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Research article

# Novel gastroprotective activity of *Basella alba* mucilage-based hydrogel beads on Diclofenac sodium-induced gastric ulcer

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## ABSTRACT

Natural polysaccharides are emerging gastroprotective agents that need extensive characterization and subsequent commercialization. Diclofenac sodium, a nonsteroidal anti-inflammatory drug, is generally used as a model drug to induce gastric ulcers experimentally. Therefore, in the present study, Basella alba mucilage is modified to form hydrogel beads, and its gastroprotective potential is judged by incorporating Diclofenac sodium in it and administered orally to Swiss albino rats at an equivalent weight of 50mg Diclofenac sodium/ kg bw for ten days. The results were compared with the rats administered Diclofenac sodium (50 mg/kg bw) and with the group of rats administered Diclofenac sodium (50mg/kg bw) and Pantoprazole (10mg/kg bw). Another group of rats were administered blank hydrogel beads, and another group served as control. The gastroprotective property was evaluated from the gastric secretory parameters, ulcer index, biochemical tests, and histopathology studies. The administration of Basella alba mucilage-based hydrogel beads in rats decreased the ulcer index, total and free acidity, lipid peroxidation, hydrogen peroxide level, and myeloperoxidase activity. It elevated the level of enzymic antioxidants and increased gastric juice's pH significantly compared to the Diclofenac-treated rats. All the evaluated parameters showed similar results for the rats treated with Diclofenac sodium-loaded Basella alba mucilage beads and those treated with Diclofenac sodium and Pantoprazole, with no significant differences. The histopathology analysis also supports the gastroprotective property of the beads. Thus, Basella alba mucilage-based hydrogel beads can be a promising gastroprotective agent against Diclofenac sodium-induced gastric ulcers.

**Keywords:** *Basella alba* mucilage, Gastroprotective, Beads, Diclofenac sodium, Gastric ulcer, Rats.

## INTRODUCTION

Gastric ulcer is one of the major disorders of the gastrointestinal system characterized by mucosal erosion leading to perforation and severe bleeding[1]. Numerous synthetic antiulcer drugs are available with serious side effects, which limits their use for gastroprotection and paves the way for the utilization of safe and effective natural gastro protectants. Natural polysaccharides have been found to exert significant gastroprotective activity by forming a protective layer on the gastric mucosa, thereby improving gastrointestinal health[2]. Mucilages are naturally occurring high molecular weight polysaccharides, which can be a promising gastroprotective candidate[3,4]. In a study by Galati et al. (2000), *Opuntia ficus indica* mucilage forms a protective layer over mucosa, defending the necrotizing agents. Moreover, being an anionic electrolyte, a change in the molecular shape due to repulsion is also said to cause gastro-protection[5]. Another study by Shatri (2022) found that *Sesamum capense* mucilage forms a gel-like substance over the mucous membrane due to its high swelling capacity, exhibiting potent acid-neutralizing capacity[6]. Altyar et al. (2022) investigated the gastroprotective activity of *Malva parviflora* leaves and fruit mucilage and found that the mucilage increased mucus secretion, thereby

protecting the gastric mucosa [7]. El-Sheikh et al. (2021) have studied the gastroprotective effect of *Solenostemma argel* mucilage, which acts by increasing the prostaglandin (PGE2), thereby proliferating cells and aiding in the ulcer repair process [8]. In another research by Sharma et al. (2014), *Bryophyllum pinnatum* mucilage has shown a potent gastroprotective effect in ethanol-induced gastric ulcers in rats [9]. Therefore, the stem and fruits of *Basella alba* L, belonging to the family Basellaceae, a rich source of mucilage, can be a potential candidate for the study [10]. Numerous natural polysaccharides as gastroprotective agents are reported in the literature, but reports on the application of mucilage as gastroprotective are limited, and there has yet to be a report on the gastroprotective property of *Basella alba* mucilage to date.

Diclofenac Sodium is a potent analgesic and nonsteroidal anti-inflammatory drug (NSAID) used to relieve pain and inflammation [11]. Chronic use of the drug leads to the development of gastric lesions due to reduced gastric defense mechanism due to prostaglandin synthesis inhibition. Therefore, it is a recommended model for ulcer induction in experimental animals [12]. Since the gastroprotective nature of mucilage can help to prevent the adverse effect of repeated and long-term administration of NSAID, therefore, it can be used to carry an ulcer-causing drug and develop an antiulcer formulation of the drug. In the present investigation, the gastroprotective potential of Diclofenac sodium-loaded hydrogel beads prepared from modified *Basella alba* mucilage was studied in Swiss albino rats.

## MATERIALS AND METHODS

Diclofenac sodium was gifted from Micro Labs Limited, Hyderabad, India. Pantoprazole was a gift sample from Alkem Laboratories, West Bengal, India. *Basella alba* was procured from the local market and authenticated by the Botanical Survey of India, Kolkata, bearing voucher no.MC0105. All other reagents were of analytical grade and used as received. Double distilled water was prepared in the laboratory and used.

### Preparation of *Basella alba* mucilage-based hydrogel beads

The mucilage was extracted and isolated from the stem and fruits of *Basella alba*. The dried stems and fruits of the plant were soaked in distilled water overnight, and the mucilage was isolated by precipitation method using acetone [13]. The mucilage obtained was dried at 35 °C and chemically modified to its carboxymethyl derivative by carboxymethylation reaction using sodium hydroxide and monochloroacetic acid by etherification process [14]. The obtained carboxymethyl derivative of the *Basella alba* mucilage was dried at 35 °C and kept in a desiccator for further use. The carboxymethylated *Basella alba* mucilage was mixed with sodium carboxymethyl cellulose in the ratio of 2:1, maintaining the total polymer concentration 6%w/v and loaded with Diclofenac sodium (20%w/w)[15]. The polymer solution was cross-linked with $Al^{3+}$ ion in an aluminium chloride solution to form hydrogel beads by inotropic gelation. The prepared hydrogel beads were dried at 35 °C and kept in a desiccator until use.

### Experimental animals

Thirty (30) albino rats weighing 120-150g were kept in ordinary cages for fourteen days under a 12-hour light and dark cycle to adapt to the environment before the experimentation. The animals were given free access to food and water as required by them. The study protocol was approved by the Institutional Animal Ethics Committee (registration no.1938/PO/Rc/S/17/CPCSEA) and followed the OECD principles of Good Laboratory Practices, Schedule Y requirements of the Drug and Cosmetics Act.

### Treatment protocol

The potential of the hydrogel beads in protecting the gastric ulcer induced by Diclofenac sodium was studied in five groups of albino rats, containing six rats in each group. The grouping was done after fourteen days. All the animal groups were devoid of food 12 hours before each administration.

Group I (Control): Received food and water

Group II: Received Diclofenac sodium (50mg/kg body weight) once a day for ten days [16]

Group III: Received Diclofenac sodium loaded beads equivalent to 50mg Diclofenac sodium /kg body weight once a day for ten days.

Group IV: Received blank beads (same weight as received by Group III) once a day for ten days

Group V: Received Diclofenac sodium (50mg/kg body weight) and Pantoprazole (10mg/kg body weight) once a day for ten days [11]

All the administrations were done orally using oral gavage.

### Pyloric Ligation

Pyloric ligation was done to collect gastric juice 24 hours after the last treatment. Under the influence of anesthesia, a small midline incision was made to open the abdomen of animals. Ligation of the pyloric portion of the stomach was done with thread to prevent damage to the blood supply [17].

### Evaluation of gastric-secretory parameters

Four hours after pyloric ligation, animals were sacrificed to cut open the stomach, and the gastric juice was collected. It was centrifuged at 3000 rpm for 10 minutes to collect the supernatant for measuring the volume of gastric juice and pH. The pH meter was used to measure pH, and the volume of gastric juice was recorded as ml/100g/4 hrs. Free acidity and total acidity were determined by titration with Sodium hydroxide using Toepfer's reagent with Phenolphthalein indicator following the method established by Card and Mark [18].

### Ulcer index studies

The gastric mucosa was examined critically for any damage, inflammation, or lesions macroscopically with a hand lens and scored. The ulcer index was calculated from the total ulcer score in an animal group divided by six. The result was expressed as mean ± SD [19].

**Gastric mucosal studies**

Mucosa from a portion of the stomach was scraped and preserved in liquid nitrogen at -70°C until use. 100mg mucosa mixed with Tris HCl buffer of pH 7.4 at 4°C was homogenized at 1000 rpm for 5 min and then centrifuged at 2000×g for 30 min to collect the supernatant to estimate biochemical parameters. The total soluble protein present in the mucosa was determined by first treatment with an alkaline copper solution and then with a Folin Phenol reagent, as stated by Lowry et al. [20]. Another part of the stomach was used to estimate the bound mucus [21].

**Analysis of Biochemical parameters**

**Determination of lipid peroxides**

The lipid peroxides in the gastric mucosa were determined by its reaction with thiobarbituric acid as developed by Okhawa et al. [22]. At first, a mixture of mucosal homogenate, sodium lauryl sulfate, thiobarbituric acid solution, and acetate buffer was prepared and heated at 100°C for one hour. N - butanol was added to the reactants after cooling and centrifuging, and absorbance was noted at 532 nm.

**Determination of Glutathione**

The gastric mucosal homogenate was precipitated and reacted with 5, 5'dithiobis 2- nitrobenzoic acid (DTNB) to estimate the reduced glutathione content, and the absorbance was measured at 412 nm as per the method stated by Elman et al. [23].

**Estimation of antioxidant enzymes**

Glutathione peroxidase was estimated by collecting supernatant and adding DTNB and disodium hydrogen phosphate as per the method Rotruck et al. [24] gave. The resultant color formed was analyzed at 420 nm. Glutathione S- transferase was estimated by adding 1- chloro 2,4- dinitrobenzene following Habig et al. [25]. The absorbance was noted every 30 s till 3 min at 340 nm. Catalase activity was determined by initiating the reaction by adding hydrogen peroxide solution, as stated by Takhara et al. [26]. The absorbance was checked every 30 s up to 3 min at 240 nm, and the decreased value was noted. Another antioxidant enzyme, Superoxide dismutase, acts by inhibiting cytochrome c reduction. It was estimated by adding epinephrine to initiate the reaction as per the method given by Misra and Frodovich [27]. The absorbance was checked at 480 nm, and the increased value was noted.

**Determination of Nonprotein sulfhydryl**

The nonprotein sulfhydryl group was determined following the method of Sedlak and Lindsay [28]. The gastric mucosal tissues were mixed with Ethylene diamine tetra acetic acid (EDTA) solution and homogenized. It was then added to trichloro acetic acid solution and centrifuged for the supernatant. A mixture of Tris-EDTA and DTNB was prepared in methanol, and the resultant solution was added to the supernatant, and absorbance was recorded at 412 nm.

**Determination of Myeloperoxidase**

The myeloperoxidase activity was analyzed by utilizing hydrogen peroxide to carry out O-dianisidine dihydrochloride oxidation, as discussed by Krawisz et al. [29]. The absorbance was noted at 550 nm.

**Histopathological studies**

Stomach tissues from animals of all groups were isolated and cleaned in saline solution for histological examination. It was dipped in fixative sera for 24 hrs and then cleaned and embedded in paraffin wax. Thin sections of 4-5µ were cut and stained with hematoxylin and eosin stain. It was cleaned and observed under a microscope to get the photographs [30].

**Statistical analysis**

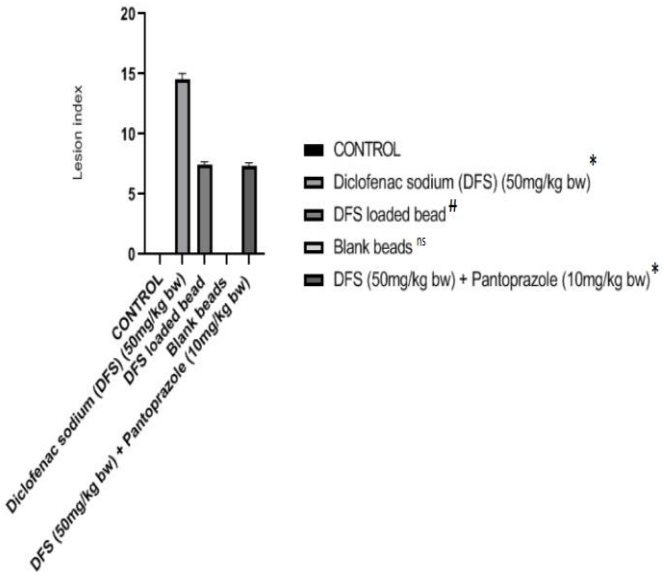
All the experiments' results were pooled and analyzed in terms of mean± SD. Statistical evaluation of the data was carried out using one-way ANOVA (Analysis of Variance) followed by a student's t-test. The significance level was considered at p-value, $p < 0.05$.

## RESULT AND DISCUSSION

**Effect of *Basella alba* mucilage-based hydrogel bead on Ulcer index**

The stomach of rats from the control group and rats administered blank beads were found to be normal and showed no ulceration, whereas the rats administered Diclofenac sodium showed the highest ulcer index of 14.5±0.73 which suggests that the drug has caused extensive erosion of gastric mucosa (Fig 1). On comparing the value of group II with the values of group III and V, there is a marked reduction ($p<0.01$) in lesion index from 14.5 to 7.44±0.45 (group III) and 7.36±0.45 (group V). This shows that compared to the protective effect of Pantoprazole, the *Basella alba* mucilage-based hydrogel bead is also similarly effective in preventing the formation of ulcers, p is non-significant (ns).

**Figure 1:** Protective effect of *Basella alba* mucilage-based hydrogel bead on lesion index



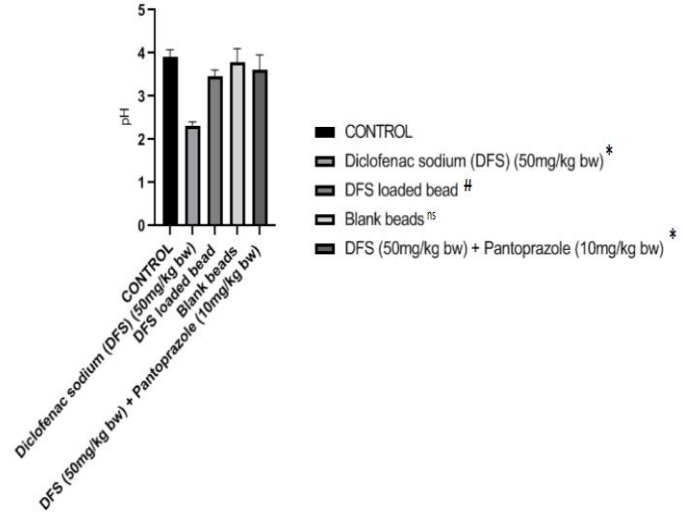

*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Effect of *Basella alba* mucilage-based hydrogel bead on Gastric secretory parameters**

The rats treated with Diclofenac sodium showed a significant decrease in gastric juice pH (2.31±0.09) as compared to the control

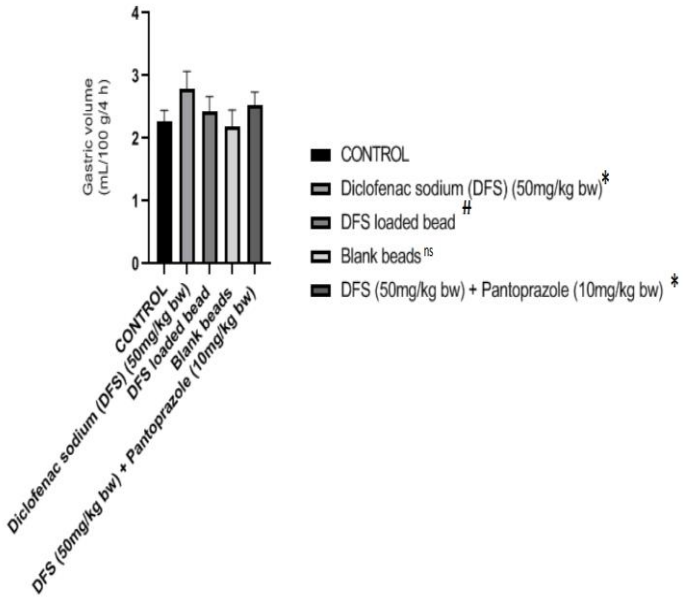
group's pH, i.e., 3.92±0.16 ($p<0.01$). The rats treated with drug-loaded beads showed an increased pH of 3.47±0.14 ($p<0.01$), which was comparable to the gastric pH of the group treated with both Diclofenac sodium and Pantoprazole (Fig 2). The pH of gastric juice of the control group and the group treated with blank beads showed similar pH (p is non-significant). The diclofenac sodium treatment group resulted in a higher gastric volume, total acidity, and free acidity than the control group ($p<0.01$). The animals treated with Diclofenac sodium-loaded mucilage beads showed a significant reduction in gastric volume, free acidity, and total acidity compared to the Diclofenac sodium treatment group ($p<0.01$). It was similar to the results of the group administered both Diclofenac sodium and Pantoprazole with no significant difference (Fig 3 and Fig 4).

**Figure 2:** Effect on the pH of gastric juice in all the treatment groups



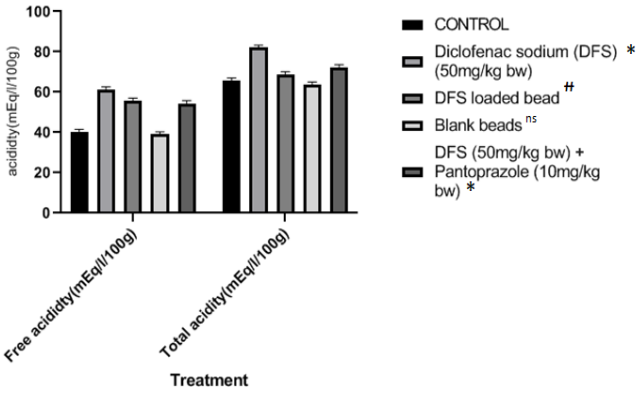

*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Figure 3:** Effect on the volume of gastric juice in all the treatment groups




*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Figure 4:** Effect on Free acidity and Total acidity in all treatment groups

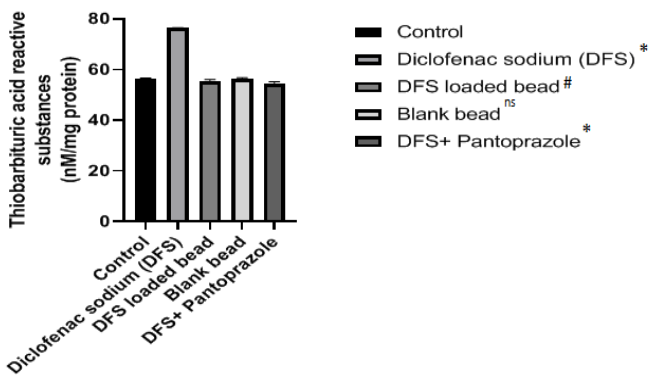



*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant, ns: non-significant)*

### Effect of *Basella alba* mucilage based hydrogel bead on Biochemical parameters

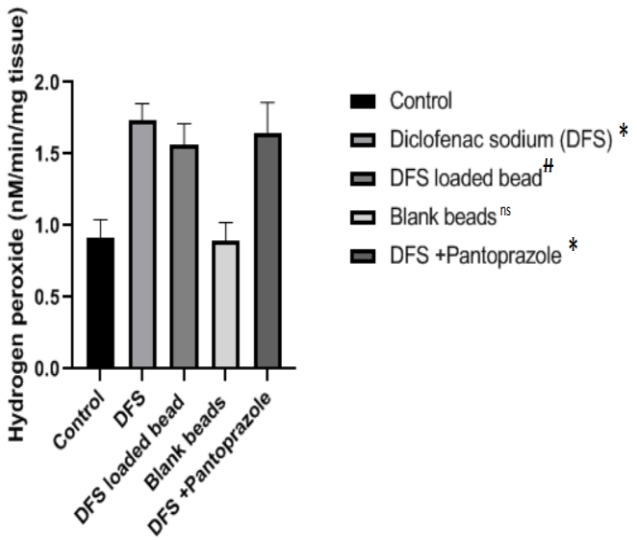
The extent of Lipid peroxidation was analyzed in terms of Thiobarbituric acid reactive substance, which showed a very high value (76.34±0.24nM/mg protein) in the case of Diclofenac sodium administered group as compared to the control group (56.35±0.32nM/mg protein) indicating $p<0.01$. Group III, administered with drug-loaded mucilage beads, showed a significantly reduced value (55.25±0.76 nM/mg protein) as compared to group II ($p<0.01$). The lipid peroxidation level of the group administered Pantoprazole with Diclofenac sodium showed a slightly reduced value (54.3±1.03 nM/mg protein) with no significant variation from the drug-loaded beads group (Figure 5). The value of Hydrogen peroxide and γ-glutamyl transpeptidase increased significantly in the Diclofenac sodium-treated group compared to the control group ($p< 0.01$). In contrast, the values of the same parameters decreased significantly in Diclofenac sodium-loaded mucilage beads compared to the drug-treated group ($p< 0.01$), as shown in Fig 6 and Fig 7. The levels of Hydrogen peroxide and γ-glutamyl transpeptidase were found to be similar in groups III and V with no significant difference as well as the values obtained in the control group and group treated with blank beads were also similar.

**Figure 5:** Level of Thiobarbituric acid reactive substance in control and treatment groups



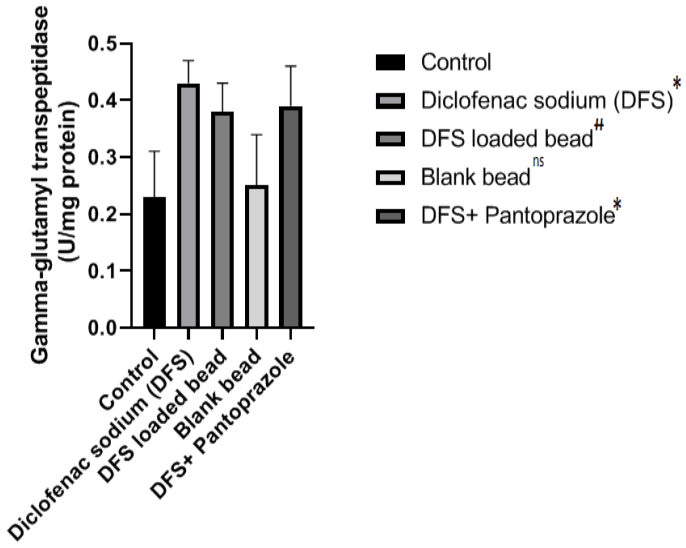

*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Figure 6:** Level of Hydrogen peroxide in control and treatment groups




*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Figure 7:** Level of γ-glutamyl transpeptidase in control and treatment groups

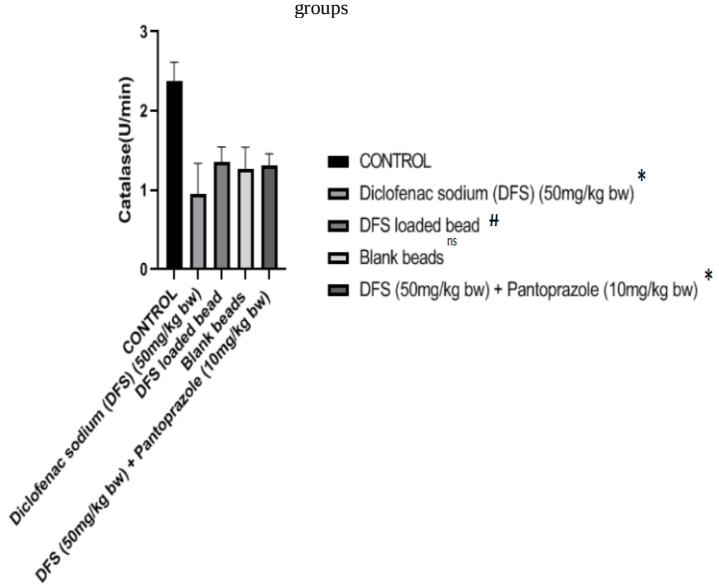



*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Effect of *Basella alba* mucilage-based hydrogel bead on Antioxidant enzymes**

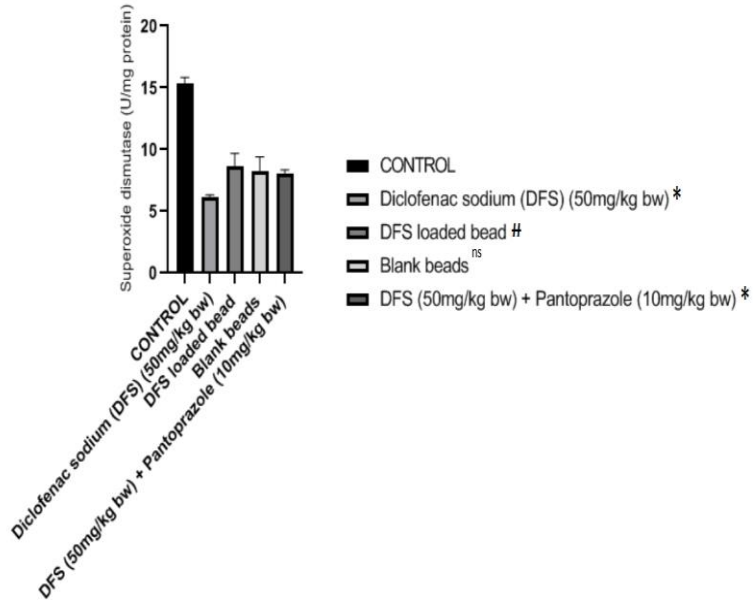
Diclofenac sodium treated group witnessed a significantly reduced value of Catalase, Superoxide dismutase, glutathione, glutathione peroxidase, and Glutathione S- transferase (p< 0.01) whereas the group treated with Diclofenac sodium loaded Basella alba mucilage beads depicted an increased value as compared to the Diclofenac sodium administered groups (p< 0.01) as shown in Fig 8,9,10,11,12 respectively. The level of antioxidant enzymes in the group treated with Diclofenac sodium-loaded beads was similar to the group where Diclofenac sodium and Pantoprazole were coadministered without any significant differences. Similarly, the antioxidant levels of the control and blank bead treatment groups were similar, with no significant difference.

**Figure 8:** Level of Catalase in control and treatment groups



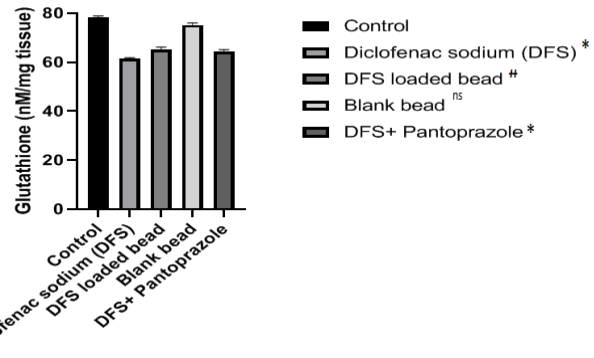

*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the Diclofenac treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Figure 9:** Level of Superoxide dismutase in control and treatment groups



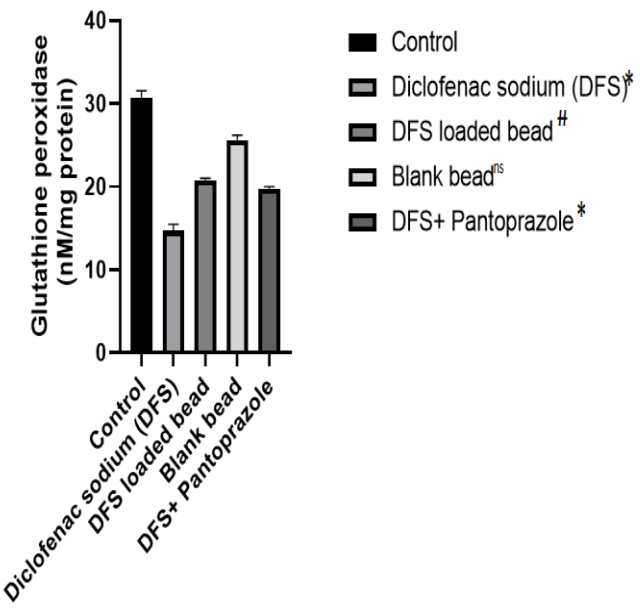

*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant).*

**Figure 10: Glutathione levels in control and treatment groups**



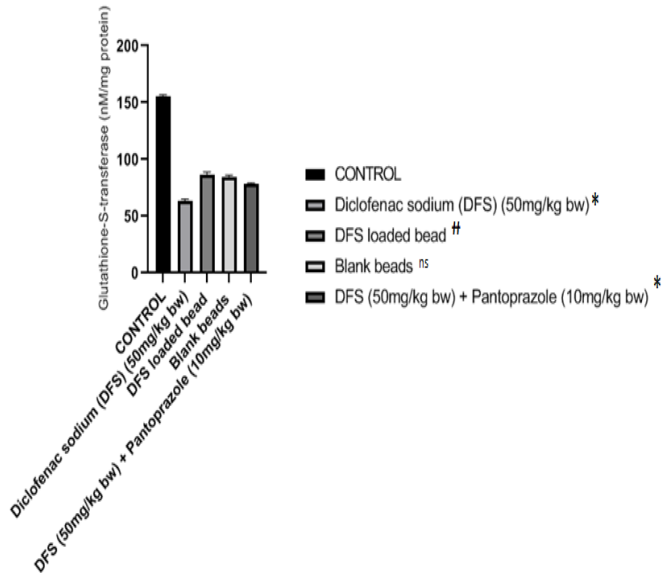

*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant, ns: non-significant)*

**Figure 11:** Glutathione peroxidase levels in control and treatment groups




*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Figure 12:** Glutathione S- transferase value in control and treatment groups

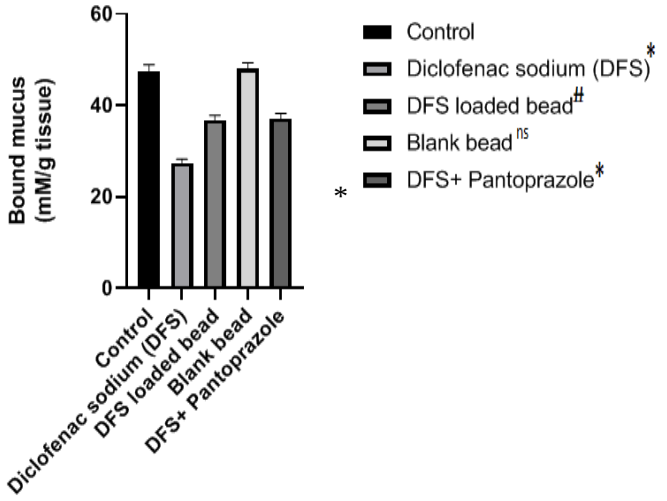



*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Effect of *Basella alba* mucilage-based hydrogel bead on bound mucus and nonprotein sulfhydryl and myeloperoxidase**

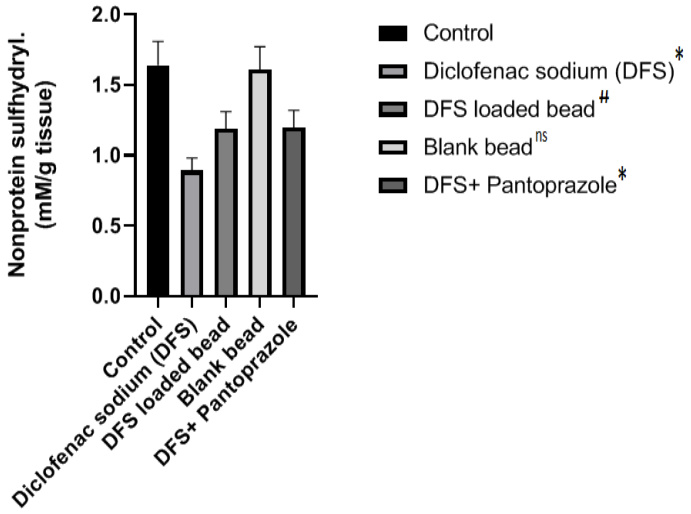
Figure 13 and Fig 14 show that there is a significant depletion of bound mucus (27.435±0.79 mM/g tissue) and nonprotein sulfhydryl level (0.89±0.09 mM/g tissue) in rats treated with Diclofenac sodium compared to the control group (p< 0.01). The following result is in contrast to the group treated with Diclofenac sodium-loaded beads, which shows a remarkable increase in the amount of bound mucus (36.78±1.05 mM/g tissue) and the level of nonprotein sulfhydryl (1.19±0.12 mM/g tissue) as compared to the Diclofenac sodium treated group (p< 0.01). The amount of bound mucus and nonprotein sulfhydryl in rats treated with Diclofenac sodium-loaded beads was similar in rats treated with Diclofenac sodium and Pantoprazole without significant differences. Similarly, the amount of bound mucus and level of nonprotein sulfhydrase were similar in rats of the control group and rats treated with blank beads without any significant difference.

**Figure 13:** Effect on bound mucus in control and treatment groups




*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Figure 14:** Level of Nonprotein sulfhydryl in control and treatment groups



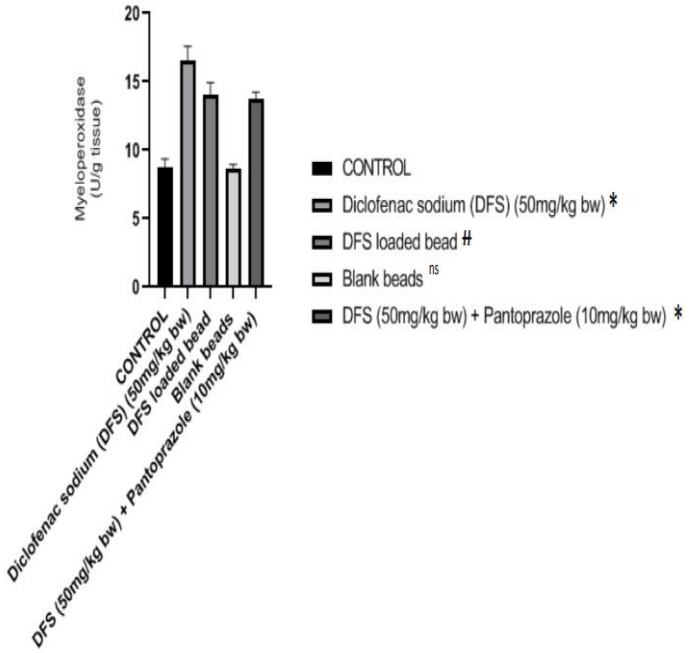

*(Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Effect of *Basella alba* mucilage-based hydrogel bead on myeloperoxidase**

Figure 15 shows that the myeloperoxidase activity was enhanced significantly by the rats treated with Diclofenac sodium (16.5395±1.03 U/g tissue) compared to the control group (p<0.01) whereas the rats treated with Diclofenac sodium loaded beads decreased the myeloperoxidase activity (13.96±0.87 U/g tissue) significantly when compared to the Diclofenac sodium treated group (p<0.01). The myeloperoxidase activity of the group treated with Diclofenac sodium beads and the combination of Diclofenac and Pantoprazole administered group were similar with no significant

difference. Similarly, the rats treated with blank beads showed similar myeloperoxidase activity with the control group rats without any significant alteration.

**Figure 15:** Level of Myeloperoxidase



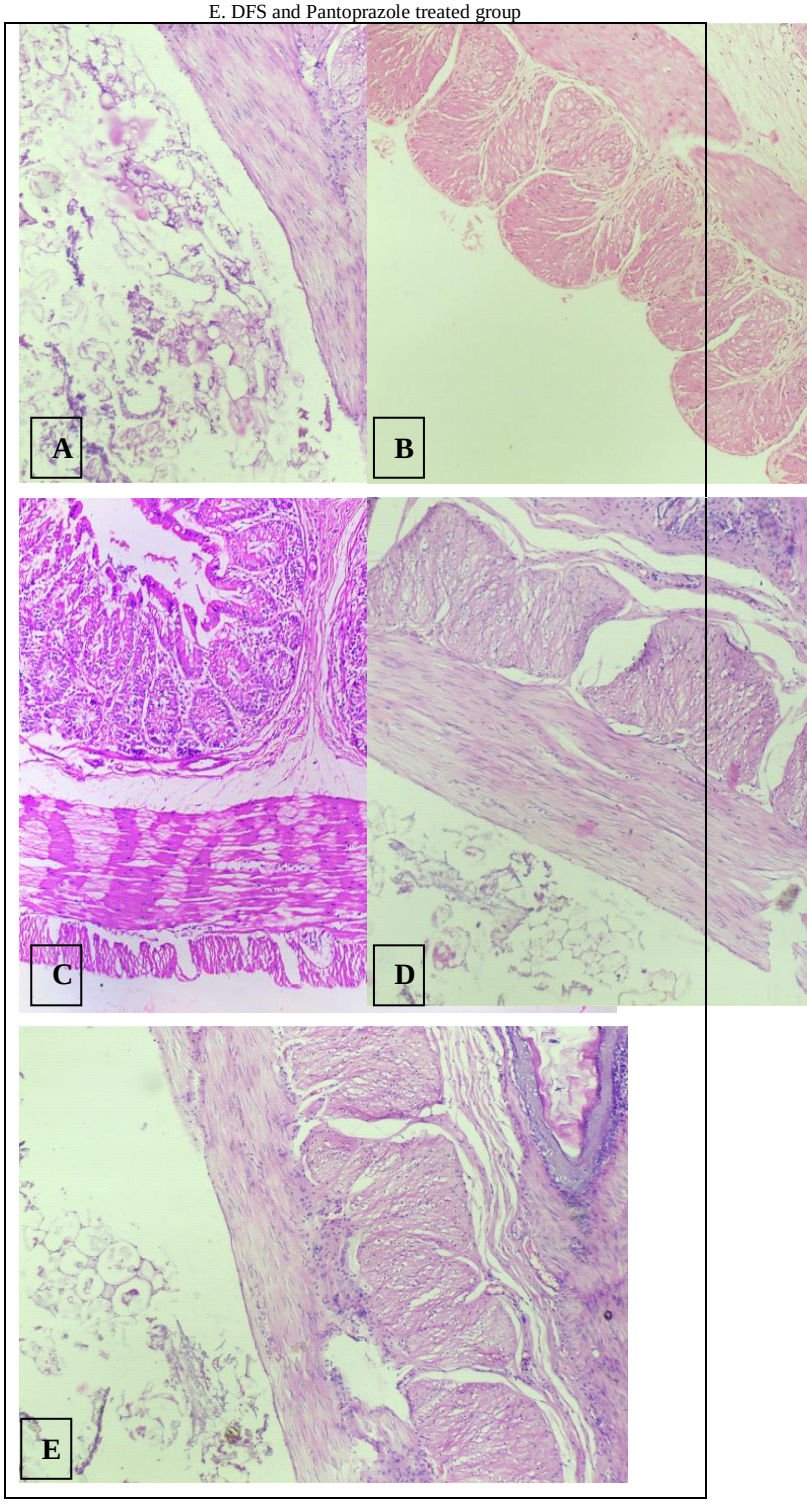

*Graph plotted from data as mean ± standard deviation (n =6). * Indicates significance at p < 0.01 from the diclofenac-treated group. # indicates significance at p < 0.01 from the control group, ns: non-significant)*

**Histopathological analysis**

Figure 16 shows the stomach histopathology of rats of the control group and treatment groups. The mucosa of the stomach of rats from the control group shows normal epithelial surface and glandular cells with no inflammation and necrosis (Figure 16A), whereas the histology of rats treated with Diclofenac sodium is showing significant changes from the control group, like extensive disruption of epithelial surface, degenerated gastric glands, erosion and ulceration of mucosa and inflammation of sub mucosa with infiltration of leukocytes (Fig 16B). The rats treated with Diclofenac sodium-loaded beads (Fig 16C) show smooth and regular epithelium, normal glandular cells, and restored mucosa with no inflammation or damage. The presence of mucilage prevented the harsh effects of the loaded Diclofenac sodium drug in the beads. The rats treated with blank beads showed normal gastric mucosa with no damage (Fig 16D). The rats treated with Diclofenac sodium along with Pantoprazole showed normal gastric mucosa. Administration of Pantoprazole prevented ulceration and mucosal erosion.

The present investigation reveals for the first time that *Basella alba* mucilage, a natural polysaccharide, can be used to carry an ulcer-causing drug, i.e., Diclofenac sodium in the form of beads and can prevent the harsh side effects of repeated administration of the NSAIDs. The gastroprotective property of *Basella alba* mucilage from Diclofenac sodium-induced ulcer is evident in various stages of the study.

**Figure 16: P**hotographs showing the stomach histopathology of albino rats of A. Control group, B. Diclofenac sodium (DFS) treated group C. DFS loaded beads treated group, D. Blank beads treated group E. DFS and Pantoprazole treated group




Diclofenac sodium inhibits prostaglandin synthesis, thereby damaging the stomach tissues with increased gastric acid secretion, increasing lipid peroxidation, and generating free radicals like myeloperoxidase [31]. The histopathology study showed the damage done to the gastric mucosa of the rats treated with Diclofenac sodium at a dose of 50 mg/kg body weight for ten days. These findings are similar to the ones reported in the literature [32]. Thiobarbituric acid reactive substance indicates lipid peroxidation, and myeloperoxidase increases

activity when neutrophils are stimulated. Therefore, increased myeloperoxidase indicates infiltration of neutrophil inflammation and causes lipid peroxidation in the presence of hydrogen peroxide [33]. So, in the current study, the Diclofenac sodium-treated group showed an elevation of myeloperoxidase, hydrogen peroxide, and thiobarbituric acid reactive substances. This result agrees with the study by Khan et al., where the same parameters were elevated on administration of Diclofenac sodium [34]. On the other hand, these parameters depleted on the administration of Diclofenac sodium loaded beads similar to the group where Diclofenac sodium and Pantoprazole were coadministered without any significant difference, indicating that *Basella alba* mucilage-based hydrogel is efficient in protecting Diclofenac sodium-induced gastric ulcer similar to Pantoprazole. This result agrees with the study where the protective effect of Pantoprazole in response to Diclofenac sodium-induced gastric was investigated [17].

Glutathione maintains the integrity of the mucosal structure; therefore, its reduction indicates gastric ulceration [35]. Moreover, the reduced glutathione level negatively affects the activity of glutathione-dependent enzymes, i.e., glutathione peroxidase and glutathione S-transferase [36]. These findings are in agreement with the results of the present study, where depleted levels of glutathione and its associated enzymes are observed in Diclofenac sodium-administered rats. In contrast, the glutathione and glutathione-dependent enzymes are increased in Diclofenac sodium-loaded beads, similar to the rats treated with Diclofenac sodium and Pantoprazole.

It is evident from the literature that antioxidants are gastroprotective in nature [37]. This complies with the result of the present study where Diclofenac sodium treated rats showed reduced antioxidant levels and Diclofenac sodium loaded beads improved the level of catalase and superoxide dismutase similar to the increase observed in rats treated with Diclofenac sodium and Pantoprazole. As per the literature reports, ulceration reduces the concentration of nonprotein sulfhydryl [38]. A similar observation is noted in the present study, where the concentration of nonprotein sulfhydryl was reduced in rats treated with Diclofenac sodium and an elevated concentration in rats treated with Diclofenac sodium loaded beads, suggesting gastro ulcer inhibition. In the current study, increased gastric pH and decreased total and free acidity were observed in rats treated with Diclofenac sodium loaded beads and the group coadministered with Diclofenac sodium and Pantoprazole which suggests gastroprotective property of Diclofenac sodium loaded *Basella alba* mucilage based beads.

## CONCLUSION

The present investigation reveals that *Basella alba* mucilage-based beads have proved to be a promising candidate in preventing gastric ulcers compared to Pantoprazole, an antacid drug. Gastroprotection might be due to the formation of a protective barrier over the gastric mucosa, due to antioxidant activity, or by promoting the gastric defense mechanism. The results of the histopathology study also support the gastroprotective property of the *Basella alba* mucilage-based beads. Therefore, the harsh side effects of repeated administration of NSAIDs can be effectively prevented by incorporating the drug in the *Basella alba* mucilage-based carrier. Further studies will be carried out to elucidate the exact mechanism of action of the present formulation against Diclofenac sodium-induced gastric ulcer.

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