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Original Article

Pharmacological insight into The Potential Efficacy of Some Halophytes in Alleviating Digestive System Disorders

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ABSTRACT

Introduction: The use of plants in disease treatment is an important therapeutic option that has long been used by Bedouins. Qassim area is one of Saudi Arabia regions gifted with plant species with diversified metabolic content. The current research aims at evidencing the traditional use of some wild plants in management of gastrointestinal disorders. **Methods:** Four plants from different plant families: *Deverra triradiata (Apiaceae), Suaeda aegyptiaca (Amaranthaceae), Heliotropium aegyptiacum,* and *Heliotropium bacciferum (Boraginaceae)* were investigated for their potential antispasmodic and antidiarrheal effects. The acute toxicity study was conducted using arithmetic Kerber`s method. The antidiarrheal efficacy was investigated using *in vivo* castor oil induced diarrhea model. The antispasmodic activity was evaluated using isolated rabbit jejunum. **Results:** Indicated highest mortality in animals received extract of the arial parts of *D. triradiata* (DTE), while the gum of the same plant (DTG) together with the extracts of the three plants: *S. aegyptiaca* (SAE), *H. bacciferum* (HBE), and *H. aegyptiacum* (HAE) caused no signs of neither over toxicity nor death during the 24 hours. observation period following oral administration of doses up to 7-10 g/kg. In castor oil induced diarrhea, all tested extracts, except for DTE, displayed a potent antidiarrheal activity expressed as 89-94.7% delay of defecation in animals received castor oil. Antispasmodic activity testing noted HAE for powerful antispasmodic efficacy estimated as 90% inhibition of contraction at a dose of 0.1 mg/100mL. **Conclusion:** The current results indicated powerful activity of *H. aegyptiacum* and *S. aegyptiaca* extracts in management of GITD. These findings recommend extensive phytochemical studies of both species in order to highlight the main metabolites responsible for the recorded activity.
Key words: Acute toxicity; Antidiarrheal; Antispasmodic; Environment and human health; *Ex-vivo* model; *In-vivo* model; Natural resource management.

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INTRODUCTION

Over years humans have recognized that they need to explore and interact with the surrounding environment and to optimize the use of the available natural resources. Plants are among the most important natural resources essential for human health and nutrition[1]. Several plant species have been documented for treatment of various human diseases. Gastrointestinal disorders (GITD) are categorized among the most common human diseases, with symptoms such as stomachaches, diarrhea, and abdominal spasm [2]. Phytotherapy is an important therapeutic option usually adopted in treatments of GITD. These disorders are usually treated with many herbal treatments such as Peppermint, Lemon Balm, Caraway, Belladonna, Greater Celandine, etc. These plants exhibit different active constituents with variable modes of action [3]. Irritable bowel syndrome is one of the most common GITD, where patients suffer abdominal pain, and switches between constipation and diarrhea or one of them [4]. Antispasmodic agents are commonly used to treat patients with diarrhea or abdominal cramp. Antimuscarinic drugs are usually used to reduce intestinal motility, however the produced side effects limit their benefits. On the other hand, drugs that act directly on the smooth muscle of GIT could reduce spasm without causing the usual side effects of the anticholinergic drugs [5].

Deverra triradiata (syn. *Pituranthos triradiatus* (Boiss.) Asch. & Schweinf) is a shrub belonging to family Apiaceae, growing in the north and middle regions of KSA and known as "Haza, or Sousse". This plant is commonly used by Bedouin population to treat GITD, hematuria, blood cough and to regulate menstruation [3]. Remarkably, *D. triradiata* produces gummy unorganized products that are, also, traditionally used for GITD. Numerous Apiaceae plants were previously reported for antispasmodic and antidiarrheal effects [5–8].

Heliotropium is a widely spread genus of family Boraginaceae. Several *Heliotropium* species have been reported for treatment of several ailments e.g. GITD, menstrual disorders, inflammation, wound healing, etc [9,10]. *H. bacciferum* (HBE) is a plant species rich in various phytochemicals e.g. alkaloids and polyphenols, this might account for the reported bioactivities such as antioxidant, antimicrobial and anticancer activities of this species [11]. Another *Heliotropium* species, *H. aegyptiacum* (HAE), was reported to be employed in folklore treatment of scorpion sting and snake bite, however no research was found discussing its biological activity or phytochemical content [12].

Suaeda aegyptiaca (SAE) is a member of Amaranthaceae family, with worldwide distribution, commonly found in saline habitats in Arabian region. The plant takes its name from the word "Suwaid", an Arabic word that means black color, which refers to the deep color of the dried plant [13]. SAE was reported to treat stomach pain, wound and skin infections [13]. The antimicrobial, antioxidant, cytotoxic, anti-inflammatory, and wound healing activities of this species were validated by many studies [13–16].

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In order to scientifically validate the traditional uses of these plant species in treatment of GITD, the current research was designed to assess the antidiarrheal and antispasmodic efficacy of each of the four plant species adopting *in vivo* and *ex-vivo* testing methods.

MATERIALS AND METHODS

Plant materials and preparation of crude extract

Aerial parts of the four plants: *Deverra triradiata* (Apiaceae), *Suaeda aegyptiaca* (Amaranthaceae), *Heliotropium bacciferum*, and *H. aegyptiacum* (Boraginaceae) as well as the gum of *D. triradiata* were collected from Qassim region and authenticated by Ibrahim Aldakhil, botanical expert, Qassim Area. Parts of the investigated plants were kept as voucher samples at college of pharmacy, Qassim University.

Plant materials were cleaned, dried, and ground to fine powder. Powdered plant material from each species (500 g) was repeatedly extracted (3 times X 2L) with 80% aqueous methanol at room temperature. Afterwards the combined extracts (from each individual plant) were evaporated utilizing rotary evaporator at 45°C. Afterwards the crude extract of each plant (free of solvent) was dissolved in normal saline (for the *in-vivo*) and in distilled water (for the *ex-vivo*) experiments.

Drugs and standards

Loperamide hydrochloride, atropine sulfate, and acetylcholine were purchased from Sigma Chemical Co, Cairo, Egypt. Castor oil and Tyrode's components (NaCl, KCl, $MgCl_2$, $CaCl_2$, H_2O, NaH_2PO_4, $NaHCO_3$, and glucose) were products of Piochem.co. Cairo, Egypt.

Animals

This investigation employed 150-170 mg healthy Wistar albino male rats obtained from the Animal House of Nahda University. They were kept in plastic cages with wire mesh in the Department of Pharmacology's animal home. They were kept in typical laboratory settings, with a 12-hour light and dark cycle, a temperature of 27°C ± 2°C, and a humidity of 60% ± 10%. They also had unlimited access to food and water. The animals were given seven days to become used to the lab environment before the test. The investigational procedures followed Nahda University rules and was approved by Nahda University's Ethical committee, Beni-Suef, Egypt (Ethical approval number NUB-023-024).

Preliminary phytochemical screenings

Extracts from different plants were tested for the presence of: triterpenoids, steroids, anthraquinone glycosides, saponins, alkaloids, flavonoids, tannins, and carbohydrate using different screening tests as previously described by (Amin et al., 2022)[17]

Acute oral toxicity

To find out the lethal dosage fifty (LD_{50}) that would kill 50% of the animals under study, the arithmetic approach of Kerber was employed. A single dose of the test medication was given at various dose levels for the acute toxicity determination, and the LD_{50} was calculated. Rats' mortalities were observed every day for a total of 14 days, starting one hour after dose and continuing every 24 hours (with a focus on the first four hours). Based on Kerber's arithmetic approach [18], the following equation was utilized:

$$LD_{50} = LD_{100} - \Sigma (a \times b)/n$$

Where, n = total number of animals in each group, a = the difference between two successive doses of administered extract, b = the average number of dead animals in two successive doses, LD_{100} = Lethal dose causing the 100% death of all test animals.

Isolated tissue preparations

After two weeks of acclimation, a male adult rabbit was slaughtered under anesthesia. After the abdominal cavity was opened, a 3-cm-long segment of the intestinal jejunum was removed. It was then mounted with cotton thread in a 50 mL glass tissue bath and kept at 37 °C, 95% oxygen, and 5% carbon using Tyrode's solution. The intestinal jejunum was hanged out in a kymograph. Acetylcholine (1 µM) was used to produce tissue contraction, and the extract's muscle inhibitory impact was compared to the baseline muscular contractility in terms of both amplitude and frequency in comparison with atropine sulfate (acetylcholine antagonist) [19].

Preparation of physiological solution

Tyrode's solution was painstakingly made using purified water and laboratory grade chemicals. The ultimate solution's pH was raised to 7.4. Tyrode's solution's composition is stated in mmol/L: NaCl, 137; KCl, 2.7; $MgCl_2$ - $6H_2O$, 0.5; $CaCl_2$ - $2H_2O$, 1.8; NaH_2PO_4, 0.4; $NaHCO_3$, 12; glucose, 5.5 [20].

Anti-spasmodic model

To describe the anti-spasmodic response of the extracts, the following protocol was used: First extracts (0.1 mg/100 mL) was injected on rabbit jejunums segment suspended in Tyrode's solution at different doses (0.2, 0.4, 0.8 mL) to determine if they cause any contraction. In order to ascertain whether the rabbit jejunum segments suspended in Tyrode's solution respond to contractile activity of Ach, 0.1 mg/100 mL of Ach was administered at 0.2, 0.4, and 0.8 mL dosages. The antispasmodic effect of each extract was then tested on rabbit jejunums pre-contracted by Ach at different doses (0.2, 0.4, 0.8 mL) compared to the standard anti-spasmodic drug, atropine (0.1 mg/100 mL). Finally, concentration response curves for different doses of each extract and atropine were constructed, and percentage of inhibition of each extract was deduced [21,22].

Castor oil-induced diarrhea

Eight groups, each of six rats, were organized. All groups were acclimatized for 7 days in the experimental shed. Prior to the experiment, the mice were fasted for eighteen hours. As a negative control, Group I (-Ve Control) received 20 milliliters of normal saline/kg; Group II (+Ve Control) received the same amount of normal saline /kg; Group III (standard) received loperamide at a standard dose of 5mg/kg; and Group IV, V, VI , VII and VIII received 250 mg /kg, orally, of the extract from DTE , DTG , SAE , HBE , and HAE, respectively for three days. Except for the negative control group, all groups experienced oral gavage of castor oil at a rate of 20 mL/kg after one hour of treatment. For the following four hours, all mice were watched for runny or watery feces. The overall quantity of wet or unformed droppings was tallied, and the mean number of droppings per rat was computed. Using the following formula [23], the percentage protection was determined for each group.

Percentage protection = ([A-B]/A) × 100

Where A=Mean number of defecations caused by castor oil.

B=Mean number of defecations caused by drug or extract.

Data analysis

Data in the current study were expressed as mean ± standard error of the mean (SEM), n=6. One-way analyses of variance (ANOVA), followed by post-hoc Turkey's test, using Graph Pad Prism version 6 for windows were utilized for statistical analysis of the data and statistical significance was established when $P<0.05$.

RESULTS

Preliminary phytochemical screening

Chemical testing for the presence of major classes of phytoconstituents in the five extracts revealed the prevalence of carbohydrates, sterols/triterpenes, and flavonoids in all tested extracts. Saponins give positive test only in SAE and alkaloids occurs only in the two *Heliotropium* species. On the other side all extracts responded negatively to anthraquinones test (Table 1).

Acute toxicity

As illustrated in Table (2) and Figure (1), no significant mortality was induced by DTG and SAE extracts for oral dose up to 10 g/kg body weight in rat, and thus the LD_{50} was undeterminable. Furthermore, administration of HAE extracts resulted in mild mortality at 7 g/kg and HBE at 8 g/kg while, DTE extract produces significant mortality at 1.5 g/kg dose level.

Antidiarrheal activity

Castor oil induced diarrhea model was utilized to assess the antidiarrheal efficacy of the five tested extracts in mice. Oral administration of DTE (250 mg/kg) did not produce any significant change in the mean weight of wet feces as per control group, the % protection of DTE (5.2%) indicated very weak or no antidiarrheal activity. On the other side came the results of DTG that displayed a significant reduction in the wet feces weight as compared to +Ve control group, with 94.7% of protection highlighting strong activity of the gum of this plant species. Testing the activity of the two Heliotropium species indicated a characteristic activity of both species with 94.7% and 89.6% protection for HAE and HBE, respectively, with HAE activity being non significantly different from the -Ve control and standard drug (Loperamide) groups. Similarly, SAE showed potent activity (94.7% protection) as compared to the +Ve control group Table (3) and Figure (2).

Antispasmodic activity

The antispasmodic activity of extracts from the four selected halophytes were assessed using rabbit ileum precontracted with acetyl choline. Both DTE and DTG were tested for antispasmodic activity at three different concentrations (0.2, 0.4 and 0.8 mL) Tables (4, 5) and Figures (3A, 3B) where aerial parts extract (DTE) displayed highest percentage of inhibition 54.3 % (at 0.4 & 0.8 mL). Interestingly, the results of gum of the plant indicated weak relaxation (24.5 % inhibition) at 0.8 mL. Considering the two *Heliotropium* species, HAE exhibited strong antispasmodic effect expressed as 90.2 % inhibition at the higher dose Table (6) and Figure (3C) while the other species HBE showed weak inhibition at different doses Table (7) and Figure (3D). SAE displayed no activity at lowest dose (0.2 mL) while it showed dose dependent antispasmodic activity at higher doses (42 % at 0.4 mL and 53.8 at 0.8 mL) Table (8) and Figure (3E).

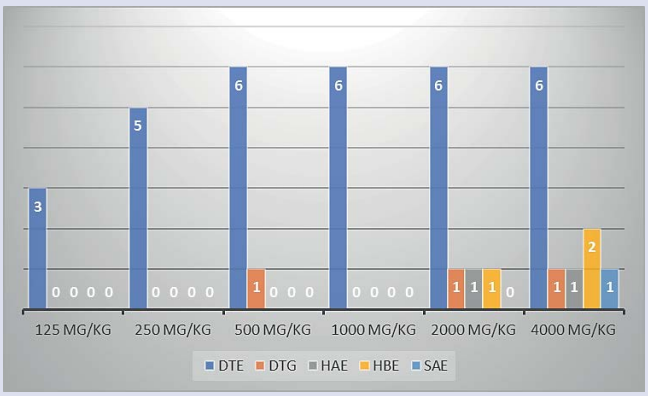

Figure 1: Effect of DTE, DTG, HAE, HBE, and SAE on mortality numbers at different doses over 24 hr. DTE: *D. triradiata* extract, DTG: *D. triradiata* gum, HAE: *H. aegyptiacum* extract, HBE: *H. bacciferum* extract, and SAE: *S. aegyptiaca* extract. (n=6).

Table 1: Preliminary phytochemical screening results of DTE, DTG, HAE, HBE and SAE methanol extracts.

Metabolite	DTE	DTG	HAE	HBE	SAE
Carbohydrates	+	+	+	+	+
Saponins	-	-	-	-	+
Flavonoids	+	+	+	+	+
Sterols/triterpenes	+	+	+	+	+
Tannins	-	-	+	+	+
Alkaloids	-	-	+	+	-
Anthraquinone glycosides	-	-	-	-	-

+: positive result, -: negative result, DTE: *D. triradiata* extract, DTG: *D. triradiata* gum, HAE: *H. aegyptiacum* extract, HBE: *H. bacciferum* extract, and SAE: *S. aegyptiaca* extract.

Table 2: LD_{50} of DTE, DTG, HAE, HBE and SAE.

Extract	LD_{50} (g/kg)
DTE	1.5
DTG	10
HAE	7
HBE	8
SAE	10

DTE: *D. triradiata* extract, DTG: *D. triradiata* gum, HAE: *H. aegyptiacum* extract, HBE: *H. bacciferum* extract, and SAE: *S. aegyptiaca* extract

Table 3: Antidiarrheal activity of DTE, DTG, HAE, HBE, and SAE on castor oil induced diarrhea in mice.

Groups	No. of mice with diarrhea	Mean weight of wet feces in 4 h	% Protection
Negative control	0	0.33 ± 0.3	0%
Positive control	6	6.33 ± 1.45 [a]	0%
Loperamide	0	0.33 ± 0.3 [b]	94.7%
Castor oil + DTE	6	6.00 ± 0.57 [a, c]	5.2%
Castor oil + DTG	0	0.33 ± 0.3 [b, d]	94.7%
Castor oil + HAE	0	0.33 ± 0.3 [b, d]	94.7%
Castor oil + HBE	0	0.66 ± 0.3 [a, b, d]	89.6%
Castor oil + SAE	0	0.33 ± 0.3 [b, d]	94.7%

DTE: *D. triradiata* extract, DTG: *D. triradiata* gum, HAE: *H. aegyptiacum* extract, HBE: *H. bacciferum* extract, and SAE: *S. aegyptiaca* extract. Values are expressed as mean+ SEM, [a]: significantly different from Negative control gp., [b]: significantly different from Positive control gp., [c]: significantly different from Loperamide gp., [d]: significantly different from DTE gp.

Table 4: Anti-spasmodic activity of DTE on acetylcholine induced – contraction in rat jejunum.

Groups	Length of contraction (cm)			Contraction%			Inhibition%		
	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL
DTE	0.0	0.0	0.0	0	0	0	0	0	0
Ach	3.5	3	3.0	100	100	100	0	0	0
Ach + Atr	0.2	0.1	0.1	6.7	2.9	2.9	93.3	97.2	97.2
Ach + DTE	2.2	1.6	1.6	73.3	45.7	45.7	26.7	54.3	54.3

Ach: Acetyl choline, Atr: Atropine, DTE: *D. triradiata* extract.

Table 5: Anti-spasmodic activity of DTG on acetylcholine induced – contraction in rat jejunum.

Groups	Length of contraction (cm)			Contraction%			Inhibition%		
	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL
DTG	0.0	0.0	0.1	0	0	1.7	0	0	0
Ach	6	5.3	5.3	100	100	100	0	0	0
Ach + Atr	0.4	0.3	0.1	6.7	5.7	1.9	93.3	94.3	98.1
Ach + DTG	6.4	5.4	4.0	106.7	101.9	75.5	-6.66	-1.9	24.5

Ach: Acetyl choline, Atr: Atropine, DTG: *D. triradiata* gum

Table 6: Anti-spasmodic activity of HAE on acetylcholine induced – contraction in rat jejunum.

Groups	Length of contraction (cm)			Contraction%			Inhibition%		
	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL
HAE	0.0	0.0	0.0	0	0	1.7	0	0	0
Ach	5.5	5.1	4	100	100	100	0	0	0
Ach + Atr	0.1	0.1	0.1	2.5	1.9	1.8	98.2	98.5	99.6
Ach + HAE	2.5	1.0	0.5	62.5	18.2	9.8	37.5	81.8	90.2

Ach: Acetyl choline, Atr: Atropine, HAE: *H. aegyptiacum* extract

Table 7: Anti-spasmodic activity of HBE on acetylcholine induced – contraction in rat jejunum.

Groups	Length of contraction (cm)			Contraction%			Inhibition%		
	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL
HBE	0.0	0.0	0.0	0	0	1.7	0	0	0
Ach	5	4.5	4	100	100	100	0	0	0
Ach + Atr	0.2	0.1	0.1	4	2.5	2.2	96	97.5	97.8
Ach + HBE	6	5.8	4	150	116	88.9	-50.0	-16	11.1

Ach: Acetyl choline, Atr: Atropine, HBE: *H. bacciferum* extract

Table 8: Anti-spasmodic activity of SAE on acetylcholine induced – contraction in rat jejunum.

Groups	Length of contraction (cm)			Contraction%			Inhibition%		
	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL	0.2 mL	0.4 mL	0.8 mL
SAE	0	0	0	0	0	0	0	0	0
Ach	6.5	5	4.4	100	100	100	0	0	0
Ach + Atr	0.1	0.1	0.1	2.27	2	1.5	97.7	98	99.8
Ach + SAE	5.5	3.0	2.9	125	58	46.2	-25	42	53.8

Ach: Acetyl choline, Atr: Atropine, SAE: *S. aegyptiaca* extract

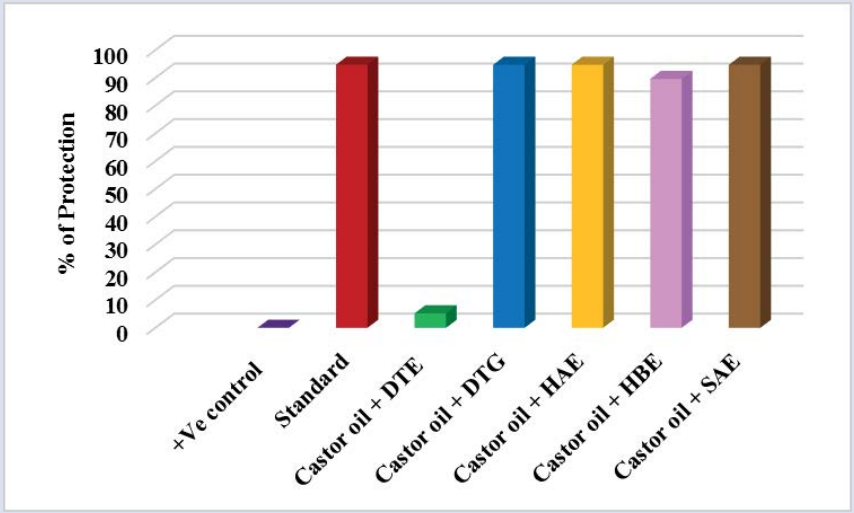

Figure 2: Antidiarrheal activity (% protection) of DTE, DTG, HAE, HBE, and SAE on castor oil induced diarrhea in mice. DTE: D. triradiata extract, DTG: D. triradiata gum, HAE: H. aegyptiacum extract, HBE: H. bacciferum extract, and SAE: S. aegyptiaca extract.

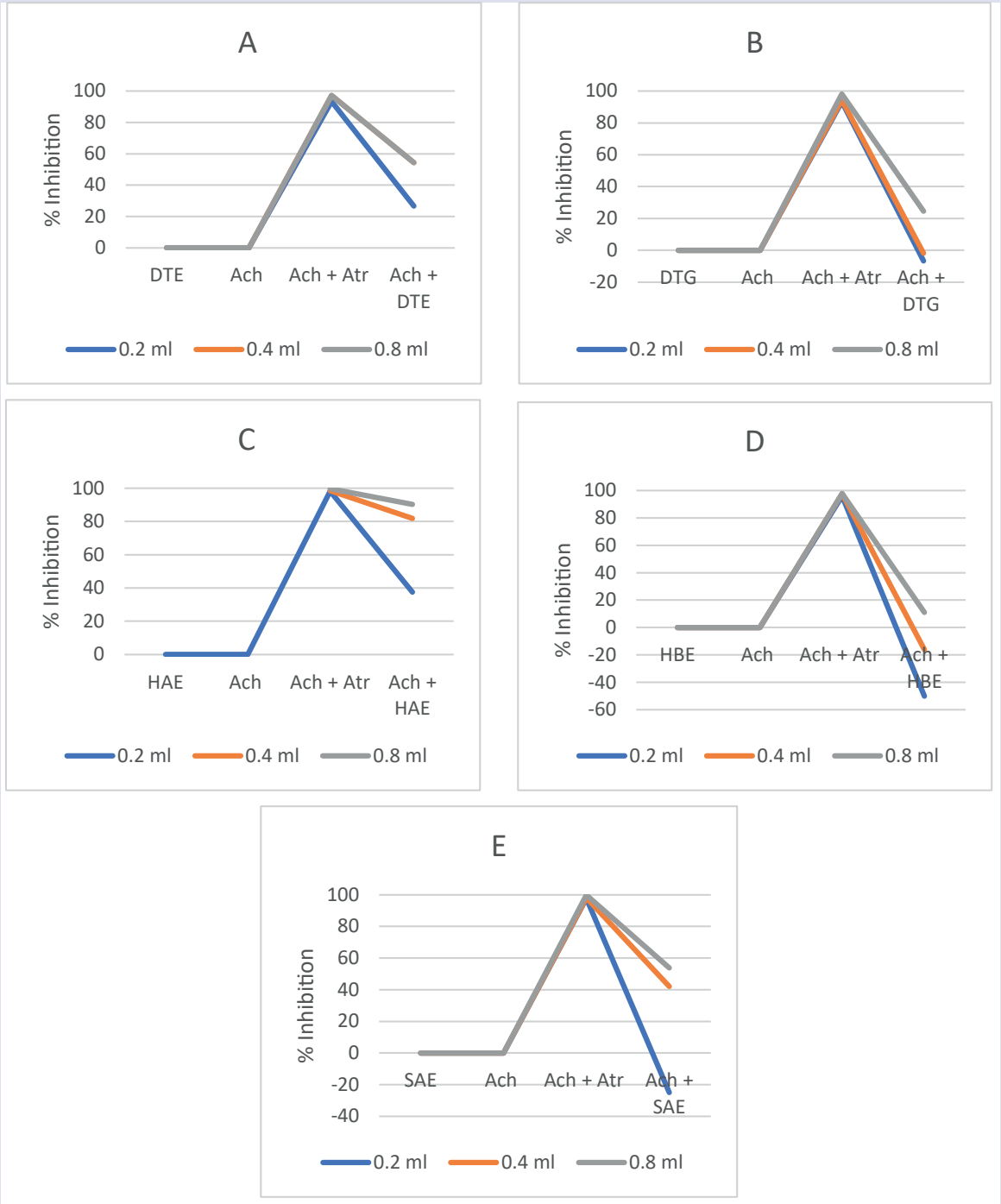

Figure 3: Antispasmodic activity (% inhibition) of DTE, DTG, HAE, HBE, and SAE on acetylcholine induced – contraction in rat jejunum. A: DTE group; *D. triradiata* extract, ***B:*** DTG group: *D. triradiata* gum, **C:** HAE group: *H. aegyptiacum* extract, **D:** HBE group: *H. bacciferum* extract, and **E:** SAE group: *S. aegyptiaca* extract.

DISCUSSION

The use of plants in disease treatment is an old therapeutic approach, it represents the corner stone in the drug discovery process. Herbal medicine research usually focuses on evidencing the activity reported in folk medicine through investigation of the efficacy, mode of action and safety of a plant extract [24]. Herein, the current research is devoted to investigation of the possible therapeutic effect of four plant species in the management of GITD. It is noteworthy that all the tested plants have previous reports for folk medicinal uses in digestive system disorders [25–27].

For safety reasons, all drugs included in the research must be free of toxicity. Acute toxicity testing is usually performed to obtain information about the safety of drugs and to evaluate their bioactivity and mechanism of action[28]. Herbal medicines are usually subjected to toxicological studies such as determination of the median lethal dose and other basic parameters of the appropriate dosage. And when needed, these herbal materials are further subjected to acute and chronic toxicity tests. Herein, the acute toxicity of each of the five extracts was calculated to assess the extent of adverse reactions to a single dose or overdose of each extract. Results indicated that increasing doses of DTE gradually administered to rats were found to be lethal, while increasing

doses of DTG, HAE, HBE, and SAE caused low or no toxicity, therefore they could be considered relatively safe.

Diarrhea is a serious health problem characterized by increased frequency of bowel movements, abdominal cramps, and loss of water and electrolytes from the body which results from elevated excretion and decreased absorption of fluids[29]. The present research investigated the efficacy of DTE, DTG, HAE, HBE, and SAE extracts on castor oil induced diarrhea in mice. Remarkably, ricinoleic acid, the main active ingredient in castor oil, which results from the hydrolytic effect of lipases enzymes, in the upper intestine, on castor oil, induces the production of prostaglandins through inflammation of the intestinal mucosa, which in turn increases motility as well as secretion of fluids. Furthermore, it inhibits Na/K ATPase in the intestine through formation of Na and K ricinolate salts, hence increasing intestinal permeability, it also activates the G protein- coupled prostanoid receptor on cells of the intestinal smooth muscle[30]. Utilizing castor oil model, the current results highlighted strong antidiarrheal activity of DTG, SAE, HAE (94.7%), and HBE (89.6) compared to the standard antidiarrheal drug, Loperamide (94.7%), while on the other hand DTE was devoid of antidiarrheal activity.

For further validation of the efficacy of DTE, DTG, HAE, HBE, and SAE in treatment of GITD, the five extracts were validated against acetylcholine-induced contractions in rabbit jejunum. The current findings confirmed that DTE produces relaxant effect (54.3 % at 0.4 and 0.8 mL) on acetylcholine- induced contractions, while DTG exhibited almost no anti-spasmodic activity as compared to atropine standard drug. Previous studies reported the traditional use of *D. triradiata* in treatment of digestive disorders, however we found no scientific research discussing the efficacy of plant extract or gum of the plant in management of GIT diseases. Experimental studies of oleogum resin from another Apiacea species: *Ferula asafoetida* has confirmed its antidiarrheal effect, moreover one clinical study stated its potency in treatment of functional dyspepsia [8]. Interestingly, the current data stated a powerful antidiarrheal activity of plant gum (DTG) with no antispasmodic effect while plant extract (DTE) exhibited a characteristic antispasmodic activity and no antidiarrheal efficacy.

Considering the two studied *Heliotropium* species, results declared strong antispasmodic effect of HAE expressed as 90.2 % inhibition at the higher dose, while on the other hand HBE exhibited a weak or no antispasmodic activity as compared to the standard drug atropine. It is noteworthy that this is the first report for the evaluation of activity of these two *Heliotropium* species in management of digestive disorders. Saeed et al. 2017, reported the antidiarrheal effect with no antispasmodic effect of *H. strigosum* [9].

Given that both HAE and DTE produce characteristic antispasmodic activity against acetylcholine-induced spasm, with HAE achieving almost the same action as atropine, it is suggested that the possible mode of action of the antispasmodic activity of HAE and DTE may depend on blocking acetylcholine receptors.

Based upon the previous results it could be concluded that all tested extract especially, HAE and SAE are promising herbal materials for treatment of GITD.

CONCLUSION

The traditional uses of four plant species in the management of gut disorders was validated using *in vivo* and *ex vivo* tests. The results showed distinct effectiveness for all extracts, with *Heliotropium aegyptiacum* and *Suaeda aegyptiaca* displaying the most promising antidiarrheal and antispasmodic activities. These results recommend a detailed phytochemical examination of these extracts to identify the plant components responsible for the recorded activities.

CONFLICT OF INTEREST

All the authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

Conceptualization, E.A.; methodology, M.A. and O.A.M.A.; validation, S.A.A.; formal analysis, E.A., M.A. and O.A.M.A.; investigation, E.A. and O.A.M.A.; resources, S.A.A. and M.A.; writing-original draft preparation, E.A.; writing-review and editing, E.A. and O.A.M.A.; supervision, E.A. All Authors have read and agreed to the published version of the manuscript.

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