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Dialium guineense fruit pulp-mediated electrolyte modulation in prophylactic intervention of ethanol-induced gastric ulcer in albino rats

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Abstract

Gastric ulcer is one of the most prevalent gastrointestinal disorders that is characterized by lesions of the mucous membrane that perforate the wall of the stomach. The aetiologies of the disease include alcohol abuse, anti-inflammatory drugs (NSAIDs), and infection by *H. pylori*. This study examined the gastroprotective effects of *Dialium guineense* fruit pulp extract and fractions on electrolyte profiles in ethanol-induced ulcerated rats, respectively, with acute and sub-acute models. This was done to determine the potential mechanism of this plant in the therapeutic effect through its effect on sodium (Na^+), potassium (K^+), chloride (Cl^-), and bicarbonate (HCO_3^-) levels in maintaining electrolyte balance during ulceration. The level of sodium and chloride showed a significant increase, $p < 0.05$, in the ulcer control group, which indicates electrolyte imbalance. Treatment with *Dialium guineense* resulted in a dose-dependent decrease in such ions and, hence, may reverse electrolyte imbalance. Fractions of the extract showed significant ($p<0.05$) increase in the modulation of electrolyte balance, especially in maintaining normal levels of sodium and chloride. The potassium and bicarbonate remained stable in the acute phase of the study but showed dramatic improvements in the sub-acute phase of the study, with fractions restoring near-normal potassium levels and reducing the concentration of bicarbonate. These findings suggest that *Dialium guineense* possesses significant gastroprotective properties, possibly by the mediation through regulation of electrolyte profiles, and could therefore serve as a promising candidate in the management of ulcers. Further studies are recommended to elucidate the specific bioactive compounds responsible for these effects.

Keywords: *Dialium guineense*, Gastric ulcer, Ethanol-induced ulcer, Electrolyte modulation, Prophylactic intervention, Sodium, Potassium, Chloride, Bicarbonate

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INTRODUCTION

Gastric ulcer is a prevalent gastrointestinal disorder characterized by mucosal lesions that penetrates the stomach lining, often resulting from factors such as excessive alcohol consumption, non-steroidal anti-inflammatory drug (NSAID) use, and *Helicobacter pylori* infection (Malfertheiner *et al*., 2009; Malik *et al*., 2023). Ethanol-induced gastric ulcers are widely used as a model for understanding ulcer pathophysiology due to ethanol's potent mucosal disruptive effects (Mascarin, *et al.,* 2023). Ethanol stimulates gastric acid secretion, decreases gastric mucosal defence, and impairs electrolyte profile, including changes in the levels of sodium (Na), potassium (K), chloride (Cl) and bicarbonate (HCO3) (Zou *et al.,* 2023; Barkas *et al*., 2013). Electrolytes play an essential role in gastric mucosal defence, and their imbalance can exacerbate ulcer formation by compromising cell membrane stability, disrupting acid-base balance, and aggravating oxidative stress (Ichikawa and Ishihara, 2011). Sodium and chloride ions contribute to gastric acid secretion, while bicarbonate serves as a buffer that protects the mucosa from excessive acidity (Kvietys, 2010). Maintaining an optimal electrolyte balance is crucial in the prophylaxis and management of gastric ulcers.

Medicinal plants have been widely investigated for their gastroprotective properties due to their rich bioactive compounds and relatively low toxicity profiles (Stéphane*, et al*., 2021). Among these, *Dialium guineense* (velvet tamarind) has attracted attention for its diverse pharmacological properties, including antioxidant, anti-inflammatory, and gastroprotective effects (Okerulu *et al*., 2015). These properties are indicative of the potentials that exist in the modulation of oxidative stress and inflammatory responses associated with gastric ulcers. Also, flavonoids and tannins among others identified in *Dialium guineense* may explain its gastroprotective activity by facilitating the processes of mucosal defence and maintaining electrolyte balance (Kuna *et al*., 2019). However, its specific role in modulating electrolyte profiles during ulcer pathogenesis remains unexplored. The present study is, therefore, proposed in a way that explains the gastroprotective effect of *Dialium guineense* fruit pulp extract and fractions on the electrolyte profile in ethanol-induced ulcerated rats using both acute and sub-acute models. The possible therapeutic mechanism of *Dialium guineense* in maintaining electrolyte balance during ulceration by analysing the level of sodium, potassium, chloride, and bicarbonate is also explained in the study.

MATERIALS AND METHODS

Plant material

The study utilized the fruit pulp of *Dialium guineense*. The fruit was purchased from Orie Ugba market, a local market in Ugba Ibeku, Umuahia North local government area, Abia State. The plant was identified and authenticated by Mr. Ibe Ndukwe of the Department of Forestry and Environmental Management, MOUAU, Abia State. A voucher specimen was kept at the herbarium in the Department of Physiology and Pharmacology, College of Veterinary Medicine, MOUAU. Further, the fruit pulp was washed with distilled water after harvesting to remove dirt, debris, or any other potential contaminants such as pesticides. Later, excess water was then blotted with paper in order to avoid excessive moist conditions in the drying process. Fresh *Dialium guineense* fruit pulp were de-seeded, and pulp was air-dried. Then the fruit pulp was ground into a fine powder using a manual grinder.

Extraction

A known weight (500g) of the pulverized pulp of *Dialium guineense* was soaked in 1.5 litres of ethanol for 48 hours. The mixture was filtered using Whatman No. 1 filter paper and the filtrate obtained concentrated to get a solid residue using a rotary evaporator. This filtrate was then dried at a temperature of 40^{o}C. This was stored for in refrigerator for further use. The ethanol pulp extract was diluted with distilled water (a portion of 20g of the extract was dissolved in 200 ml of water to produce the stock solution as 100mg/mL) concentration just before administration to the experimental animals.

The fractions from the crude extract were obtained by column fractionation using the solvents as the mobile phase (hexane, chloroform pet ether, ethyl acetate, ethanol and methanol). Silica gel was used as the stationary phase. Fractions were collected based on the differences in polarity and monitored using thin layer chromatography. The collect fractions were pooled based on similar TLC profiles, concentrated and stored at of 4^{o}C until further use.

Animals

Adult albino rats (male and female) weighing (150-200 g) was used for the study. The animals were housed under standard conditions, 12/12h light-dark cycle starting at 7:00 am at the temperature of 25±2^{o}C. The animals underwent seven days of acclimatization before the experiments. The rats were fed with standard grower pellets (Grand Cereals Ltd, Abia State) and had access to clean drinking water *ad libitum*. All animal experiments in this study were performed following the protocols outlined in the "Principles of laboratory animal care" (NIH Publication No. 85- 23, revised 1985) and approved by the appropriate animal Care and Ethics Committee. Efforts were made to minimize animal suffering and reduce the number of animals used.

Experimental design

The study comprised an acute phase using the crude extract and a sub-acute phase for both the crude extract and fractions. In phase one (1), sixty (60) adult albino rats were used for the experiment, thirty (30) were used for the acute and sub-acute of the crude extract respectively following the methodology of Raeesi *et al.* (2019). The animals were randomly assigned into six groups of five (5) animals each. Group 1 was the normal control that received feed and water alone (no treatment), Group 2 was the negative control (ethanol-induced without treatment). Group 3 received 20 mg/kg body weight of omeprazole Group 4, 5, and received 250 mg/kg, 500 mg/kg and 1000 mg/kg body weight of *Dialium guineense* fruit pulp extract. In phase two (2), sixty – five (65) animals in thirteen experimental groups were used. Group 1-3were the same as in phase 1. Groups 4-13 orally treated with 250 and 500 mg/kg body weight of *Dialium guineense* bioactive fractions. Gastric ulcer was induced via oral administration of ethanol (5 mL/kg body weight, 80% v/v) following a 24-hour fasting period for 30 minutes after treatment. Two hours post-ethanol induction, the animals were sacrificed, Blood samples were collected for the analyses.

Macroscopic evaluation of the stomach (ulcer index)

The stomachs were excised and carefully opened along the line of greater curvature to expose the walls. The stomach contents were then washed off and viewed with the aid of a light microscope (x 100) to determine the ulcer scores using the method of Zatorski (2017). The ulcerative lesions were counted and scored as follows: a normal stomach was scored as 0, the presence of pinhole lesions was scored as 1.0, spot ulceration was given a score of 1.5, hemorrhagic streaks were assigned 2.0, small erosions were scored as 2.5, large erosions were rated 3.0, and perforations were scored as 3.5.

The mean ulcer score for each animal was used to express the ulcer index. The ulcer index (U.I) was calculated by using the formula:

$$U := \frac{1x\,(\text{No.of lesions of grades } 1) + 2\,x\,(\text{No.of lesions of grade } 2) + 3\,x\,(\text{No.of lesions of grades } 3)}{10}$$

The percentage of ulcer protection was determined using the formula

$$\text{Protection index} = 1 - \frac{\text{Ulcer index with extract}}{\text{Ulcer index with distilled water}} \times 100$$

Determination of Serum electrolyte concentrations

Sodium ion concentration was determined using the method described by Maruna (1958). Potassium ion concentration was measured following the method outlined by Terri and Sesin (1958). Chloride ion concentration was determined using the method described by Tietz (1995). Bicarbonate ion concentration was measured using a titration method according to Chaney and Marbach (1962).

Statistical analysis

All values were expressed as mean and standard deviation (s.d). Data was analysed by one-way ANOVA, followed by Turkey's post-hoc test and significant differences between groups were determined using SPSS software version 23.0. The acceptable level of significance was $p< 0.05$.

RESULTS

Table 1 shows the effect of acute study of *Dialium guineense* fruit pulp extract on the levels of serum electrolyte in experimental rats. Serum sodium ion levels were significantly ($p<0.05$) higher in ulcer control group as compared with normal control and extract-treated groups. Observed values of sodium ion levels decreased in a dose dependent manner in the extract treated groups. Variations in potassium levels were not significant, $p > 0.05$ between ulcer control and extract treated groups. While in the ulcer control group, the chloride ion levels were significantly higher, extract-treated groups resulted in a dose-dependent decrease as compared to the standard drug group. There is, similarly, a significant enhancement in the level of bicarbonate, which remained highly significant $p<0.05$), while extract treatments caused a dose-dependent reduction in the groups as compared to omeprazole.

Table 2 shows the subacute effect of the crude extract *Dialium guineense* fruit pulp extract on serum electrolyte levels in the experimental rats. In pairwise comparison, there was a significant ($p<0.05$) increase in sodium and chloride levels in the ulcer control group compared to that observed for normal control and extract-treated groups. The extract produced a dose-dependent and an appreciably higher reduction in chloride level when compared to omeprazole even at the dose of 20 mg/kg. Although potassium levels varied between the groups, no significant ($p>0.05$) difference was observed between the ulcer and extract-treated groups. In contrast, while there was a significant ($p<0.05$) increase in the ulcer control group, it showed a dose-dependent reduction in the bicarbonate levels in the extract-treated groups compared to omeprazole.

Table 3 shows the effect of subacute study of the fractions of the *Dialium guineense* fruit pulp on the serum electrolytes level in the experimental rats. Sodium and chloride were significantly ($p<0.05$) higher in the ulcer control group than in the normal control and extract-treated groups. Chloride was dose-dependently decreased by the fractions; this effect was more active than omeprazole treated at 20 mg/kg. While potassium levels varied, no significant ($p>0.05$) difference was observed between the ulcer control and most of the treated groups except for Fraction IV at 250 mg/kg and 500 mg/kg. The bicarbonate level increased significantly ($p<0.05$) in the ulcer control group but was reduced in a dose-dependent manner in fraction-treated groups when compared to omeprazole.

Table 1: The effect of crude extract of *Dialium guineense* on serum electrolyte concentration in ethanol-induced ulcer in albino rats (acute study)

Groups	**Sodium** (mmol/L)	**Potassium** (mmol/L)	**Chloride** (mmol/L)	**Bicarbonate** (mmol/L)
Normal control	135.04±1.22^{a}	4.44±0.09^{a}	91.04±1.06^{a}	19.49±0.09^{a}
Ulcer control	144.80±3.33^{d}	4.60±0.19^{a}	97.02±1.18^{b}	20.15±0.53^{b}
Omeprazole 20 mg/kg	139.06±1.13^{c}	4.45±0.14^{a}	96.86±1.20^{b}	19.94±0.15^{ab}
Dialium guineense 250 mg/kg	137.820±1.18^{ab}	4.53±0.06^{a}	95.30±0.63^{b}	20.07±0.57^{b}
Dialium guineense 500 mg/kg	136.72±1.01^{ab}	4.56±0.10^{a}	91.02±0.89^{a}	19.91±0.18^{ab}
Dialium guineense 1000 mg/kg	136.64±1.15^{ab}	4.45±0.18^{a}	91.03±0.63^{a}	19.52±0.13^{a}

Values are presented as mean ± standard deviation (n = 5). Means with different superscripts along the rows are statistically significantly different p<0.05(n=5).

Table 2: The effect of crude extract of *Dialium guineense* on serum electrolyte concentration in ethanol-induced ulcer in albino rats (sub-acute study)

Groups	**Sodium** (mmol/L)	**Potassium** (mmol/L)	**Chloride** (mmol/L)	**Bicarbonate** (mmol/L)
Normal control	134.99±1.39^{a}	4.42±0.03^{a}	89.49±1.03^{a}	19.50±0.26^{a}
Ulcer control	143.45±2.14^{d}	4.56±0.05^{b}	94.85±0.44^{d}	20.24±0.14^{d}
Omeprazole 20 mg/kg	139.66±0.58^{c}	4.48±0.09^{ab}	94.36±0.69^{d}	19.89±0.13^{b}
Dialium guineense 250 mg/kg	138.53±1.09^{bc}	4.45±0.05^{ab}	93.35±0.92^{dc}	19.88±0.21^{b}
Dialium guineense 500 mg/kg	136.49±1.69^{bc}	4.51±0.61^{ab}	91.65±1.31^{bc}	19.96±0.09^{bc}
Dialium guineense 1000 mg/kg	138.43±0.36^{ab}	4.47±0.07^{ab}	90.73±0.42^{ab}	19.75±0.17^{ab}

Values are presented as mean ± standard deviation (n = 5). Means with different superscripts along the rows are statistically significantly different p<0.05(n=5).

Table 3: The effect of the fractions of *Dialium guineense* on serum electrolyte concentration in ethanol-induced ulcer in albino rats (sub-acute study)

Groups	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
1	130.09±0.78^{a}	4.40±0.07^{a}	89.77±1.06^{a}	19.56±0.31^{a}
2	135.56±0.81^{e}	4.63±0.12^{b}	101.65±1.59^{g}	20.70±0.52^{d}
3	133.37±0.68^{cd}	4.47±0.03^{ab}	95.14±0.63^{cde}	19.72±0.19^{ab}
5	132.79±0.30^{bcd}	4.51±0.03^{ab}	95.41±0.99^{cdef}	20.30±0.14^{cd}
6	133.93±1.44^{de}	4.48±0.08^{ab}	97.31±1.80^{ef}	20.21±0.38^{bcd}
8	132.5±0.71^{de}	4.45±0.11^{ab}	97.16±0.58^{f}	20.10±0.07^{abc}
9	133.00±0.85^{bcd}	4.48±0.10^{ab}	94.52±1.14^{bcd}	20.08±0.03^{abc}
10	131.29±0.75^{abc}	4.41±0.13^{a}	92.52±1.46^{b}	19.88±0.12^{abc}
11	131.58±1.09^{ab}	4.38±0.06^{a}	92.93±1.01^{bc}	19.84±0.14^{abc}
12	132.39±0.79^{bcd}	4.56±0.04ab	95.53±2.06^{cdef}	19.96±0.16^{abc}
13	132.83±0.78^{bcd}	4.50±0.05^{ab}	94.56±0.66^{b}	19.88±0.25a^{bc}

Values are presented as mean ± standard deviation (n = 5). Means with different superscripts along the rows are statistically significantly different p<0.05(n=5). Group1=Normal control, group 2=Ulcer control, group 3=Omeprazole, 20 mg/kg group,4=Fraction I, 250 mg/kg bw, group 5=Fraction I, 500 mg/kg bw group,6=Fraction II, 250 mg/kg bw, group 7=Fraction II, 500 mg/kg bw , group 8=Fraction III, 250 mg/kg bw, group 9=Fraction III, 500 mg/kg bw, group 10=Fraction IV, 250 mg/kg bw, group 11=Fraction IV, 500 mg/kg bw, group 12=Fraction V, 250 mg/kg bw, group 13=Fraction V, 500 mg/kg bw

DISCUSSION

The serum electrolyte effects of the crude extract and fractions of fruit pulp of *Dialium guineense* were investigated in rats with ethanol-induced peptic ulcers. Electrolyte imbalance has also contributed to the pathophysiology of gastric ulcers; hence, normal levels of ions such as sodium, potassium, chloride, and bicarbonate are necessary for physiological performance in the stomach (Mao *et al*., 2020). From this study, the crude extract and its fractions have a significant level of modulation in these electrolyte levels, possibly presenting therapeutic benefits

The significant elevation, p<0.05, of sodium ion levels in the ulcer control group, is consistent with previous reports that electrolyte imbalances, such as hypernatremia, are frequent in gastric ulcers due to extreme gastric secretion and breakdown of epithelial integrity (Johnlouis *et al*., 2024). In the acute study, sodium was significantly high in the ulcer control group (144.80 ± 3.33 mmol/L) when compared to the normal control group (135.04 ± 1.22 mmol/L). Treatment with *Dialium guineense* at doses of 250 mg/kg, 500 mg/kg and 1000 mg/kg lowered sodium to 137.82 ± 1.18 mmol/L, 136.72 ± 1.01 mmol/L and 136.64 ± 1.15 mmol/L respectively. Treatment with the crude extract and fractions of *Dialium guineense* showed the restoration of sodium levels to values close to the normal control, In the subacute study, levels of sodium in the ulcer-control group (143.45±2.14 mmol/L) was significantly elevated compared to the levels of those of normal controls of134.99±1.39mmol /L). Treatments administered at the same doses led to the decrease in sodium concentrations to values ranging between 136.49 ± 1.69 and 138.43 ± 0.36 mmol/L, which is comparable to the effect obtained with omeprazole (139.66 ± 0.58 mmol/L). In the sub-acute study, the fractions of

Dialium guineense also affected sodium levels, with Fraction I at a dose of 500 mg/kg and Fraction III at 250 mg/kg reducing sodium levels to 132.79 ± 0.30 mmol/L and 132.5 ± 0.71 mmol/L, respectively. This, therefore, may infer that the extracts exert some modulatory role in mitigating ulcer-induced disturbance in sodium balance. In this respect, the bioactive principles, especially the polyphenols and saponins present in the fruit pulp, may fortify cellular membranes against damage and reduce the entry of sodium into the cell (Abu *et al*., 2022; Agbaje and Doe, 2015).

There was no significant difference in the level of potassium between the ulcer control and extract-treated groups, except in groups treated with Fraction IV at both doses, indicating a minimal disturbance in potassium ion regulation by crude extract and most fractions. (Serafim *et al*., 2020; Asmara *et al*., 2023) Hence, the effect of Fraction IV may indicate some sort of specific interaction with the pathways that are involved in the transport or absorption of potassium ions (Tijani *et al*., 2022). It tends to exhibit graver disturbances in the stomach with potassium imbalance; hence, the mechanism of this regulation by Fraction IV deserves further investigation.

The ulcer control group showed high levels of chloride concentrations (acute: 97.02 ± 1.18 mmol/L; sub-acute: 94.85 ± 0.44 mmol/L) compared with the normal control group (acute: 91.04 ± 1.06 mmol/L; sub-acute: 89.49 ± 1.03 mmol/L) which indicated gastric acid hypersecretion. The extracts of *Dialium guineense* produced a significant lowering of chloride levels.

In the acute study, the extract at 500 mg/kg and 1000 mg/kg reduced chloride levels to 91.02 ± 0.89 mmol/L and 91.03 ± 0.63 mmol/L, respectively, comparable to the normal control. Similarly, in the sub-acute study, fractions such as Fraction I at 500 mg/kg and Fraction III at 500 mg/kg reduced chloride level to 95.41 ± 0.99 mmol/L and 94.52 ± 1.14 mmol/L, respectively. The dose-dependent observed decrease in chloride levels in the extract and fraction-treated groups suggests the view that *Dialium guineense* mitigates gastric hypersecretion and excessive hydrochloric acid production characteristic in ulcer conditions (Júnior *et al*., 2021). This makes the plant extracts even more effective than omeprazole, a standard anti-ulcer medication, underlining the potential of *Dialium guineense* to reduce acid-related damage through its phytochemical constituents by potentially inhibiting the over activation of acid-secreting parietal cells (Mao *et al*., 2020)

Bicarbonate levels in the ulcer control group were significantly raised (acute: 20.15 ± 0.53 mmol/L; sub-acute: 20.24 ± 0.14 mmol/L) compared to the normal control (acute: 19.49 ± 0.09 mmol/L; sub-acute: 19.50 ± 0.26 mmol/L). Treatment with extracts and fractions *of Dialium guineense* significantly reduced the bicarbonate levels dose-dependently with the highest reduction at 1000 mg/kg (acute: 19.52 ± 0.13 mmol/L; sub-acute: 19.75 ± 0.17 mmol/L). The secretion of bicarbonate is a compensatory event to the enhanced acidity within the stomach (Júnior *et al*., 2021). The sharp reduction in the levels of bicarbonate ion in extract-treated groups in the current study could mean that crude extract and fractions of *Dialium guineense* reduce the excessive acid load that, if not nullified, would have otherwise served as a stimulant for increased bicarbonate secretion against the background of protecting the gastrointestinal tract (Makrane, 2019). The dose-dependent decrease in the level of bicarbonate ion by the plant extracts, compared to omeprazole, thus further reflects the potential of *Dialium* guineense to effectively regulate the gastric pH through antioxidant and anti-inflammatory pathway. The antioxidant and anti-inflammatory properties of the phytochemicals present in *Dialium guineense*, such as polyphenols and saponins, may contribute to its ability to regulate gastric pH. These bioactive compounds can inhibit acid secretion, neutralize free radicals, and promote mucosal defence mechanisms, thereby effectively managing the gastric acid-base balance (Ahmed, 2020, Ogu *et al.* 2013).

This is further reflected in the dose-dependent decrease in the level of bicarbonate ion by the *Dialium guineense* extracts, as opposed to omeprazole. This, in essence, speaks volumes about the therapeutic potential of *Dialium guineense* in the management of peptic ulcers through anti-oxidative and anti-inflammatory pathways which modulate gastric pH (Besong *et al*., 2016; Ogu *et al*., 2013; Ogu and Amiebenomo, 2012).

The diverse phytochemical composition of *Dialium guineense* is fundamental to its recognized therapeutic benefits. Phytochemicals such as flavonoids, polyphenols, and tannins exhibit high antioxidant and anti-inflammatory activities, hence protecting the gastric mucosa from oxidative damage and inflammation caused by ethanol exposure. These phytochemicals protect the gastric mucosal barrier by inhibiting excessive acid production, neutralizing free radicals, and enhancing mucosal protective processes (Besong *et al.*, 2016; Ogu and Amiebenomo, 2012). In addition, the improved efficacy of the extracts compared to omeprazole indicates their potential as alternative or adjuvant therapies in peptic ulcer treatment. The observed effects in this study are, therefore, probably consequent to the rich phytochemical profile of *Dialium guineense*. Indeed, there are reports that flavonoids, polyphenols, and tannins have high anti-inflammatory and antioxidant activities by protecting gastric mucosa against ethanol-induced oxidative damage and inflammation. These compounds can also improve gastric mucosal barrier by preventing acid secretion, neutralizing free radicals, and enhancing mucosal protective mechanisms.

CONCLUSION

The extracts and fractions obtained from the fruit pulp of *Dialium guineense* have exhibited high efficacy in correcting ethanol-induced peptic ulcers by restoring the balance of electrolytes, thus justifying its use in folk medicine. The fact that its fractions are dose-dependent adds more credence to the assurance this plant has shown regarding its therapeutic potential. This study provides strong evidence concerning the modulatory effects of *Dialium guineense* extracts on serum electrolyte levels in ethanol-induced peptic ulcers. Their ability to restore sodium and chloride balance, regulate bicarbonate secretion, and attenuate potassium disturbances points to the therapeutic potential of these extracts. These effects are likely mediated through the antioxidant and anti-inflammatory actions of the phytochemicals present in the plant, which would alleviate the gastric acid-base disturbances and prevent mucosal damage.

The current study is limited by several factors, such as a lack of detailed histological analysis that would have enhanced the protective effects on gastric mucosa. Further studies are needed to illuminate the precise molecular mechanisms underlying the therapeutic effects of *Dialium guineense*. Characterizing the bioactive components responsible for the observed effect and understanding their interactions at the level of cellular targets will greatly provide important avenues toward understanding the potential use of this plant in managing ulcers. Long-term safety and efficacy studies concerning *D. guineense* are, therefore, strictly required using detailed toxicological studies and clinical trials.

Future studies need to be directed at identification of the bioactive principles responsible for these effects, exploration of their pharmacokinetics, and assessment of the long-term safety of *Dialium guineense* in ulcer management. However, histological analysis could give in detail the protective effects of the extract on gastric mucosa.

Conflict Interest

Authors have no conflict of interest to declare.

Author contribution

EAE identified the research problem, designed the experiment, and wrote the manuscript. AGS supervised the experimental set-up, OE proofread the manuscript. EAE handled the data analysis, EB conducted the literature review, AGS designed the study while AKA assembled the methodology.

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