsin secretion and increase in mucosal protective factors like mucus secretion, cellular mucus and life span of mucosal cells (Rao et al., 2008). The role of free radicals in gastric ulcerations is well documented. EESI significantly reduced lipid peroxidation in rat gastric mucosa. SOD scavenges the super oxide radical O2−, one of the reactive oxygen species (ROS) responsible for lipid peroxidation. This reaction leads to increase in generation of peroxyl radical H_2O_2−, which is also capable of producing more oxidative damage. Hence, the anti-oxidant activity in gastric mucosal homogenates observed from decrease in LPO may be due to increase in SOD and CAT levels. The increase in SOD was due to increased ROS generation during mucosal damage. This led to increased generation of H_2O_2- and its accumulation due to decreased CAT level. This evidently caused increased lipid peroxidation and mucosal damage as seen from the increase in ulcer index in comparison to the control group (Goel et al., 2003).

SOD converts the reactive O2 to H_2O_2, which if not scavenged by the CAT can by itself cause lipid peroxidation by increase in the generation of hydroxyl radicals. Hence decrease in CAT levels has led to increase in accumulation of these reactive products and thus, has caused increased lipid peroxidation and tissue damage (Sairam et al., 2002).

Prostaglandins have long been known to afford protection to the gastric mucosa. They do so by inhibiting acid secretion and increasing mucosal defences. PGs are reported to restore mucosal defense, and thereby prevent damage by several irritants and influence repair of gastric ulcers. PGs are reported to act through endogenous prostaglandin (EP) receptors and the subtype EP-3 in the stomach and duodenum has been reported to be responsible for bicarbonate secretion (Goel et al., 2003). Omiprazole has been reported to protect against ethanol-induced damage by increased accumulation of PGs rather than reduction of acid secretion.

Acid is considered as an important factor in the development of acute and chronic gastric mucosal lesions. Suppression of gastric acid by surgical and a variety of pharmacological means provides effective and rapid healing of ulcer. Increase in mucosal resistance and decrease in aggressive factors mainly acid and pepsin are associated with gastric protection offered by prostaglandins. Mucosal barriers are the most significant factors for gastric protection. More the production of mucous, the less was the degree of ulceration. Mucus also protects the mucosa and sub-mucosa from inflammatory reaction. The higher the mucin contents the lower is the free acidity.

Flavonoids demonstrate a wide range of biochemical and pharmacological effects including anti-oxidation, anti-inflammation, anti-platelet, anti-thrombotic action, and antiallergic effects. They can inhibit enzymes such as prostaglandin synthase, lypoxygenase, and cyclooxygenase, closely related to tumorigenesis (Baumann et al., 1980; Laughton et al., 1991). In *S. indicum*, it is observed that the total flavonoid content (free + bound) was higher in leaf followed by stem (Priyanka and Renu, 2012). Quercetin and kaempferol has anticancer, antiinfla-mmatory, antiviral, fibromyalgia, metabolic syndrome etc (Laughton et al., 1991).

Several flavonoids prevent gastric mucosal lesions produced by various models of experimental ulcer and protect the gastric mucosa against various necrotic agents. They are the most important plant constituents associated with anti-ulcer activity and also stabilize membranes and this may be the mechanism by which they inhibit ulcer induction (Martin and Motilva, 1993).

Conflicts of interest: Not declared

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