

Research Article

Gastric Acid-reducing Effect and Bioactive Compound Content of Leaves of *Capparis sepiaria* L. and *Maerua angolensis* DC (Capparidaceae)

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Abstract

In traditional medicine, the leaves of *Capparis sepiaria* and *Maerua angolensis*, known as kal-yanga and Zilogo respectively in the local Moore language, are used to treat gastric and duodenal ulcers and other gastrointestinal disorders. This study aimed firstly to evaluate *in vivo* the ability of the extracts to reduce gastric acidity and secondly to determine the contents of bioactive compounds potentially responsible for this effect. The pylorus ligation model in rats was used to assess the plant extracts effect on gastric acidity. Total phenolics were determined using the Folin–Ciocalteu reagent, while the flavonoid, condensed tannin, and hydrolysable tannin contents were determined by the aluminum trichloride, vanillin and sodium iodate method respectively. The best gastric acid-reducing activity equal to 32.88 milliequivalent of hydrogen ions per liter (mEq H⁺/L) was obtained with the *Maerua angolensis* leaves extract at a dose of 500 mg/kg.w.c., compared to the effect of the reference substance, omeprazole (24.88 mEq H⁺/L) used at 150 mg/kg.w.c. Quantification of the compounds potentially responsible for this activity showed high levels of total phenolic (637.80 mg GAE/g) and tannins (209.27 ± 45.94 mg CE/g; 175.08 ± 11.42 mg TAE/g) condensed and hydrolysable respectively for *Capparis sepiaria*, and a high level of total flavonoids (53.35 ± 3.10 mg QE/g) for *Maerua angolensis*. These two plants represent important sources for the development of new improved traditional medicines or nutraceuticals for the management of gastroduodenal ulcers.

Keywords

Maerua angolensis, *Capparis sepiaria*, Ulcer, Acidity, Flavonoids

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1. Introduction

Gastric and duodenal ulcers constitute a major public health problem, particularly in developing countries [1]. Recent studies report a combined prevalence of approximately 15.2% worldwide. This prevalence exceeds 20% in West Africa and 15% in East Africa [2]. In Burkina Faso specifically, prevalence reaches 7% according to studies conducted at the Yalgado Ouedraogo University Hospital Center [3]. Gastroduodenal ulcers result from a disruption of the balance between factors that damage the gastric or duodenal mucosa (gastric acid secretion, pepsin, *Helicobacter pylori* infection) and those that protect it (mucus, bicarbonate, prostaglandins) [4]. Stress, alcohol, tobacco, and certain dietary habits further exacerbate this imbalance [5]. Gastroduodenal ulcers generally present with gastric pain, acid reflux, and nausea, but serious complications can occur, including gastrointestinal hemorrhage, perforations, and pyloric stenosis, which may lead to significant morbidity and mortality, as well as a marked deterioration in quality of life [6]. Treatment involves reducing gastric acid production, strengthening gastric mucosal defenses, and eradicating *Helicobacter pylori* infection [7]. However, resistance to certain antibiotics and the high cost of some modern therapies entail significant socioeconomic consequences [8]. Indeed, a study conducted in 2015 at the Yalgado Ouedraogo University Hospital Center reported that 12% of patients admitted for digestive surgery died [3]. Traditional medicine is an important healthcare resource for African populations. It encompasses a vast repertoire of medicinal plants containing numerous secondary metabolites such as flavonoids, tannins, saponins, and alkaloids that are recognized for their gastroprotective properties [9, 10]. *Maerua angolensis*, known as Zilogo in the Moore language, is a 5 to 10 m tall tree widespread from the Sahel to southern Africa. In traditional medicine, its roots, leaves, and bark are used to treat various ailments, including abdominal pain, diarrhea, dysentery, skin conditions, and malaria [11]. *Capparis sepiaria*, known as kalyanga in Moore, is a spiny shrub. Its roots and leaves are used in many traditional remedies [12]. In addition to their therapeutic properties, the leaves of both plants are edible in many regions of Burkina Faso. However, very few scientific data exist on the biological properties of these plants. The objective of the present study was therefore twofold: on the one hand, to evaluate the ability of the extracts to reduce gastric acidity and on the other hand, to determine the content of bioactive compounds potentially responsible for this effect.

2. Material and Methods

2.1. Material

2.1.1. Plant Material

The leaves of *Maerua angolensis* and *Capparis sepiaria* were collected in August 2025 in Tanghin Dassouri, a locality situated on the southwestern outskirts of Ouagadougou, the

capital. Following taxonomic identification by specialists from the National Herbarium of Burkina Faso (HNBU), the leaves of each plant were thoroughly washed and dried in a well-ventilated room under continuous airflow. After two weeks of drying, the plant materials were ground into fine powders using an electric grinder. The resulting powders were then packaged in transparent bags and stored in the laboratory until further use.

2.1.2. Experimental Animals

Wistar rats weighing between 100 g and 300 g and aged 3 to 5 months were used in this study. The animals were obtained from the animal facilities of the Institute for Health Sciences Research (IRSS)/CNRST and Joseph KI-ZERBO University. They were housed in plastic cages containing wood shavings as bedding, fed with pellets composed of 29% protein, and provided with tap water *ad libitum*. The animals were maintained under controlled environmental conditions, including air conditioning at 23–25°C, an alternating light/dark cycle, and relative humidity of approximately 75%.

2.1.3. Reagents and Solvents

The chemicals used in this study included ethyl acetate (Blulux Laboratories, Abron, India), injectable ketamine hydrochloride USP (Rotex Medica, Germany), absolute methanol (Alpha Chemika, India), *n*-hexane (Central Drug House (P) Ltd., India), distilled water (UJKZ, Laboratory of Biochemistry and Applied Chemistry), dichloromethane (Nice Chemicals Lab, Kerala, India), concentrated hydrochloric acid, phenolphthalein (Rankem, India), absolute ethanol (Blulux Laboratories, India), omeprazole tablets (30 mg), and 0.9% normal saline solution (Sansheng Pharmaceutical PLC, Ethiopia). Additional reagents included glacial acetic acid (Loba Chemie, India), 2% ferrous and ferric chloride solutions, 10% sodium hydroxide, and concentrated sulfuric acid. All chemicals were of analytical grade and were procured from authorized pharmaceutical supply services.

2.2. Methods

2.2.1. Preparation of Crude Extracts and Fractions

For the preparation of the crude extract, 50 g of dried leaves powder were mixed with 500 mL of distilled water in a 1000 mL round-bottom flask. The resulting mixture was brought to a boil under reflux for 30 minutes and then filtered using filter paper and a funnel. The filtrate obtained was concentrated under reduced pressure using a rotary evaporator (Buchi) and subsequently lyophilized. The resulting dry extract was stored at 4°C in a refrigerator until further use. Fractionation was performed by first dissolving 10 g of the dry extract in 50 mL of *n*-hexane. The mixture was vigorously agitated to facilitate the dissolution of nonpolar compounds and then transferred into

a separatory funnel. After phase separation, the hexane fraction was collected in a beaker. This extraction step was repeated four times to ensure exhaustive recovery of hexane-soluble constituents. The residual phase was subjected to extraction with dichloromethane following the same procedure, thereby enabling a progressive extraction of compounds according to their polarity. The different fractions obtained (hexane, dichloromethane and aqueous fractions) were concentrated and dried in an oven at 60°C, and then stored for subsequent phytochemical and biological analyses.

2.2.2. Determination of the Gastric Acid-reducing Effect of Extracts

The ability of the extracts to reduce gastric acidity was evaluated using the pylorus ligation method as described by Arunachalam and *al.* [13]. This method is based on the principle that blocking the passage between the stomach and the intestine, an accumulation of gastric juice occurs in the stomach, allowing the study of acidity and the protective mechanisms of the stomach lining. Following an 18-hour fasting period with free access to water, the animals were randomly divided into four groups of three rats. Each animal was individually marked for identification throughout the experiment. The animals were anesthetized via the intraperitoneal (i.p.) route using ketamine at a dose of 80 mg/kg.w.c. A midline laparotomy

was then performed in the epigastric region to gently exteriorize the stomach, and the pylorus was ligated using a thread (2.5 mm diameter). After pyloric ligation, treatments were administered intraduodenally as follows: animals in Group 1 received distilled water; those in Groups 2 and 3 received the plant extract at doses of 400 mg/kg.w.c. and 500 mg/kg.w.c. respectively; and Group 4 received the reference drug, omeprazole, at a dose of 150 mg/kg.w.c. A uniform administration volume of 5 mL/kg.w.c. was used. After treatment, the stomach was carefully repositioned into the abdominal cavity to avoid internal injury, and the abdomen was sutured using a 2.5 mm thread and a surgical needle.

Six hours post-treatment, the animals were sacrificed by prolongation of anesthesia using a higher dose of ketamine (120 mg/kg.w.c.). The abdomen was reopened, the stomach excised, and the esophagus was ligated to prevent leakage of gastric contents. Figure 1 illustrates the main steps in the removal of the animal's stomach. Then, the stomach was washed externally with 0.9% saline solution and blotted dry using absorbent paper. Gastric content was collected into labeled 10 mL tube and centrifuged at $2000 \times g$ for 10 minutes. The supernatant was carefully collected into 10 mL beaker, and its pH was measured using a pH meter at 25°C. Total acidity was determined by titration with 0.01 N NaOH up to $\text{pH } 7.00 \pm 0.02$, using phenolphthalein as an indicator. Total acidity was calculated using the following formula:

$$\text{Total acidity (mEq H}^+/\text{L)} = (\text{Volume of NaOH} \times \text{N} \times 100 \text{ mEq/L}) / 0.1$$

where N represents the normality of NaOH.

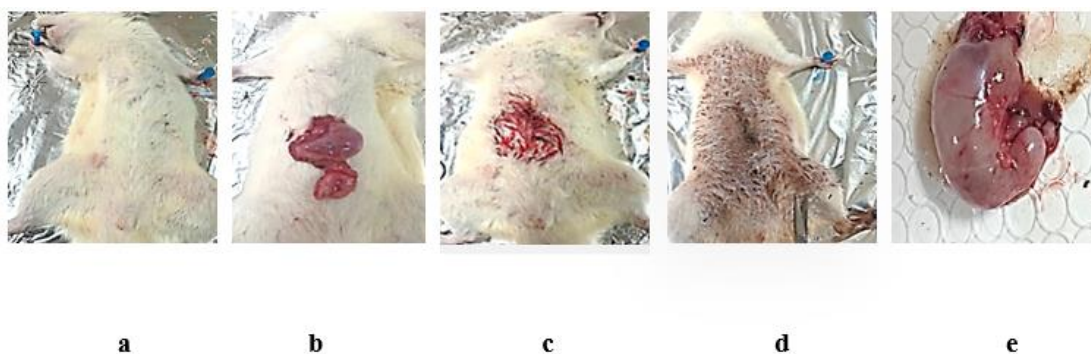


Figure 1. Main steps in the removal of the animal's stomach (Photos: BADO D., 2026).

a: anesthetized rat; b: laparotomy and pyloric ligation; c: stomach replaced in its cavity and sulcus of the abdomen; d: condition of the animal six hours after intraduodenal administration of the extract; e: stomach removed for recovery of gastric contents

2.2.3. Determination of Bioactive Compounds

(i). Total Phenolic Content

Total phenolic content was determined using the Folin–Ciocalteu reagent (FCR) according to the method described by Meda *et al.* [14]. In 96-well microplates, 25 μL of extract or fraction (1 mg/mL) were mixed with 125 μL of FCR (0.2 N)

and incubated for 10 minutes. Subsequently, 100 μL of Na_2CO_3 solution (75 g/L) were added, followed by incubation for 1 hour. Absorbance was measured at 760 nm against a blank consisting of the same mixture in which the extract was replaced with distilled water. Total phenolic content was quantified using a standard calibration curve of gallic acid ($y =$

$10.174x + 0.0826$; $R^2 = 0.9994$). All experiments were performed in triplicate, and results were expressed as the mean of three independent measurements. Values were expressed as milligrams of Gallic Acid Equivalents per gram of dry extract (mg GAE/g).

(ii). Total Flavonoid Content

Total flavonoid content was determined according to the method described Compaore *and al.* [15]. In a 96-well plate, a mixture of 100 μ L of extract or fraction (1 mg/mL) and 100 μ L of $AlCl_3$ (2%) was prepared and incubated for 10 minutes at room temperature. Absorbance was measured at 415 nm against a blank in which the extract was replaced with distilled water. Flavonoid content was quantified using a standard calibration curve of quercetin ($y = 10.972x - 0.2075$; $R^2 = 0.9998$). The experiment was conducted in triplicate, and results were expressed as the mean value. Data were expressed as milligrams of Quercetin Equivalents per gram of dry extract (mg QE/g).

(iii). Determination of Condensed Tannins

Condensed tannin content was determined according to the method described by Heimler *et al.* [16], adapted to 96-well microplates. Briefly, 50 μ L of extract were mixed with 150 μ L of 4% vanillin solution in methanol and 75 μ L of concentrated HCl. The mixture was incubated at 37°C for 20 minutes, and absorbance was measured at 500 nm. Quantification was performed using a catechin standard calibration curve ($y = 3.8984x + 0.128$; $R^2 = 0.9991$). The assay was carried out in triplicate, and results were expressed as milligrams of Catechin Equivalents per gram of dry extract (mg CE/g).

(iv). Determination of Hydrolyzable Tannins

Hydrolyzable tannin content was determined using the method described by Çam and Hışıl [17], adapted to 96-well microplates. In a test tube, 0.3 mL of extract (1 mg/mL) was

mixed with 1.5 mL of $NaIO_3$ (2.5%). The mixture was vortexed for 10 seconds and incubated for 2 minutes. Subsequently, 300 μ L of the mixture were transferred into a 96-well plate, and absorbance was measured at 550 nm against a distilled water blank. Quantification was performed using a tannic acid calibration curve ($y = 0.1918x + 0.0251$; $R^2 = 0.9903$). The assay was conducted in triplicate, and results were expressed as milligrams of Tannic Acid Equivalents per gram of dry extract (mg TAE/g).

3. Statistical Analysis

Results were expressed as mean \pm standard error of the mean (SEM) ($n = 3$). Data were analyzed using one-way analysis of variance (ANOVA) with GraphPad software. Differences were considered statistically significant at $p < 0.05$.

4. Results

4.1. Gastric Acid-reducing Effect of Plant Extracts

The results presented in Table 1 showed the evolution of total gastric acidity and the pH of the medium. We noted a significant reduction in gastric acidity and an increase in pH. The most pronounced acid-reducing activity was observed with the leaves extract of *Maerua angolensis* (32.88 mEq H^+ /L) at a dose of 500 mg/kg.w.c., compared to the effect of the reference drug, omeprazole (24.88 mEq H^+ /L) administered at 150 mg/kg.w.c. Indeed, the pH of the gastric medium increased from 4.35 ± 0.7 in the absence of extract to 6.78 ± 0.35 in its presence. These findings are consistent with the observations of Getachew *and al.* [18], who also reported that certain medicinal plants can reduce gastric acidity and elevate the pH of the gastric environment.

Table 1. Changes in total gastric acidity and pH.

| Parameters | Extracts (mg/kg.w.c) | | | | | Reference substance (mg/kg.w.c) |
|--------------------------------------|----------------------|--------------------------|------------------|--------------------------|------------------|---------------------------------|
| | Negative control | <i>Maerua angolensis</i> | | <i>Capparis sepiaria</i> | | omeprazole |
| | Distilled water | 400 | 500 | 400 | 500 | 150 |
| Total gastric acidity (mEq H^+ /L) | 92.25 ± 9.86 | 40.39 ± 7.57 | 32.88 ± 6.81 | 56.67 ± 1.93 | 43.87 ± 6.95 | 24.88 ± 3.83 |
| pH | 4.35 ± 0.7 | 6.33 ± 0.68 | 6.78 ± 0.35 | 6.23 ± 0.25 | 6.30 ± 0.66 | 7.03 ± 0.21 |

$P < 0.5$ mean \pm standard error of the mean (SEM), $n = 3$

4.2. Bioactive Compound Contents

Table 2 presents the contents of total phenolic compounds, total flavonoids, condensed tannins, and hydrolyzable tannins. The results indicate that *Capparis sepiaria* exhibited the highest levels of total phenolic compounds (both crude extract and fractions), with values of 637.80 mg GAE/g for the aqueous fraction and 587.18 ± 17.05 mg GAE/g for the hexane fraction. This plant also showed the highest tannin contents (both condensed and hydrolyzable), with 209.27 ± 45.94 mg CE/g for the aqueous fraction and 175.08 ± 11.42 mg TAE/g for the crude extract. In this study, the total phenolic and flavonoid contents of *Maerua angolensis*, estimated at 443.68 ± 9.83 mg GAE/g and 53.35 ± 3.10 mg QE/g, respectively, were higher than those reported in our previous work Bado *and al.* [19] for

plant samples collected in Zitenga and than those of Meda and *al.* [14] which were 128.043 ± 2.690 mg GAE/g and 11.994 ± 0.074 mg QE/g, respectively. This difference in levels could be explained by the fact that the content of extracted chemical compounds varies considerably depending on the nature of the soil (pH, humidity, organic matter) and the methodology used (type of solvent, temperature, duration).

Similarly, the contents of total phenolics, flavonoids, and tannins obtained from *Capparis sepiaria* leaves in the present study were markedly higher than those reported by Yassi *and al.* [20], which were 73.8 ± 0.33 mg GAE/g; 3.37 ± 0.54 mg QE/g and 16.66 ± 0.73 mg TAE/g, respectively. This discrepancy could be explained by the plant parts used, as the present study focused on leaves, whereas the previous study analyzed root.

Table 2. Bioactive Compound Contents.

| Extracts | Contents | | | | | | | |
|----------------------------|---------------------------|--------------------------|----------------------------|--------------------------|-----------------------------|--------------------------|----------------------------------|--------------------------|
| | Total phenolic (mg GAE/g) | | Total flavonoids (mg QE/g) | | Condensed tannins (mg CE/g) | | Hydrolysables tannins (mg TAE/g) | |
| | <i>Maerua angolensis</i> | <i>Capparis sepiaria</i> | <i>Maerua angolensis</i> | <i>Capparis sepiaria</i> | <i>Maerua angolensis</i> | <i>Capparis sepiaria</i> | <i>Maerua angolensis</i> | <i>Capparis sepiaria</i> |
| Crude Extracts | 443.68 ± 9.83 | 498.07 ± 56.52 | 53.35 ± 3.10 | 13.90 ± 2.24 | 70.54 ± 12.70 | 153.31 ± 11.40 | 44.93 ± 10.46 | 175.08 ± 11.42 |
| Hexane Fractions | 386.99 ± 24.58 | 587.18 ± 17.05 | 38.60 ± 1.42 | 20.13 ± 2.63 | 49.38 ± 5.09 | 161.31 ± 38.93 | 107.17 ± 4.81 | 117.99 ± 31.25 |
| Dichloro-methane fractions | 363.74 ± 16.86 | 483.65 ± 40.55 | 40.66 ± 0.82 | 20.21 ± 1.77 | 65.84 ± 7.77 | 158.48 ± 25.41 | 68.44 ± 17.73 | 86.74 ± 3.61 |
| Aqueous fractions | 359.48 ± 38.40 | 637.64 ± 43.74 | 36.02 ± 0.47 | 15.42 ± 0.73 | 51.73 ± 18.79 | 209.27 ± 45.94 | 173.41 ± 7.22 | 48.88 ± 4.21 |

P < 0.5 mean \pm standard error of the mean (SEM), n = 3

5. Discussion

The gastric mucosa is directly protected by a layer of mucus and bicarbonate, which together form the first barrier against injurious factors. Gastroduodenal ulcers arise from failure of this mucosal defense system, especially when excess acidity is involved [21, 22]. Indeed, gastric acid excess causes acidification of epithelial cells, leading to their necrosis and resulting in lesions of the gastric mucosal epithelium. Our results showed that the plant extracts significantly reduced gastric acidity while raising the pH of the gastric environment. In particular, the greatest acid-reducing effect was observed with the crude leaves extract of *Maerua angolensis* (32.88 mEq H⁺/L) at a dose

of 500 mg/kg.w.c., compared to 24.88 mEq H⁺/L for the reference drug omeprazole (150 mg/kg). Accordingly, the pH of the medium increased from 4.35 ± 0.70 in the absence of extract to 6.78 ± 0.35 in its presence. Studies showed that acid-reducing capacity is likely due to secondary metabolites such as flavonoids and tannins. These compounds are believed to be capable of irreversibly blocking the ATPase enzyme (H⁺/K⁺-ATPase), commonly known as the "proton pump."

By blocking the proton pump, these plant-based compounds could prevent the final stage of hydrochloric acid production, thereby reducing the volume and acidity of gastric secretions [23]. In particular, this inhibition of the H⁺/K⁺-ATPase is linked to specific structural features of flavonoids due to the presence of two adjacent catechol-type hydroxyl groups, three adjacent

pyrogallol-type hydroxyl groups, or hydroxyl groups at the C-3, C-5, and C-7 positions on the flavonoid [24, 25]. Moreover, flavonoids can stimulate the synthesis of protective prostaglandins, which act to enhance mucus and bicarbonate secretion and improve gastric microcirculation. In this context, bicarbonate plays a buffering role in the stomach by releasing HCO_3^- ions that neutralize gastric H^+ , thus limiting their diffusion into the epithelial cells of the gastric mucosa. Previous studies have also shown that, due to their antihistaminic activity, flavonoids can reduce histamine release involved in inflammation of the digestive mucosa [26, 27]. The presence of tannins also contributes to the acid-reducing activity of the plant extracts. Owing to their astringency, tannins can precipitate proteins in the digestive mucosa, thereby forming a protective barrier that diminishes the harmful effect of gastric acid by reducing H^+ diffusion [24].

6. Conclusion

The objective of this study was to evaluate the gastric acid-reducing potential of *Maerua angolensis* and *Capparis sepiaria*. The presence of bioactive compounds such as flavonoids and tannins may be responsible for the observed reduction in gastric acidity exhibited by these two plants. This finding supports their traditional use in the management of digestive disorders, particularly gastroduodenal ulcers. The regular consumption of these plants by local populations may therefore be encouraged. Furthermore, the development of a nutraceutical or an improved traditional medicine derived from these plants could represent a promising alternative for the management of gastroduodenal ulcers.

Abbreviations

| | |
|-------|---|
| HNBU | National Herbarium of Burkina Faso |
| IRSS | Institute for Health Sciences Research |
| CNRST | National Center for Scientific and Technological Research |
| FCR | Folin–Ciocalteu Reagent |

Author Contributions

David Bado: Writing – original draft

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Kisito Sidibe: Methodology

Nabere Ouattara: Writing – review & editing

Moussa Compaore: Writing – review & editing

Martin Kiendrebeogo: Writing – review & editing

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Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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