



## THERAPEUTIC PROPERTIES OF MEDICINAL PLANTS: A REVIEW OF THEIR GASTRO-INTESTINAL EFFECTS ( PART 1)

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### ABSTRACT

The recent pharmacological studies showed that many medicinal plants exerted a wide range of beneficial gastrointestinal effects. This review highlight the gastrointestinal effects of the medicinal plants.

**Keywords:** Medicinal plant, Pharmacology, Gastrointestinal, Gastric, Intestinal.

### INTRODUCTION

Traditional medicine is based on beliefs and practices that existed before the development of so-called modern medicine or scientific drug therapy. However, many active ingredients were isolated from the medicinal plants, their pharmacological effects and modes of action were determined. The recent pharmacological studies showed that many medicinal plants exerted beneficial gastrointestinal effects [1-48]. This review was designed to highlight the gastrointestinal effects of the medicinal plants.

### GASTRIC EFFECTS

#### *Agrimonia eupatoria*

A compound herb preparation containing agrimony has been used to treat 35 patients suffering from chronic gastroduodenitis. After 25 days of therapy, 75% of patients claimed to be free from pain, 95% from dyspeptic symptoms and 76% from palpitation pains. Gastroscopy indicated that previous erosion and haemorrhagic mucous changes had healed [49].

#### *Alhagi maurorum*

Ethanollic extract of *Alhagi maurorum* exerted gastroprotective effects against ulcers induced by phenylbutazone, indomethacin and ethanol, increase locomotor activity, and induced sexual stimulation [50].

The anti-ulcerogenic effects of an aqueous extract of *Alhagi maurorum* (AME) (150, 300 and 450mg/kg, PO)

was evaluated *in* two models of gastric ulcers induced by alcohol and water immersion restraint-stress in rats. The AME protected rats against water immersion restraint-stress and ethanol-induced ulcers in a dose-dependent manner. In water immersion restraint induced ulcerated rat, the AME increased pH and reduced gastric acid content [51].

*Alhagi maurorum* ethanolic extract (oral daily 100mg/kg bw) and ranitidine (oral daily 100mg/kg bw) were used in rats to protect against administration of aspirin ASP (oral 200mg/kg body weight) for two times through the 10 days. Some rats were sacrificed after first and second aspirin administrations and the rest were sacrificed in the end of the experiment. Gastro fluid volume has been decreased in ASP group, and acid output was decreased for plant extract followed by ranitidine. No ulcer patterns have been shown in the histopathological study, but some inflammation in the gastric wall and vascular change dilatation of blood vessels were detected [52].

Chrysoeriol 7-O-xyloside and kaempferol-3-galactorhamnoside showed a promising antiulcerogenic activity with curative ratios 66.31%, 69.57%, 75.49%, and 77.93%, respectively in ethanol 50% (v-v) induced gastric ulcer in rats when used in a dose of 100 mg/kg [53].

#### *Aloe vera*

Aloe-emodin inhibited growth of *Helicobacter pylori* in

a dose-dependent fashion. *Aleo vera* inhibited gastric acid secretion in mice and rats and has protective effects against gastric mucosal damage in rats. Pretreatment with *Aloe vera* extract reduced aspirin-induced gastric mucosal injury by 70% in experimental rats. *Aloe vera* extracts also suppressed the ulcerogenic effects of stress in experimental rats. Intraperitoneal injection of ethanol extract exerted a gastroprotective effect in acute gastric mucosal lesions induced by 0.6 M HCl in rats. A clinical study showed that *Aloe vera* gel might be helpful in treating patients with duodenal ulcers [54-59].

#### ***Alpinia galanga***

The constituents of *Alpinia galanga* exerted antiulcer and antisecretory effects. 1'S-1'- Acetoxychavicol acetate and 1'S-1'-acetoxyeugenol acetate, isolated from seeds have markedly inhibited the ethanol-induced gastric mucosal lesions in rats. Ethanolic extract at a dose of 500mg/kg, was significantly reduce gastric secretion in pyloric ligation and hypothermic restraint stress models in rats, a significant cytoprotective effect has been reported against 80% ethanol, 0.6M HCl, 0.2M NaOH, and 25% NaCl induced gastric cytodestruction [60-62].

#### ***Ammannia baccifera***

The whole *Ammannia baccifera* was extracted with ethanol and the ethanolic extract was fractionated with petroleum ether, methanol, chloroform and water. All the fractions were tested for their antiulcer property at a dose of 400mg/kg bw po against pyloric ligation and indomethacin induced gastric ulcer model in albino rats. All the fractions of *Ammannia baccifera* significantly inhibited ulcer index. The fractions reduced gastric volume, total acidity, free acidity and increased pH of gastric juice. The methanolic fraction produced more significant ( $p < 0.001$ ) antiulcer activity followed by aqueous, petroleum ether and chloroform fractions in pylorus ligation model. The antiulcer activity was almost comparable to that of reference standard ranitidine (20mg/kg bw po). All fractions shown similar results (reduction in ulcer index and increased percent inhibition) in indomethacin induced ulcer model [63].

The chloroform and ethanol extracts of *Ammannia baccifera* were evaluated for antioxidant, gastric antisecretory, and gastroprotective properties. Ethanol extract of *Ammannia baccifera* (EAB) at a dose of 200 mg/kg reduced the free acidity to 142.66 mEq/L and total acidity to 451.22 mEq/L. It reduced the gastric secretion with increase in pH from 2.2 to 3.15. Possessing good antisecretory activity, it also reduced the ulcer by 92.2% in aspirin and pylorus ligation induced gastric ulcer models. EAB increased the mucus secretion and adherent mucus in the tissues with a 71.43% reduction of ulcerin HCl-ethanol induced ulcer models, at a dose of 200 mg/kg [64].

#### ***Anchusa italica***

The antiulcer activity of different extracts from the aerial parts and the roots of *Anchusa italica* was investigated. No antigastric ulcer activity was recorded in indomethacin-induced gastric damage in rats [65].

#### ***Anchusa strigosa***

Anti-ulcer activity of different root extracts of *Anchusa strigosa* was studied in ethanol-induced ulcer model in rats. Petroleum ether-soluble fraction was the most effective in reducing ulcer index and gave 91% protection. Chloroform soluble fraction gave 86% protection while butanol-soluble fraction was less effective (65% protection). On the other hand, water-soluble fraction was not effective in protecting the stomach from the ulcerative agent [66].

The ulcer index values expressed as a percentage of total stomach surface area affected by the ulcer was lowered when *Anchusa strigosa* root extracts was administration at a dose of 0.080 g prior to ethanol induction of stomach ulcer in rats. Treatment of the induced ulcer in guinea pigs was achieved by oral administration of *Anchusa strigosa* root extracts at the therapeutic dose of extract of 0.286 g/kg body weight/day for 24 days [67].

A pepsin inhibitor of undetermined chemical composition was isolated from the aqueous extracts of the roots of *Anchusa strigosa*. The extract of 1 g dry roots inhibited  $9380 \pm 390$   $\mu$ g of pepsin [68].

#### ***Anethum graveolens***

*Anethum graveolens* seed extracts possessed significant mucosal protective and antisecretory effects in the gastric mucosa lesions induced in mice by oral administration of HCl (1 N) and absolute ethanol. The acidity and total acid content were reduced by the orally or intraperitoneally administration of the extracts [69]. *Anethum graveolens* seed extracts exerted moderate activity against *Helicobacter pylori* [70].

#### ***Apium graveolens***

The antiulcerogenic activity of *Apium graveolens* extracts was evaluated in rats by the HCl/EtOH method. Inhibition of gastric lesions by *A. graveolens* extracts was dose-dependent for both aerial part (53–76%) and seeds (51–95%) extracts. The methanolic and aqueous extracts in a dose of 300 mg/kg exhibited highly significant inhibition of gastric lesions (91% and 95%, respectively) which was similar to that induced by omeprazole (94%). *Apium graveolens* boiling water extract (5%) inhibited the mean height of rabbit jejunum smooth muscle contractions to 35% in comparison with normal contractions [71].

#### ***Asphodelus fistulosus***

*Asphodelus fistulosus* possessed stomach protective and antiulcerogenic effects against ethanol induced gastric lesions [72]. *Asphodelus fistulosus* also induced relaxation of rabbit gastric smooth muscles [73].

#### ***Bacopa monnieri***

Fresh *Bacopa monnieri* juice exerted significant antiulcerogenic activity [74]. *Bacopa* have a protective and curative effect for gastric ulcers. In rats, the *Bacopa* extract standardized for bacoside-A was evaluated for its prophylactic and healing effects in five models of gastric ulcers. At a dose of 20 mg/kg for 10 days, *Bacopa* extract significantly healed penetrating ulcers induced by acetic acid, significantly strengthened the mucosal barrier, and decreased mucosal exfoliation. The extract also alleviated stress-induced ulcers as observed by significant reduction in lipid peroxidation in rat gastric mucosa. It was also exerted anti *H. pylori* effect [75-76].

#### ***Bauhinia variegata***

In gastric ulcer induced by pyloric ligation and in aspirin induced ulcer model in rats, the ethanolic extract of *B. variegata* decrease the volume of gastric secretion, total free acidity and ulcer index [77].

#### ***Bellis perennis***

The methanolic-eluted fraction of the methanolic extract from the flowers of *Bellis perennis* was found to inhibit gastric emptying in olive oil-loaded mice at a dose of 200 mg/kg, orally [78].

#### ***Benincasa hispida***

The free radical scavenging and antiulcer potential of the methanol extract of *Benincasa hispida* seeds was evaluated by DPPH method for antioxidant effect and by using pyloric ligation, water immersion stress and indomethacin induced gastric ulcer model for antiulcer effects in rats. The methanolic extract showed concentration dependent DPPH radical scavenging activity. It was also inhibited gastric ulceration by decreasing the gastric volume and free and total acidity. The high dose (300 mg/kg bw) showed significant reduction in the above parameters which was comparable to the standard drug ranitidine ( $p < 0.05$ ). The methanol extract of *Benincasa hispida* seeds caused 52.7, 67.4 and 61.2% inhibition of ulcers in pyloric ligation, water immersion stress and indomethacin induced ulcer models, respectively at a dose of 300 mg/kg [79].

Antiulcer activity of petroleum ether and methanol extracts of *Benincasa hispida* were also investigated in rats. Petroleum ether and methanol extracts were administered orally at a dose of 300 mg/kg bw, and omeprazole (reference standard) at the dose of 20 mg/kg bw. Both extracts produced significant reduction in ulcer index ( $P < 0.05$ ) in all the models (ethanol-induced gastric mucosal damage, pylorus ligated ulcer model, cold and

restraint stress-induced gastric ulcer model), and the results were comparable with that of omeprazole-treated group. Furthermore, a significant reduction in vascular permeability ( $P < 0.05$ ) was also observed. However, in cold and restraint stress-induced gastric ulcer model, MDA content was significantly reduced along with increase in CAT levels as compared to control group [80].

Various doses of the methanol extract of *Benincasa hispida* (MEBH) (0.2-1 g/kg, ip) were administered to Swiss albino mice to investigate the anorectic effect. (MEBH) significantly reduced the cumulative food intake over a 7 hours period in a dose-dependent manner. The percentage reduction of cumulative food intake at 7<sup>th</sup> hour for MEBH treated mice with 0.2, 0.6 and 1 g/kg was 27%, 38% and 54% respectively. The 4 hours gastric emptying was not significantly influenced by MEBH when compared to control. It was postulated that the anorectic activity of *Benincasa hispida* was mediated through the central nervous system without affecting the gastric emptying [81].

#### ***Bidens tripartita***

Intra-gastric administration of methanolic and aqueous extracts of the aerial parts of *Bidens tripartita* (500 mg/kg bw) to rats showed antiulcer activity against aspirin-induced, but not indomethacin-induced ulcers [82].

#### ***Brassica nigra***

Internally, mustard is a stimulating condiment and appetizer, and excites gastric activity and promotes digestion. If the amount be large, however, it is intense irritation and promptly causes vomiting [83].

#### ***Bryophyllum calycinum***

The methanol-soluble fraction of the leaf extract inhibited the development of a variety of acute ulcers induced in the stomach and duodenum of rats and guinea pigs. Premedication tests in rats revealed that the extract possessed significant protective action against the gastric lesions induced by aspirin, indomethacin, serotonin, reserpine, stress and ethanol. A significant protection with extract was occurred for aspirin-induced ulcer in pylorus-ligated rats and for histamine-induced duodenal lesions in guinea pigs. A significant enhancement of the healing process was also occurred in acetic acid-induced chronic gastric lesions in rats [84].

#### ***Calendula officinalis***

Calendulozide B-trioside, isolated from rhizomes of *Calendula officinalis*, in doses of 5, 10, 20 and 50 mg/kg exerted an antiulcerous action in 3 experimental ulcer models of different genesis (caffeine-arsenic, butadiol and ligation of pylorus) and also displayed a certain antiphlogistic and sedative action<sup>(87)</sup>. The influence of *Calendula officinalis* on heparin-binding epidermal growth factor (HB-EGF)-like growth factor gene

expression in KATO-III cells under the stimulation of *H. pylori* strain N6 using real-time PCR was investigated with and without addition of and *Calendula officinalis*. Addition of *Calendula officinalis* led to a significant reduction of *H. pylori* induced increase in gene expression of HB-EGF (reduced to  $75.32 \pm 1.16\%$  vs. control;  $p < 0.05$ ) [85].

170 patients with duodenal ulcers and/or gastroduodenitis, treated with a herbal combination containing calendula showed improvement of symptoms in 90% [86]. 24 adults with non-specific colitis treated with herbal tea included calendula, showed improved symptoms in 96% of the patients within two weeks [87].

### ***Calotropis procera***

The protective effect of methanolic extract of *Calotropis procera* latex was investigated on experimentally induced gastric ulcers in rats. The methanolic extract was found to inhibit mucosal damage in both ethanol (85-95%) and aspirin (70- 80%) model, with maintaining the tissue integrity and significant reduction in gastric hemorrhage. Oxidative stress markers (glutathione, thiobarbituric acid reactive substance and superoxide dismutase) were found to be regulated [88].

The gastromucosal protective effect of chloroform extract (CH) and hydroalcoholic extract (HE) of the stem bark of *Calotropis procera* was investigated in rats. CH extract at 400 mg/kg was found to have a significant gastromucosal protective effect. As part of investigations to obtain compounds with gastromucosal protective effects, a bioassay was carried out with fractions obtained from the CH extract with n-hexane (NF1), 1-butanol (BF1), ethyl acetate (EF1) and chloroform (CF1). The HE extract of the stem bark was fractionated with n-hexane (NF2), 1-butanol (BF2), ethyl acetate (EF2), chloroform (CF2) and water (WF2). The fractions were evaluated for their gastromucosal protective effects. Fractions NF1 and BF2 (20 mg/kg) showed gastromucosal protective effects which further supported by histopathological examination of the open excised rat stomach [89].

The chloroform fraction of *Calotropis procera* root extract demonstrated significant anti-ulcer activity against aspirin, indomethacin, ethanol, indomethacin + ethanol, or stress-induced ulcerations. Significant inhibition of gastric secretory volume and total acidity in pylorus ligated rats were observed to occur with the extract. It was also observed that the root extract significantly inhibited arachidonic acid metabolism induced by soyabeian lipoxygenase. The anti-ulcer activity of the extract might be attributable to the inhibition of 5-lipoxygenase [90].

The methanol and acetone extracts from *Calotropis procera* exhibited strong anti-*H. pylori* activity, almost comparable activity with tetracycline, but were found to be less potent than amoxicillin and clarithromycin [91].

### ***Capsicum annum* and *Capsicum frutescens***

The effect of aqueous extracts of *Capsicum frutescens* on the healing acute gastric ulcer induced by aspirin was investigated in rats (at doses of 300 and 600 mg/kg bw for seven days). The results revealed that oral administration of the aqueous extract at a dose of 600mg/kg bw, reduced the length of gastric ulcer, volume of gastric juice, and improved histopathological changes [92].

Capsaicin protected the gastric mucous against ulceration by ethanol when used at low concentrations (0.13–160  $\mu\text{M}$ ) in rats. Capsaicin exerted protective effects against ethanol- and indomethacin-associated gastropathy in 84 healthy human subjects, with a dose dependent decrease in base gastric acid output ( $\text{ED}_{50}$  for 400  $\mu\text{g}$  capsaicin) and increased gastric emptying [93, 94]. Gastrointestinal system also contained capsaicin-sensitive sensory nerves which plays a crucial role in maintenance of gastrointestinal mucosa integrity against injurious interventions. A low dose of capsaicinoids could increase the basal gastric mucosal blood flow and gastric mucus secretion, and facilitate gastric epithelial restitution, which were beneficial to gastrointestinal defense [95].

### ***Carthamus tinctorius***

Inhibition zone of the methanol extract of *Carthamus tinctorius* at concentration of 2 mg/disc against *H. pylori* clinical isolates was  $18.77 \pm 0.56\text{mm}$ , while, MIC and MBC for the same extract were 691.25 and 691.25  $\mu\text{g/ml}$ , respectively [96]. 200 and 400mg/kg of *Carthamus tinctorius* extract with carbachol protected rat from gastric ulceration after pylorus ligation. The doses were significantly decreased volume of gastric secretion, free acidity, mEq/dl of gastric secretion, total acidity, mEq/dl of gastric secretion and ulcer index. They significantly increased the PH of gastric juice and gave 78 and 83% gastric protection respectively [97].

### ***Carum carvi***

Pretreatment with oral doses of 250 and 500 mg/kg was found to provide a dose dependent protection against ulcerogenic effect of different necrotizing agents in rats, ethanol induced histopathological lesions, depletion of stomach wall mucus and nonprotein sulfhydryl groups (NP-SH) and pylorus ligated accumulation of gastric acid secretion. The mechanism of action might be due to flavonoids related suppression of cytochrome P450 IAI (CYPIAI) which known to convert xenobiotics and endogenous compounds to toxic metabolites [98].

The antiulcerogenic activity was also evaluated by the HCl/ethanol method, which causes injury to the gastric mucosa. The results showed that *C. carvi* essential oil enhanced a significant inhibition of 47%, 81% and 88%, respectively, for three doses (100, 200 and 300 mg/kg)

of essential oil used, which was similar to that induced by omeprazole (95%) ( $p < 0.005$ ) [99].

Extracts from the *Carum carvi* was investigated for a potential anti-ulcerogenic activity against indometacin induced gastric ulcers in rat as well as for their antisecretory and cytoprotective activities. The extracts produced a dose dependent anti-ulcerogenic activity associated with a reduced acid output and an increased mucin secretion, an increase in prostaglandin  $E_2$  and a decrease in leukotrienes release [100]. In addition, methanol extracts of *Carum carvi* showed anti *H. pylori* effect with MIC of 100 microg/ml [101].

#### ***Casuarina equisetifolia***

The anti-ulcer effect of the Ethanol extract of *Casuarina equisetifolia* (L.) extract was studied in albino rats. Ethanol extract at the doses of 200 and 400 mg/kg was administered orally to evaluate anti-ulcer activity in ethanol, indomethacin, and cold-restraint stress induced gastric ulcer models in Albino rats. Ethanol extract caused dose dependent inhibition in ethanol induced gastric lesions, ethanol extract showed 70.37 % protection at 400 mg/kg, and 52.7% protection at 200 mg/kg, In indomethacin induced gastric lesions, ethanol extract showed 68.3% protection at 400 mg/kg and 51.7% protection at 200 mg/kg, it also showed dose dependent inhibition in cold-restraint stress induced gastric lesions. Ethanol extract showed 75.02% protection at 400 mg/kg, and 45.86% protection at 200 mg/kg. All the results were found statistically significant ( $p \leq 0.05$ ) [102].

The anti-*Helicobacter pylori* and urease inhibition activities of extracts of *Casuarina equisetifolia* were investigated. The extracts exhibited lower activity than the standard antibiotics used in this study [103].

#### ***Centaurea cyanus***

Pharmacological studies carried out on Wistar rats with stress-induced ulcer shown a very gastro-protective activity (protection percents over 80%) of the *Centaurea cyanus* extract [104]. Moschamine a safflomid-type phenylpropenoic acid amide found in *Centaurea cyanus* was a very potent COX-II inhibitor, it inhibited COX-II by 54% ( $p < 0.014$ ), at the concentration of 0.1  $\mu$  mol/l [105].

#### ***Chenopodium album***

The effect of alcoholic extract of *Chenopodium album* was investigated in rats to evaluate the antiulcer activity by using three models, pyloric ligation, ethanol and cold restraint stress induced ulcers. Alcoholic extract significantly decreases the volume of gastric acid secretion, free acidity, total acidity and ulcer index with respect to control. Sections of ulcerated area revealed that there was a significant increase in regenerated glandular epithelium width after treatment with the alcohol extract. The collagen content in the ulcerated tissue was significantly increased

by alcohol extract and ranitidine as positive control. No significant difference on capillary density in scar tissue was observed after treatment with alcohol extract or ranitidine [106].

### **INTESTINAL EFFECTS**

#### ***Ailanthus altissima***

The methanolic extract of root bark of *Ailanthus altissima* (MEA) was investigated for anti-diarrhoeal activity in castor oil induced diarrhoea and small intestine transit method on mice. The methanolic extract of root bark of *Ailanthus altissima* 200 mg/kg reduced the total weight of the faeces [107].

#### ***Alhagi maurorum***

The antidiarrhoeal activity of *Alhagi maurorum* extract (200 and 400 mg/kg) and its effect on motility of isolated rabbit's duodenum was investigated. *Alhagi maurorum* in a 200 mg/kg dose exhibits a significant anti-diarrhoeal effect against castor oil-induced diarrhea. *Alhagi maurorum* increased the contractile force in concentrations between 0.4 and 1.6 mg/ml, while higher concentrations ( $> 3.2$  mg/ml) caused a rapid depressant effect. The depressant effect appeared to be due to calcium channel blocking effect [108].

#### ***Aloe vera***

The leaf lining (latex, resin or sap) contained anthraquinone glycosides (aloin, aloe-emodin and barbaloin) which are potent stimulant laxatives. These water soluble glycosides are split by intestinal bacteria into aglycones which have laxative action stronger than senna, cascara or rhubarb root. The anthraquinones found in the latex stimulate chloride and water secretion into the large intestine, inhibit their reabsorption and stimulate peristalsis. The onset of action is 6–12 hours after a single oral dose. On the other hand, it has severe side effects including diarrhea, nausea, and cramping. For medicinal use, the leaf lining is dried and the residue is used as herbal laxative. The products are taken at bedtime which are poorly absorbed after oral administration. These products excreted in urine, bile, feces and breast milk. The products usually avoided during pregnancy due to the risk of stimulating uterine contractions and during lactation due to the risk of excretion in breast milk [109-111].

#### ***Anchusa italica***

*Anchusa italica* boiling water extract (5%) inhibited the mean height of rabbit jejunum smooth muscle contractions to 35% in comparison with normal contractions [112].

#### ***Anethum graveolens***

The essential oil of *Anethum graveolens* reduced contractions of rabbit intestine [113]. Ethanol extract inhibited acetylcholine and histamine induced contractions

of guinea-pig ileum[114].

Dill seeds have been used as household remedy to relief digestive problems such as stomachache, indigestion and flatulence. Dill water is believed to have a soothing effect and is given to babies to treat gripe, relieve hiccups and colic[115].The essential oil was a mild carminative and reduced foaming *in vitro*[116].

#### ***Asparagus officinalis***

The effects of cooked whole asparagus and its purified bioactive, rutin, were studied on colitis symptoms and disease progression in mice. C57BL/6 mice were fed a basal diet supplemented with 2% asparagus or 0.025% rutin for 3 weeks. Colitis was induced by 2% dextran sodium sulfate in drinking water for 7 days. Asparagus diet was determined to contain higher antioxidant capacities than rutin diet through antioxidant assays. During active colitis, consumption of asparagus alleviated some clinical symptoms (stool consistency, stool blood, and spleen hypertrophy) of colitis. In recovery, asparagus-fed mice were improving in terms of regenerating crypts, surface epithelial, and goblet cells, potentially due to its rutin content [117].

#### ***Asphodelus fistulosus***

*Asphodelus fistulosus* induced relaxation of rabbit intestinal smooth muscles [118].

#### ***Avena sativa***

Two broiler experiments with almost identical basal diets were conducted to investigate the effect of dietary oat hulls, access to litter and the antimicrobial compound narasin on gizzard erosion and ulceration syndrome (GEU). The effects on particle size of duodenal digesta, ileal starch concentration, caecal *Clostridium perfringens* counts, necrotic enteritis and production performance were also examined. Oat hulls reduced GEU severity and starch levels in the ileum in both experiments. Access to litter reduced GEU scores when oat hulls were included in the feed. Access to litter also improved feed efficiency and reduced *C. perfringens* counts. Oat hulls were associated with improved feed efficiency in Experiment 1 and impaired feed efficiency in Experiment 2. The inconsistent effect of oat hulls on production performance appeared to be related to an association between oat hulls and high *C. perfringens* counts in Experiment 2; an association that was absent in Experiment 1. In general, oat hulls interacted with litter access and narasin in exerting a positive effect on gizzard health. However, the association between oat hulls and necrotic enteritis detected in Experiment 2 suggests that the positive effect of oat hulls on GEU occasionally may be outweighed by a negative effect on gut health [119].

Oats have been shown to absorb intestinal toxins and increase excretion of intestinal toxins. The combination of taurine and oat were investigated on

endotoxin release in a rat liver ischemia/reperfusion model. The results showed that the combination of taurine (300mg/kg/ day) and oat fiber (15g/kg/ day) significantly reduced endotoxin levels in the portal vein by 36.3% when compared to the control group (0.168±0.035Eu/ml in the treatment group vs 0.264±0.058Eu/ml in the control group, P<0.01). The treatment by taurine and oat fiber induced 21.5% and 18.4% reduction in endotoxin levels respectively, when compared to the control group (P<0.05) [120].

Oat bran has been proposed as a dietary treatment for ulcerative colitis and has been shown to increase endogenous butyrate production and provide symptomatic relief of abdominal pain [121].

#### ***Bacopa monnieri***

The ethanol extract of the whole plant of *Bacopa monnieri* was showed antidiarrhoeal effect on castor oil induced diarrhea in mice. It increased mean latent period and decreased frequency of defecation significantly at the oral dose of 500 mg/kg comparable to loperamide 50mg/kg [122].

A double-blind, randomized, placebo controlled trial of 169 patients with irritable bowel syndrome, effects of an Ayurvedic preparation containing *Bacopa monnieri* and *Aegle marmelos* was compared with standard therapy (clidinium bromide, chlordiazepoxide, and psyllium). Subjects were randomly assigned to standard drug treatment, botanical treatment, or placebo for six weeks. Treatment was administered orally as drug, botanical, or placebo three times daily. Ayurvedic therapy was superior to placebo, however, the two botanicals were not given separately, and the benefit could not link specifically to the *Bacopa* portion of the Ayurvedic preparation[123].

#### ***Benincasa hispida***

The methanolic extract of fruit of *Benincasa hispida* (BHFE) was evaluated for its antidiarrheal potential against several experimental models of diarrhea in rats. BHFE treated animals showed significant inhibitory activity against castor oil induced diarrhea and inhibited PGE<sub>2</sub> induced enter pooling in rats. It also showed significant reduction in gastrointestinal motility following charcoal meal in rats [124].

#### ***Bidens tripartita***

The crude flavonoids isolated from the aerial parts of the plant (500 mg/kg body weight bw orally) were significantly induced choleric activity. It also caused an increase of cholic acids and cholesterol in bile[125].

500 patients with dysentery, 65 with acute enteritis and 248 with chronic enteritis were used the aerial parts of the plant. Several different dosage forms of the herb were used: 200 g of fresh whole herb and 100 g of dried herb in decoctions (in three divided doses per day); granules containing 5 g of dried aqueous extract, three

times daily; 0.5 g tablets of dried aqueous extract, 10 tablets each time three times daily; and injection, 2 ml per injection (dose not stated), 2–3 times daily. The herbal preparations were administered for 3–10 days to patients who already had diarrhoea. 387 of the 500 patients with chronic dysentery were reported to have been cured, 13 had not responded within 3 days. All 313 patients with enteritis were reported to have been cured [126].

#### ***Caesalpinia bonducella***

Antidiarrhoeal activities of fractions of methanolic leaf extracts of *Caesalpinia crista* were evaluated at two doses (200 and 400 mg/kg) and compared with loperamide in castor oil-induced diarrhoeal model in rat. All fractions exhibited dose-dependent antidiarrhoeal action ( $P < 0.05$ ). Ethyl acetate fraction exerted maximum inhibition (51.11%) against defecation, whereas 57.75% inhibition was obtained for loperamide [127].

#### ***Calotropis procera***

The dry latex (DL) of *Calotropis procera* was evaluated for its anti-diarrhoeal activity. Like atropine, a single oral dose of DL (500 mg/kg) produced a significant decrease in the frequency of defecation and the severity of diarrhea as well as protecting from diarrhoea in 80 % of rats treated with castor oil. The effects of DL on intestinal transit, castor oil-induced intestinal fluid accumulation (enteropooling) and electrolyte concentration in intestinal fluid were also evaluated. Dry latex produced a decrease in intestinal transit (27%–37%) compared with both normal and castor oil-treated animals. Unlike atropine, dry latex significantly inhibited castor oil induced enteropooling. However, it did not alter the electrolyte concentration in the intestinal fluid compared with castor oil-treated rats [128].

#### ***Canna indica***

The anti diarrheal effect of *Canna indica* methanolic extract was evaluated in castor oil-induced diarrhoea, charcoal meal transit and acetylcholine-induced contractions of the isolated rat ileum models. In the castor oil induced diarrhoea, loperamide (5 mg/kg) 50, 100 and 200 mg/kg of the extract were used and compared with a control (tween 80), while in the gastrointestinal transit, atropine (2.5 mg/kg), 100 and 200 mg/kg were used and also compared with a control (tween 80). A dose of 10 mg/ml of the extract was used against acetylcholine induced contractions in the isolated ileum experiments. The extract of *Canna indica* was significantly ( $p < 0.05$ ) reduced both the castor oil induced diarrhoea and the charcoal plug transit time in a dose dependent manner. In the castor oil induced diarrhoea, the extract decreased the intraluminal fluid content in mice, with the highest reduction recorded at 200 mg/kg dose of the extract, though this was slightly better than that of loperamide. In the charcoal plug transit, both doses of the extract and

atropine were significantly ( $p < 0.05$ ) decreased the distance travelled by the charcoal plug in the intestine of the mice, with the 200 mg/kg producing an inhibitory effect higher than that of atropine. The effect of *C indica* on the isolated rat ileum showed that the extract produced significant ( $p < 0.0001$ ) inhibitory effect on acetylcholine induced contraction [129].

#### ***Carum carvi***

The direct effects of *Carum carvi* ethanol extract was tested in dispersed intestinal smooth muscle cells (SMC) of guinea pigs. Effects of the plant extract on SMC and of acetylcholine (Ach) pretreated SMC were measured by micrometric scanning technique. Ethanol extract of *C. carvi* (2.5 mg/ml, 250 mug/ml, and 25 mug/ml) reduced significantly the response of dispersed SMC to Ach. Pretreatment of SMC with the highest concentration of *C. carvi* ethanol extract (2.5 mg/ml) has significantly inhibited the response of SMC to Ach. The result showed a dose-dependent inhibition of the contraction induced by Ach. This response may explain, in part, the beneficial effect of caraway in relieving gastrointestinal symptoms associated with dyspepsia [130]. It was efficient aromatic carminative and gentle stomachic; both the fruit and the oil are of value in flatulent colic [131].

The effect of the *Carum carvi* plant on resumption of bowel motility after Cesarean section was investigated by a randomized controlled pilot study conducted on 20 women undergoing elective Cesarean section under general anesthesia. The patients were randomly divided into two groups. The intervention group drank 10 ml of *Carum carvi* syrup containing 2 g of *Carum carvi* in 20 ml of syrup at 8 to 8<sub>1/2</sub> hours after surgery. The control group was given 10 ml of the placebo syrup at 8 to 8<sub>1/2</sub> hours after surgery. Demographic characteristics, time of first peristaltic, first gas passage, first bowel movement, and time until hospital discharge were compared for the two groups. The results showed that compared to the control group, the intervention group had significantly shorter mean interval of the first intestinal sounds ( $10.0 \pm 2.03$  h vs.  $19.28 \pm 3.95$  h); mean time to first passage of flatus ( $15.91 \pm 3.73$  h vs.  $26.82 \pm 5.83$  h), mean time to first bowel movement ( $20.31 \pm 4.63$  h vs.  $31.7 \pm 10.2$  h) and mean length of hospitalization ( $31.71 \pm 7.57$  h vs.  $50.6 \pm 16.49$  h) ( $p < 0.05$ ). There were no serious side effects associated with consumption of the syrup. Accordingly, the use of *Carum carvi* after caesarean section can speed the resumption of post-operative bowel motility [132].

The effects of caraway hydroalcoholic extract (CHE) and its essential oil (CEO) were investigated in an immunological model of colitis in rats induced by trinitrobenzene sulfonic acid (TNBS). Different doses of CHE (100, 200, 400 mg/kg) and CEO (100, 200, 400  $\mu$ l/kg) were administered orally and also doses of CHE (100, 400 mg/kg) and CEO (100, 400  $\mu$ l/kg) were given intraperitoneally. Administration of the doses started 6 h

after induction of colitis and continued daily for 5 consecutive days. CHE and CEO at all tested doses were effective in reducing colon tissue lesions and colitis indices and the efficacy was nearly the same when different doses of plant fractions were administered orally or intraperitoneally [133].

### *Casuarina equisetifolia*

The anti-diarrhoeal effects of ethanolic (90%) extract of *Casuarina equisetifolia* Linn (EECE) was studied in rats. Antidiarrhoeal activity of 90% ethanol extract of *Casuarina equisetifolia* was investigated using castor oil-induced diarrhoea, enteropooling and small intestinal transit models in rats. The weight and volume of intestinal content induced by castor oil were studied by enteropooling method. Standard drug diphenoxylate (5 ml/kg, po) caused significant reductions in fecal output and

frequency of droppings whereas EECE at the doses of 200 and 400 mg/kg po significantly ( $P < 0.001$ ) reduced the castor-oil induced frequency and consistency of diarrhoea and enteropooling. The gastrointestinal transit rate was expressed as the percentage of the longest distance travelled by the charcoal divided by the total length of the small intestine. EECE at the doses of 200 and 400 mg/kg significantly inhibited ( $P < 0.001$ ) the castor oil induced charcoal meal transit. The EECE showed marked reduction in the number of diarrhoea stools and the reduction in the weight and volume of the intestinal contents, as well as a modest reduction in intestinal transit [134].

### CONCLUSION

This review highlight the gastrointestinal effects of the medicinal plants to open the door for their clinical uses as a result of efficacy and safety.

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