ORIGINAL ARTICLE

Quantitative assessment of acid-neutralizing capacity in antibacterial and antiulcer herbal drugs

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Abstract

Background: Peptic ulcers and gastric acidity are prevalent gastrointestinal disorders. Although over-the-counter antacids provide temporary relief, their long-term use is associated with significant side effects, leading to increased interest in safer, herbal alternatives. **Objective:** This study aimed to evaluate the acid-neutralizing capacity (ANC) of selected herbal drugs with known antibacterial and antiulcer properties, and compare them with commercially available antacid formulations. **Methods:** Twenty herbal samples and one commercial antacid (Gelusil) were analyzed for their ANC using a standardized back-titration method. The ANC was calculated by measuring the moles of hydrochloric acid neutralized per gram of sample. **Results:** Commercial antacid Gelusil exhibited ANC value of 1.48 mEq/g. Among herbal drugs, *Acacia arabica* (0.54 mEq/g), *Terminalia chebula* (0.46 mEq/g), and *Aloe barbadensis* (0.35 mEq/g) demonstrated relatively higher acid-neutralizing potential. **Conclusion:** Several herbal drugs showed promising ANC values, suggesting their potential as natural alternatives to synthetic antacids. Further studies on formulation, safety, and clinical efficacy are recommended to validate their therapeutic use.

Key words: Acid neutralizing capacity, antacid, gastric acidity, herbal antibacterial drugs, herbal antiulcer drugs, pH and reaction of herbal drugs, Rossett-Ricetest

INTRODUCTION

Gastric ulcers (stomach) and duodenal ulcers (duodenum) are two forms of peptic ulcer, that result from mucosal erosion in the upper gastrointestinal tract and can lead to complications, such as bleeding or perforation [Figure 1]. The primary symptom is burning pain, which often occurs when the stomach is empty, although it may persist for minutes to hours at any time, accompanied by additional symptoms such as indigestion, blood in vomit or stool, appetite loss, and unintentional weight loss. These ulcers develop because of an imbalance between digestive acid-pepsin secretions and the mucosal defense system, with duodenal ulcers being 2–4 times more common than gastric ulcers. While gastric ulcers may cause nausea, vomiting, and weight loss regardless of acid production levels, duodenal ulcers typically present with episodic epigastric pain that frequently awakens patients at night but subsides after eating. The main causes include Helicobacter pylori infection (in most cases) and chronic NSAID use (e.g., aspirin and ibuprofen). Conventional treatments such as antacids, proton pump inhibitors (PPIs), and antibiotics offer quick relief but have limitations; long-term antacid/PPI use can trigger rebound acidity, nutrient deficiencies (iron, calcium, vitamin B_{12}), and gut dysbiosis, whereas antibiotic risk resistance and side effects such as nausea and diarrhea, underscoring the need for safer, alternative therapies.[1]

Gastric acidity, manifested through symptoms such as heartburn, indigestion, and bloating, represents a widespread health concern affecting millions worldwide. This condition arises from the overproduction of hydrochloric acid (HCl) in the stomach, which can lead to gastric inflammation and ulcer formation. An epidemiological study revealed particularly high incidence rates, with gastroesophageal reflux disease

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(GERD) affecting approximately 22.2% of the population in southern India alone, highlighting the significant burden of acid-related disorders in this region. To manage acid-related symptoms, many individuals takes help of antacids, which are readily available over-the-counter (OTC) medications that provide quick relief by neutralizing stomach acids. These self-prescribed drugs function through multiple mechanisms: They elevate gastric pH by chemical neutralization, suppress acid secretion from parietal cells, and inhibit pepsin proteolytic activity.[2] The U.S. Food and Drug Administration classifies antacids as substances designed to counteract stomach acidity, making them a popular first-line treatment for digestive discomfort.[3] These medications have become excessively common and are often unnecessarily prescribed for minor digestive discomfort. Antacids are the third most frequently purchased OTC medications, following pain relievers and allergy medicines. Their widespread availability significantly increases their potential for misuse.[4] Although antacids provide temporary heartburn relief, they are associated with significant risks. By elevating the gastric pH, these medications trigger gastrin release, which paradoxically stimulates excessive HCl production, creating a cycle of acid rebound that may lead to dependency. Chronic use can impair parietal cell function, potentially causing hypochlorhydria or achlorhydria.[5] Furthermore, antacids interfere with nutrient absorption in the gastrointestinal tract. Aluminum- and magnesium-based formulations disrupt calcium assimilation, whereas most antacids reduce phosphorus bioavailability. These medications may also deplete vitamin B_{12}, vitamin D, potassium, folic acid, zinc, and iron, with sodium bicarbonate and calcium carbonate formulations exhibiting particularly strong iron-blocking effects.[6]

The well-documented controversies and adverse effects surrounding chronic antacid use have prompted the exploration of safer natural alternatives for managing acid-related disorders. Traditional Indian remedies, many using common kitchen ingredients with centuries of safe use, offer promising solutions.[2]

Acid Neutraslizing Capacity (ANC)

ANC is a measure of a substance's ability to neutralize acidic solutions, typically expressed in milliequivalents (mEq) of acid neutralized per unit weight or volume of the substance. It is commonly used to assess the effectiveness of antacids, buffering agents, and environmental materials in counteracting acidity. For pharmaceuticals, ANC is crucial for evaluating antacid formulations, ensuring their ability to relieve the symptoms of acid reflux and gastritis. The benefits of ANC are: Effective Gastric Acid Control (helping maintain gastric pH within a therapeutic range, reducing symptoms of acid reflux, gastritis, and ulcers), and Antacid Efficiency (Higher ANC values indicate greater potency in neutralizing stomach acid, aiding in the selection of effective formulations).[7-10]

MATERIALS AND METHODS

Selection of Samples

Herbal drugs exhibiting both antibacterial and antiulcer activities were prioritized through systematic literature evaluation and assessment of local availability.

Preparation of Samples

Both the selected herbal drugs (processed through collection, cleaning, and drying) and commercial antacids were procured for the study.

Analysis of ANC of Selected Sample

The acid-neutralizing capacity (ANC) was analyzed using the Rossett-Rice test, which employs a back-titration methodology. This technique involves dissolving the antacid in an excess volume of acid, followed by titration with a standardized base solution to the endpoint. ANC was calculated as the difference between the initial moles of acid added and the number of moles of base required for neutralization during back titration.[2]

Procedure (antacid sample)

The antacid sample was first dissolved in excess HCl. The unreacted acid was quantified by titration with a standardized sodium hydroxide (NaOH) solution. During this process, the antacid neutralizes a portion of the initial HCl, the remaining HCl reacts stoichiometrically with NaOH ($H^+ + OH^- \rightarrow H_2O$) and the endpoint occurs when moles of NaOH added equal to the moles of residual HCl.[2]

Herbal sample

Precisely weighed 1 g of each raw herbal drug was homogenized using a mortar and pestle, transferred to conical flasks, and treated with 25 mL of 0.1 M HCl (USP-standardized). 2–3 drops of the phenolphthalein indicator were added to each flask. Titration was performed using 0.1 M NaOH (USP-standardized) until the pink endpoint was observed. Minimum triplicate measurements.[2]

Calculation

Two equations were used for the calculation. The first equation gives the moles of acid neutralized, and the second equation is used to calculate the ANC per gram of antacid.[2]

Equation 1

Moles of acid neutralized = Moles of acid added − Moles of alkali required

$$= (\text{Volume}_{HCl} \times \text{Molarity}_{HCl}) - (\text{Volume}_{NaOH} \times \text{Molarity}_{NaOH})$$

Equation 2

$$\text{Acid neutralizing capacity per gram of antacid} = \frac{\text{Moles of HCl neutralized}}{\text{Grams of antacid}}$$

Selected Commercially Available Antacid Drugs

Various over-the-counter antacid formulations are commercially available in pharmacies. For this study, we selected two commonly used antacid products based on their widespread consumer use and local pharmacy availability, detailed specifications are provided in Table 1.

Both ENO and Gelusil are OTC (non-prescription) drugs. They are easily available in pharmacies without requiring a doctor's prescription. However, doctors may recommend Gelusil for chronic acidity or GERD as part of a treatment plan. Therefore, Gelusil was selected for ANC evaluation.

Selected Antibacterial and Antiulcer Herbal Drugs for AMC Evaluation

Twenty herbal drugs with documented antibacterial and antiulcer properties were selected through a literature review for ANC evaluation, as detailed in Table 2. According to their pH they are classified as acidic, acidic to neutral, neutral to alkaline and alkaline as shown in Table 3.

RESULTS

ANC Value of Selected Commercial Antacid Drugs

We quantified the acid-neutralizing property of a commercial antacid (Gelusil) by back-titration, and the results are detailed in Table 4.

One milliliter of antacid of the oral suspension (containing a strong base as active ingredients) was analyzed. The ANC was determined by measuring the HCl neutralization, with higher values indicating superior efficacy. Table 5 summarizes the ANC properties of these formulations.

Gelusil (magnesium hydroxide based) achieved the 1.48 (mEq/g) an ANC value in this study as quantified by back-titration.

Each herbal sample (1.0 g) was tested for its ANC to assess antacid activity.

ANC Value of Selected Herbal Drugs

The ANC was determined through a standardized back-titration methodology, consistent with commercial antacid testing protocols, with the quantitative data shown in Table 6.

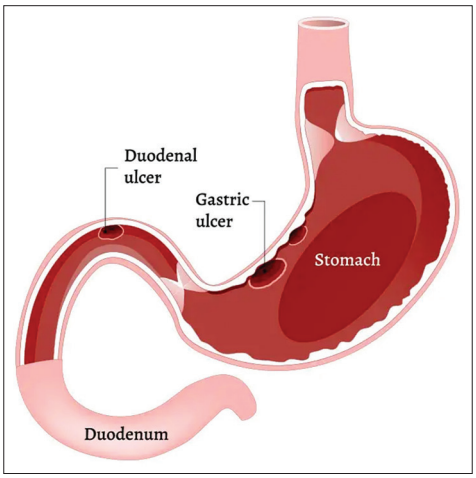

Figure 1: Gastric ulcer and duodenal ulcer (Courtesy: Can Fasting Help Stomach Ulcer? – Intermittent Dieter)

Table 1: Selected commercially available antacid drugs (image courtesy: www.amazon.in)

S. No.	Sample	Price/unit in INR	Active ingredient	Marketed product
1	ENO	ENO Fruit Salt Regular Antacid Sachet Of 5 G for INR 10	Sodium bicarbonate – 2 g	
2	Gelusil	Gelusil MPS - Bottle of 200 mL Syrup for INR 130.05	Magnesium Aluminium Silicate Gel: 4% w/v	

Table 2: pH and reactions of selected traditionally used herbal antibacterial and antiulcer drugs[11,12]

S. No.	Drug	Botanical name	Family	h	Reaction
1	Babool, Indian Gum Arabic tree	*Acacia Arabica*	Leguminoseae	~9.0–10.0	Alkaline
2	Bael, Bengal quince, golden apple, Japanese bitter orange, stone apple, wood apple, Belli	*Aegle marmelos L.*	Rutaceae	~8.0–8.5	Alkaline
3	Garlic, Lassan	*Allium sativum*	Amaryllidaceae	~6.0–6.5	Slightly acidic
4	Aloe vera, Gwar Patha, Kuwar Patha	*Aloe barbadensis M.*	Asphodelaceae (Liliaceae)	~8.0–8.5	Alkaline
5	Neem	*Azadirachta indica*	*Meliacea*	~6.5–7.0	Acidic to neutral
6	Daruharidra, Indian Barberry, Tree Turmeric, Chitra	*Berberis aristata*	*Berberidaceae*	~7.0–7.5	Neutral to alkaline
7	Beet root	*Beta vulgaris L.*	Amaranthaceae	~5.0–6.0	Mildly acidic
8	Papaya, Papita, Melon tree	*Carica papaya*	Caricaceae	~5.0–5.5	Slightly Acidic
9	Peepal, Peepdi	*Ficus religiosa*	Moraceae	~7.0–7.5	Neutral to alkaline
10	Gurhal, China rose, Jasod	*Hibiscus rosa sinensis*	Malvaceae	~6.0–6.5	Slightly acidic
11	Mango, Aam	*Mangifera indica*	Anacardiaceae	~5.5–6.0	Slightly Acidic
12	touch me not, Sensitive plant, Lajjamdi	*Mimosa pudica*	Fabaceae	~7.0–7.5	Neutral to alkaline
13	Drumstick tree, Horseradish tree, Senjana, Seeng	*Moringa oleifera*	Moringaceae	~7.5–8.0	Alkaline
14	Tulsi, Holi basil	*Ocimum sanctum*	Lamiaceae	~7.0–8.0	Neutral to alkaline
15	Bhuaamla, Gale of the wind, Stone breaker, Seed under leaf	*Phyllanthus niruri*	Phyllanthaceae	~6.5–7.0	Acidic to neutral
16	Mokoi, Black nightshade	*Solanum nigrum*	Solananceae	~6.0–6.5	Slightly acidic
17	Imli, Tamarind, Amli	*Tamarindus indica*	Caesalpiniaceae	~2.0–3.5	Highly Acidic
18	Harra, Myrobalan, Chebulic myrobalan, Harad, Harde	*Terminalia chebula*	Combretaceae	~8.5–9.0	Alkaline
19	Bhringraj, False daisy, trailing eclipta, Kesharaj, Bhingdo	*Eclipta alba*	Asteraceae	~7.0–7.5	Neutral to alkaline
20	Podina, Field mint, Wild mint, Corn mint, Fudina	*Mentha arvensis*	Lamiaceae	~6.5–7.0	Acidic to neutral

Table 3: Classification of herbal drugs as per the pH and reactions

pH and Reactions			
Acidic	**Acidic to neutral**	**Neutral to alkaline**	**Alkaline**
Tamarindus indica (pH: ~2.0–3.5)	*Mentha arvensis* (pH: ~6.5–7.0)	*Mimosa pudica* (pH: ~7.0–7.5)	*Moringa oleifera* (pH: ~7.5–8.0)
Carica papaya (pH: ~5.0–5.5)	*Azadirachta indica* (pH: ~6.5–7.0)	*Ficus religiosa* (pH: ~7.0–7.5)	*Aegle marmelos* L. (pH: ~8.0–8.5)
Beta vulgaris L. (pH: ~5.0–6.0)	*Phyllanthus niruri* (pH: ~6.5–7.0)	*Berberis aristata* (pH: ~7.0–7.5)	*Aloe barbadensis* M. (pH: ~8.0–8.5)
Mangifera indica (pH: ~5.5–6.0)	--	*Eclipta alba* (pH: ~7.0–7.5)	*Terminalia chebula* (pH: ~8.5–9.0)
Allium sativum (pH: ~6.0–6.5)	--	*Ocimum sanctum* (pH: ~7.0–8.0)	*Acacia arabica* (pH: ~9.0–10.0)
Solanum nigrum (pH: ~6.0–6.5)	--	--	--
Hibiscus rosa-sinensis (pH: ~6.0–6.5)	--	--	--

Table 4: ANC value of selected commercial antacid

Particulars	Antacid (Gelusil)
Active ingredient	Magnesium Hydroxide, Aluminum Hydroxide, Simethicone
Weight of active ingredient per gram or mL of product	0.04 g or 40 mg
Weight/Amount of product	1 g
% of active ingredient	4%
Volume of NaOH used for titration (mL)	10.2
Volume of HCl neutralized by NaOH (mL)	25
Volume of HCl neutralize d by antacids	14.8
Moles of HCl neutralized	1.48

Table 5: ANC value of the selected commercial antacid

Sample	Moles of HCl neutralized	Antacid weight	ANC (mEq/g)
Gelusil	1.48	1 g	1.48

ANC: Acid-neutralizing capacity

ANC Value of Herbal Drugs

ANC testing identified *A. Arabica* (0.54 mEq/g) and *T. chebula* (0.46 mEq/g) as clinically relevant herbal antacids, contrasting with *Tamarindus indica* and *Carica papaya* which showed no practical ANC (<0.1 mEq/g) as shown in Table 7. Arrangement of herbal drugs according to their ANC Values from strong to weak with their key components contributing to ANC are given in Table 8.

DISCUSSION

ANC experiments were performed on commercial antacids as standard and herbal drugs. It was found that the ANC values of herbal drugs i.e., *Acacia Arabica* showed 0.54 mEq/g *Terminalia chebula* showed 0.46 mEq/g and commercial antacid Gelusil showed 1.48 mEq/g on comparing with the standard it was observed that *A. Arabica* and *T. chebula* show mild efficacy (0.46–0.54 mEq/g) and could be suitable for mild acidity or as adjunct therapy to reduce synthetic antacid dependence [Figure 2]. Although commercial antacids have higher ANC, they have a risk of rebound acidity and nutrient malabsorption, similar to B_{12} deficiency. Despite the lower ANC of herbal drugs, they are safer for long-term use, and

Table 6: Moles of HCl neutralized by antacid

S. No.	Drug	Mass of sample (g) measured	Average volume of NaOH used for titration (mL)	Volume of HCl neutralized by NaOH (mL)	Volume of HCl neutralize d by herbal drugs	Moles of HCl neutralized by herbal drugs
1	Babool (*Acacia arabica*)	1 g	19.6	25.0	5.4	0.54
2	Bael (*Aegle marmelos* L.)	1 g	21.8	25.0	3.2	0.32
3	Garlic (*Allium sativum*)	1 g	22.4	25.0	2.6	0.26
4	Aloe vera (*Aloe barbadensis* M.)	1 g	21.5	25.0	3.5	0.35
5	Neem (*Azadirachta indica*)	1 g	24.3	25.0	0.7	0.07
6	Daruharidra (*Berberis aristata*)	1 g	23.7	25.0	1.3	0.13
7	Beet root (*Beta vulgaris* L.)	1 g	24.8	25.0	0.2	0.02
8	Papaya (*Carica papaya*)	1 g	24.9	25.0	0.1	0.01
9	Peepal (*Ficus religiosa*)	1 g	23.9	25.0	1.1	0.11
10	Gurhal (*Hibiscus rosa sinensis*)	1 g	24.4	25.0	0.6	0.06
11	Mango (*Mangifera indica*)	1 g	24.8	25.0	0.2	0.02
12	Touch me not (*Mimosa pudica*)	1 g	24.1	25.0	0.9	0.09
13	Drumstick tree (*Moringa oleifera*)	1 g	22.5	25.0	2.5	0.25
14	Tulsi (*Ocimum sanctum*)	1 g	23.3	25.0	1.7	0.17
15	Bhuaamla (*Phyllanthus niruri*)	1 g	24.1	25.0	0.9	0.09
16	Mokoi (*Solanum nigrum*)	1 g	24.5	25.0	0.5	0.05
17	Imli (*Tamarindus indica*)	1 g	25.0	25.0	0.0	0.00
18	Harra (*Terminalia chebula*)	1 g	20.4	25.0	4.6	0.46
19	Bhringraj (*Eclipta alba*)	1 g	23.6	25.0	1.4	0.14
20	Podina (*Mentha arvensis*)	1 g	24.4	25.0	0.6	0.06

Table 7: ANC value of the herbal drugs

S. No.	Samples	Moles of HCl neutralized	Drug taken (g)	ANC (mEq/g)
1	Babool (*Acacia arabica*)	0.54	1.0	0.54
2	Bael (*Aegle marmelos* L.)	0.32	1.0	0.32
3	Garlic (*Allium sativum*)	0.26	1.0	0.26
4	Aloe vera (*Aloe barbadensis* M.)	0.35	1.0	0.35
5	Neem (*Azadirachta indica*)	0.07	1.0	0.07
6	Daruharidra (*Berberis aristata*)	0.13	1.0	0.13
7	Beet root (*Beta vulgaris* L.)	0.02	1.0	0.02
8	Papaya (*Carica papaya*)	0.01	1.0	0.01
9	Peepal (*Ficus religiosa*)	0.11	1.0	0.11
10	Gurhal (*Hibiscus rosa sinensis*)	0.06	1.0	0.06
11	Mango (*Mangifera indica*)	0.02	1.0	0.02
12	Touch me not (*Mimosa pudica*)	0.09	1.0	0.09
13	*Drumstick tree (Moringa oleifera*)	0.25	1.0	0.25
14	Tulsi (*Ocimum sanctum*)	0.17	1.0	0.17
15	Bhuaamla (*Phyllanthus niruri*)	0.09	1.0	0.09
16	Mokoi (*Solanum nigrum*)	0.05	1.0	0.05
17	Imli (*Tamarindus indica*)	0.00	1.0	0.00
18	Harra (*Terminalia chebula*)	0.46	1.0	0.46
19	Bhringraj (*Eclipta alba*)	0.14	1.0	0.14
20	Podina (*Mentha arvensis*)	0.06	1.0	0.06

Table 8: Arrangement of herbal drugs according to their ANC values from strong to weak

Drug	ANC (mEq/g)	Key components contributing to ANC
Acacia arabica	0.54	Gum arabic (highly alkaline)
Terminalia chebula	0.46	Chelbulic acid (strong Ayurvedic antacid)
Aloe barbadensis M.	0.35	Polysaccharides (buffering)
Aegle marmelos L.	0.32	Marmelosin (mucilage+alkaloids)
Allium sativum	0.26	Allicin (mild buffering)
Moringa oleifera	0.25	Calcium/magnesium (natural antacid)
Ocimum sanctum	0.17	Eugenol (anti-inflammatory)
Eclipta alba	0.14	Wedelolactone (mild ANC)
Berberis aristata	0.13	Berberine (antiulcer alkaloid)
Ficus religiosa	0.11	Tannins (mucosal protection)
Mimosa pudica	0.09	Mucilage (coats stomach)
Phyllanthus niruri	0.09	Phyllanthin (liver support, weak ANC)
Azadirachta indica	0.07	Nimbidin (bitter, weak ANC)
Mentha arvensis	0.06	Menthol (soothing, minimal ANC)
Hibiscus rosa-sinensis	0.06	Citric/ascorbic acid (some mineral buffering)
Solanum nigrum	0.05	Solanine (weak base)
Mangifera indica	0.02	Polyphenols (negligible ANC)
Beta vulgaris L.	0.03	Betalains (weak alkalizing post-digestion)
Carica papaya	0.01	Papain (digestive enzyme, minimal ANC)
Tamarindus indica	0.00	Tartaric acid (acidic, no neutralization)

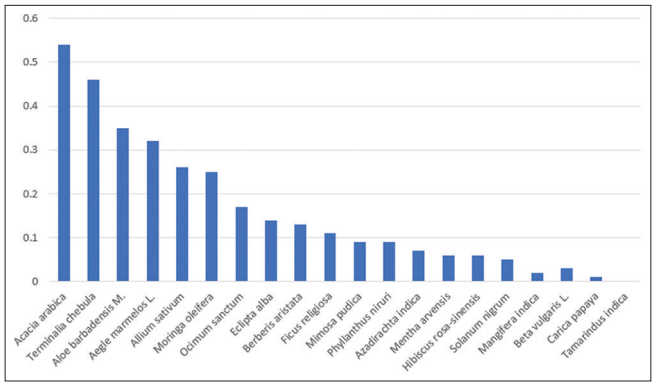

Figure 2: Acid-neutralizing capacity (mEq/g) of herbal drugs

there are no reported side effects. If ANC ≥ 1.0 mEq/g is the clinical threshold, herbal drugs may require dose optimization or combination therapy.

CONCLUSION

Antacids represent a therapeutic strategy for peptic ulcers by reducing gastric acidity, although the prolonged use of synthetic formulations may lead to adverse effects. The potential side effects and risks of chronic antacid use have prompted interest in exploring safer natural alternatives to manage acidity. Growing public reliance on unverified internet remedies lacking scientific backing underscores the need for evidence-based solutions. This study's evaluation of the revealed several effective traditional options, listed in ascending order of potency: *A. arabica*, *T. chebula*, *Aloe barbadensis,* and *Aegle marmelos*. These botanicals offer practical advantages owing to their widespread cultural acceptance, proven historical use, and ready availability in many communities. However, these drugs have been extensively utilized traditionally for gastrointestinal health, wound/skin healing, metabolic health, and microbial infection. Studies have shown that an increase in the dose or combination of two or more drugs can give the desired effects. Herbal formulations combining proven traditional remedies can provide safe and effective relief for mild acid reflux, offering rapid symptom relief without adverse effects while enhancing therapeutic benefits. More research is necessary to identify the ideal combinations of these herbal remedies.

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