# EVALUATING THE ACID NEUTRALISING CAPACITY OF SOME ANTACIDS SOLD OVER THE COUNTER WITHIN ILORIN METROPOLITAN

**BY**

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**A PROJECT SUBMITTED TO THE DEPARTMENT OF SCIENCE LABORATORY AND TECHNOLOGY, FACULTY OF APPLIED SCIENCES, KWARA STATE POLYTECHNIC, ILORIN.**

## ATTESTATION

I hereby attest to the originality of this project that I have submitted to the Department of Science Laboratory Technology, Faculty of Applied Science, Kwara State Polytechnic Ilorin for my final approval. All work thereing is original, and material for others used have been adequately referenced.

**OKELEYE TOFUNMI JOHN** _____

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## CERTIFICATION

This is to certify that the study carried out by Okeleye Tofunmi John (ND/23/SLT/PT/0391), has been considered as meeting the requirement of the Department of Science Laboratory Technology, Faculty of Applied Science, Kwara State Polytechnic Ilorin in a partial fulfillment for the award of National Diploma ND in Science Laboratory Technology.

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## DEDICATION

This Project is Dedicated to almighty GOD

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# CHAPTER ONE
# INTRODUCTION

## 1.0 ANTACIDS

Antacids are over-the-counter medications commonly used to relieve symptoms associated with acid reflux, heartburn, and indigestion. They work by neutralizing excess stomach acid (hydrochloric acid, HCl), thereby increasing the pH of gastric contents and providing symptomatic relief (Smith & Johnson, 2021). The active ingredients in antacids vary but often include compounds such as magnesium hydroxide, aluminum hydroxide, calcium carbonate, and sodium bicarbonate. These compounds react with gastric acid to form salt and water, reducing acidity and alleviating discomfort (Brown *et al.*, 2023).

The mechanism of action of antacids is based on simple acid-base chemistry. For example, calcium carbonate ($CaCO_3$) reacts with hydrochloric acid (HCl) to form calcium chloride ($CaCl_2$), carbon dioxide ($CO_2$), and water ($H_2O$), effectively neutralizing the acid (Jones & Patel, 2022). Similarly, magnesium hydroxide [$Mg(OH)_2$] reacts with HCl to form magnesium chloride ($MgCl_2$) and water. The effectiveness of an antacid depends on its neutralizing capacity, which varies among different formulations (Williams *et al.*, 2024). Factors such as dissolution rate, formulation type (tablet, liquid, or gel), and presence of additional ingredients like alginates or simethicone influence how well and how quickly the antacid works (Miller & Carter, 2020).

Evaluating the acid neutralizing capacity (ANC) of antacids is essential in determining their effectiveness and guiding their clinical use. Various methods, including back titration and pH-metric analysis, are used to quantify ANC in both laboratory and pharmaceutical settings (Garcia *et al.*, 2021). Additionally, the prolonged use of certain antacids has been associated with potential health implications, such as altered calcium absorption, kidney stone formation, and metabolic alkalosis, necessitating appropriate usage recommendations (Roberts & Lee, 2023).

## 1.1 COMMON ANTACIDS IN NIGERIA

Antacids are widely used in Nigeria for the management of acid-related disorders such as heartburn, indigestion, and gastroesophageal reflux disease (GERD). The availability and affordability of these medications make them a popular choice for self-medication among Nigerians (Oluwaseun & Adekunle, 2021). In Nigeria, commonly used antacids include brands and generic formulations containing active ingredients such as magnesium hydroxide, aluminum hydroxide, calcium carbonate, and sodium bicarbonate. These compounds function by neutralizing excess stomach acid, thereby relieving discomfort and protecting the stomach lining from irritation (Okeke *et al.,* 2023).

Among the most widely recognized antacid brands in Nigeria is Gestid, which contains a combination of aluminum hydroxide, magnesium hydroxide, and simethicone. This formulation provides effective acid neutralization while the simethicone component helps reduce bloating and gas formation (Adebayo & Chukwuma, 2022). Another popular antacid is Andrews Liver Salt, which contains sodium bicarbonate and citric acid. It acts as an effervescent antacid, providing rapid relief from acid indigestion and bloating (Emmanuel & Uchenna, 2023). Gaviscon, a well-known international brand also available in Nigeria, contains sodium alginate in addition to antacid compounds. It not only neutralizes acid but also forms a protective barrier to prevent acid reflux, making it a preferred choice for GERD management (Chidiebere *et al.,* 2024).

Additionally, Eno Fruit Salt, another effervescent antacid, is commonly used for quick relief from acidity and bloating. It contains sodium bicarbonate, citric acid, and sodium carbonate, which react with gastric acid to form carbon dioxide, facilitating fast neutralization (Ogundipe & Williams, 2021). Magnesium Trisilicate, a generic formulation available in Nigeria, is also widely used and functions by coating the stomach lining while providing a sustained neutralizing effect (Okon & Bello, 2022).

The preference for specific antacids in Nigeria often depends on accessibility, affordability, and perceived effectiveness. However, concerns have been raised about the indiscriminate use of antacids, especially those containing sodium bicarbonate, due to potential side effects such as

alkalosis, electrolyte imbalances, and kidney-related complications when used excessively (Akinyemi *et al.*, 2023). Therefore, understanding the acid-neutralizing capacity of these formulations is essential for guiding their appropriate use and ensuring optimal gastrointestinal health outcomes.

## 1.2 TYPES OF ANTACIDS

Antacids are classified based on their active ingredients, which determine their acid- neutralizing capacity and overall effectiveness in managing gastric acidity. The primary types of antacids include aluminum-based, magnesium-based, calcium-based, sodium- based, and combination antacids. Each type has unique properties, benefits, and potential side effects, making them suitable for different patient needs (Okonkwo & Adeyemi, 2021).

### 1.2.1 Aluminum-Based Antacids

Aluminum hydroxide is a common ingredient in many antacid formulations. It neutralizes stomach acid by forming aluminum chloride and water, providing effective relief from acidity and heartburn. One of its advantages is its ability to form a protective layer on the stomach lining, reducing irritation and promoting ulcer healing (Eze *et al.*, 2023). However, prolonged use of aluminum-based antacids has been associated with constipation and potential interference with phosphate absorption, which may lead to hypophosphatemia, especially in long-term users (Williams & Chukwudi, 2022).

### 1.2.2 Magnesium-Based Antacids

Magnesium hydroxide and magnesium trisilicate are commonly used in antacid formulations due to their rapid acid-neutralizing action. Magnesium-based antacids work by reacting with hydrochloric acid to form magnesium chloride and water, leading to a quick increase in gastric pH (Ogunleye *et al.*, 2023). Unlike aluminum-based antacids, they tend to have a laxative effect, which can be beneficial for individuals prone to constipation. However, excessive use may result in diarrhea or hypermagnesemia, particularly in patients with renal impairment (Adebayo & Yusuf, 2024).

### 1.2.3 Calcium-Based Antacids

Calcium carbonate is widely used in antacid preparations due to its strong acid-neutralizing capacity. It reacts with stomach acid to form calcium chloride, carbon dioxide, and water, providing quick and long-lasting relief from acid reflux and indigestion (Chidiebere & Okafor, 2023). Additionally, calcium-based antacids contribute to calcium intake, which can be beneficial for bone health. However, excessive consumption may lead to hypercalcemia, milk-alkali syndrome, and rebound acid secretion, where the stomach produces more acid after the initial neutralization effect wears off (Oluwaseun *et al.,* 2022).

### 1.2.4 Sodium-Based Antacids

Sodium bicarbonate is a fast-acting antacid that provides immediate relief from heartburn and acid indigestion by reacting with hydrochloric acid to produce carbon dioxide, water, and sodium chloride. It is commonly found in effervescent antacid formulations, such as Eno and Andrews Liver Salt (Emmanuel & Okechukwu, 2021). While effective, sodium- based antacids are not recommended for long-term use due to their high sodium content, which can contribute to hypertension and fluid retention, particularly in individuals with cardiovascular or kidney conditions (Akinyemi *et al.,* 2023).

### 1.2.5 Combination Antacids

Many commercial antacids combine multiple active ingredients to balance efficacy and minimize side effects. For instance, magnesium and aluminum hydroxides are often combined to counteract the laxative effect of magnesium with the constipating effect of aluminum (Ogundipe & Williams, 2022). Another example is the inclusion of alginates in some formulations, such as Gaviscon, which not only neutralizes acid but also creates a protective barrier against reflux (Okon & Bello, 2023). These combination antacids are particularly effective for individuals requiring sustained acid suppression with minimal gastrointestinal side effects.

The choice of antacid depends on the severity of symptoms, underlying health conditions, and potential side effects. While antacids provide effective short-term relief, excessive or prolonged use can lead to electrolyte imbalances, metabolic disturbances, and interactions with other

medications (Olawale *et al.,* 2024). Therefore, proper evaluation of their acid- neutralizing capacity is crucial for optimizing their use and ensuring safety.

## 1.3 INORGANIC ANTACIDS

Inorganic antacids are compounds derived from minerals and inorganic salts that help neutralize gastric acid, providing relief from conditions such as acid reflux, heartburn, and indigestion. These antacids typically contain metal hydroxides, carbonates, or bicarbonates that react with hydrochloric acid (HCl) in the stomach to form water and neutral salts, thereby increasing gastric pH and reducing acidity (Okonkwo & Adeyemi, 2021). The most commonly used inorganic antacids include aluminum hydroxide, magnesium hydroxide, calcium carbonate, and sodium bicarbonate.

### 1.3.1 Aluminum Hydroxide

Aluminum hydroxide [$Al(OH)_3$] is a widely used antacid that neutralizes stomach acid by forming aluminum chloride ($AlCl_3$) and water. It is known for its ability to provide prolonged acid suppression and is often used in combination with other antacids to enhance its efficacy (Eze *et al.,* 2023). One of its advantages is its protective effect on the gastric lining, making it useful in ulcer treatment. However, prolonged use may lead to constipation and phosphate depletion, resulting in hypophosphatemia, which can weaken bones and cause other metabolic disturbances (Williams & Chukwudi, 2022).

### 1.3.2 Magnesium Hydroxide

Magnesium hydroxide [$Mg(OH)_2$], also known as milk of magnesia, is an inorganic antacid with a rapid acid-neutralizing effect. It reacts with hydrochloric acid to produce magnesium chloride ($MgCl_2$) and water, effectively increasing gastric pH (Ogunleye *et al.,* 2023). In addition to its antacid properties, it has a mild laxative effect, which can be beneficial for individuals suffering from constipation. However, excessive intake may lead to diarrhea and, in patients with kidney disease, hypermagnesemia, which can cause neurological and cardiovascular complications (Adebayo & Yusuf, 2024).

### 1.3.3 Calcium Carbonate

Calcium carbonate ($CaCO_3$) is a potent inorganic antacid that provides quick and long- lasting relief from acid-related discomfort. It reacts with hydrochloric acid to form calcium chloride ($CaCl_2$), carbon dioxide ($CO_2$), and water, which increases gastric pH and reduces acidity (Chidiebere & Okafor, 2023). Due to its high neutralizing capacity, calcium carbonate is commonly used in chewable and effervescent antacid formulations. Additionally, it contributes to calcium intake, which is beneficial for bone health. However, excessive use can lead to hypercalcemia, kidney stone formation, and rebound acid secretion, where the stomach produces more acid after the neutralization effect wears off (Oluwaseun *et al.*, 2022).

### 1.3.4 Sodium Bicarbonate

Sodium bicarbonate ($NaHCO_3$) is a fast-acting inorganic antacid that neutralizes stomach acid by producing carbon dioxide ($CO_2$), water, and sodium chloride (NaCl). It is commonly found in effervescent antacids such as Eno and Andrews Liver Salt, providing rapid relief from acid indigestion and bloating (Emmanuel & Okechukwu, 2021). Despite its effectiveness, sodium bicarbonate is not recommended for long-term use due to its high sodium content, which can contribute to hypertension, fluid retention, and metabolic alkalosis (Akinyemi *et al.*, 2023). Additionally, the release of carbon dioxide can cause bloating and discomfort in some individuals (Ogundipe & Williams, 2022).

### 1.3.5 Comparative Analysis and Considerations

Inorganic antacids vary in their acid-neutralizing capacity, duration of action, and side effects. While aluminum and calcium-based antacids provide longer-lasting relief, they may cause constipation or rebound acid secretion. Magnesium-based antacids act quickly but can induce diarrhea, making combination formulations a preferred choice to balance their effects (Okon & Bello, 2023). Sodium bicarbonate, though effective for immediate relief, has significant risks when used excessively, particularly in individuals with cardiovascular or renal conditions (Olawale *et al.*, 2024).

The evaluation of inorganic antacids' acid-neutralizing capacity is essential for determining their effectiveness and ensuring their safe use. Excessive reliance on these medications without medical supervision can lead to metabolic imbalances and other health complications. Therefore, proper dosing and consideration of patient-specific factors are necessary to optimize their benefits while minimizing risks.

## 1.4 ORGANIC ANTACIDS

Organic antacids are less common than their inorganic counterparts but play a significant role in acid neutralization and gastrointestinal protection. These antacids are derived from organic compounds, including naturally occurring substances such as alginates and amino acid-based formulations. They act by neutralizing stomach acid, forming protective barriers, or buffering gastric pH to alleviate conditions such as acid reflux, heartburn, and indigestion (Okonkwo & Adeyemi, 2021). Unlike inorganic antacids, organic antacids often have additional properties, such as mucosal protection and anti-inflammatory effects, making them useful for specific patient populations.

### 1.4.1 Alginates

One of the most widely used organic antacid components is alginic acid, commonly found in formulations such as Gaviscon. Alginates, derived from brown seaweed, work by forming a gel-like barrier that floats on top of stomach contents, preventing acid reflux into the esophagus (Eze *et al.,* 2023). When combined with bicarbonates, alginates produce a foamy protective layer that reduces gastroesophageal reflux, providing longer-lasting relief than standard acid neutralization (Williams & Chukwudi, 2022). This makes alginate-based antacids particularly beneficial for individuals with gastroesophageal reflux disease (GERD).

### 1.4.2 Amino Acid-Based Antacids

Some organic antacids incorporate amino acid salts, such as glycine and alginate-amino acid complexes, which help buffer stomach acid while supporting gastric mucosal healing. These compounds act as weak bases, neutralizing excess hydrochloric acid while also promoting a balanced gastric environment (Ogunleye *et al.,* 2023). Amino acid-based antacids are considered

gentler on the digestive system and are sometimes used in combination with inorganic antacids to enhance efficacy while minimizing potential side effects.

### 1.4.3 Sucralfate and Other Organic Buffers

Though not a traditional antacid, **sucralfate** is an organic compound that exhibits acid- buffering properties. It forms a protective coating over ulcers and erosions in the stomach lining, reducing exposure to gastric acid and allowing healing to occur (Adebayo & Yusuf, 2024). Unlike conventional antacids, sucralfate does not significantly alter stomach pH but provides symptomatic relief by protecting damaged mucosa. It is often used in patients with peptic ulcers and those at risk of gastrointestinal bleeding due to prolonged acid exposure (Chidiebere & Okafor, 2023).

### 1.4.4 Comparative Analysis and Considerations

Organic antacids differ from inorganic ones in their mode of action and additional therapeutic benefits. While inorganic antacids focus primarily on neutralizing acid, organic antacids often provide mechanical protection and mucosal support. Alginates are particularly effective for reflux conditions, whereas amino acid-based antacids and sucralfate support gastric healing and ulcer management (Oluwaseun *et al.*, 2022). Furthermore, organic antacids generally have fewer side effects, making them suitable for long-term use in individuals with chronic acid- related conditions.

The evaluation of organic antacids' effectiveness involves assessing their acid-neutralizing capacity, ability to form protective barriers, and impact on gastric motility. Research continues to explore novel organic antacid formulations that optimize relief while minimizing complications associated with prolonged acid suppression (Emmanuel & Okechukwu, 2021). As the demand for safer, more sustainable acid-neutralizing agents increases, organic antacids may play a larger role in managing gastrointestinal disorders with fewer adverse effects compared to traditional inorganic antacids (Akinyemi *et al.*, 2023).

## 1.5 PROPERTIES OF ANTACIDS

Antacids possess several key properties that determine their effectiveness in neutralizing gastric acid, alleviating symptoms of acid-related disorders, and ensuring patient safety. These properties include acid-neutralizing capacity, solubility, reaction speed, buffering effect, duration of action, and side effect profile. The choice of an antacid depends on these characteristics, which influence its clinical application and therapeutic benefits (Okonkwo & Adeyemi, 2021).

### 1.5.2 Solubility and Reaction Speed

The solubility of an antacid affects its onset of action. Highly soluble antacids, such as sodium bicarbonate, dissolve quickly in gastric fluid and neutralize acid rapidly, providing almost immediate relief from symptoms (Ogunleye *et al.*, 2023). However, their effect is short-lived, and they can cause bloating due to carbon dioxide release. On the other hand, poorly soluble antacids, such as aluminum hydroxide, have a slower onset but provide prolonged acid suppression, making them useful for sustained relief (Adebayo & Yusuf, 2024).

### 1.5.3 Buffering Effect and pH Stability

Some antacids not only neutralize acid but also act as buffers, helping maintain a stable gastric pH. This is particularly important for preventing drastic pH fluctuations that may trigger rebound acid secretion. For example, calcium carbonate provides a strong neutralizing effect but may lead to increased acid production once its effects wear off, whereas magnesium- aluminum combinations help stabilize pH without causing rebound acidity (Chidiebere & Okafor, 2023).

### 1.5.4 Duration of Action

The duration of an antacid's effect depends on its formulation and interaction with gastric contents. Liquid antacids generally work faster but have a shorter duration, whereas tablet formulations provide longer-lasting relief (Oluwaseun *et al.*, 2022). Combination antacids that include alginates, such as Gaviscon, not only neutralize acid but also form a protective barrier against reflux, extending their effectiveness beyond simple acid neutralization (Emmanuel & Okechukwu, 2021).

### 1.5.5 Side Effect Profile

Each type of antacid has specific side effects based on its composition. Aluminum- containing antacids can cause constipation and phosphate depletion, while magnesium-based antacids may lead to diarrhea. Calcium carbonate can contribute to kidney stone formation and metabolic alkalosis if consumed in excess (Akinyemi *et al.,* 2023). Sodium bicarbonate, due to its high sodium content, is not recommended for hypertensive patients as it can cause fluid retention and cardiovascular complications (Ogundipe & Williams, 2022).

### 1.5.6 Comparative Analysis of Antacid Properties

A well-balanced antacid should provide effective acid neutralization, have minimal side effects, and offer sustained relief. Magnesium-aluminum hydroxide combinations are widely preferred because they balance rapid action with prolonged effects while minimizing gastrointestinal disturbances (Okon & Bello, 2023). Additionally, modern antacid formulations incorporate ingredients such as simethicone to reduce bloating and alginates to prevent acid reflux, enhancing their overall therapeutic benefits (Olawale *et al.*, 2024).

Understanding the properties of antacids is crucial in selecting the most suitable formulation for different clinical conditions. Ongoing research aims to develop improved antacid formulations that maximize efficacy while reducing adverse effects, ensuring better management of acid-related disorders (Eze *et al.*, 2023).

## 1.6 FACTORS AFFECTING ANTACIDS' EFFECTIVENESS

### 1.6.1 Gastric pH and Acid Load

The pre-existing acidity level in the stomach affects how well an antacid works. When gastric pH is extremely low (high acidity), a stronger antacid with higher ANC is required to achieve the desired neutralization effect (Ogunleye *et al.,* 2023). Additionally, if the stomach produces excessive acid due to stress, diet, or underlying conditions such as gastroesophageal reflux disease (GERD), a single dose of an antacid may not provide sufficient relief, necessitating repeated administration (Adebayo & Yusuf, 2024).

### 1.6.2 Food Intake and Gastric Emptying Rate

Food consumption can significantly impact antacid effectiveness. Taking antacids after meals prolongs their duration of action because food delays gastric emptying, allowing the antacid to remain in the stomach for a longer period (Chidiebere & Okafor, 2023). However, taking antacids on an empty stomach leads to rapid gastric clearance, reducing their effectiveness as they are quickly expelled into the intestines. Fatty and protein-rich foods can also influence acid secretion, affecting how much acid needs to be neutralized (Oluwaseun *et al.,* 2022).

### 1.6.3 Dosage and Frequency of Use

The effectiveness of antacids is also dependent on the correct dosage and frequency of administration. Underuse may result in insufficient acid neutralization, while excessive use can lead to side effects such as alkalosis, electrolyte imbalances, or rebound acid hypersecretion (Emmanuel & Okechukwu, 2021). Some formulations, such as chewable tablets, require thorough chewing for optimal effectiveness, as incomplete chewing may reduce the dissolution rate and delay acid neutralization (Akinyemi *et al.,* 2023).

### 1.6.4 Formulation Type (Liquid vs. Tablet vs. Effervescent)

The physical formulation of an antacid plays a crucial role in determining its onset of action and overall efficacy. Liquid antacids act faster because they are already dissolved and can immediately interact with gastric acid (Ogundipe & Williams, 2022). In contrast, chewable tablets require time to break down and dissolve in the stomach, leading to a slightly delayed effect. Effervescent antacids, such as sodium bicarbonate-based formulations, dissolve quickly in water and provide rapid relief but may cause bloating due to carbon dioxide release (Okon & Bello, 2023).

### 1.6.5 Drug Interactions

Antacids can interact with other medications, affecting their absorption and overall therapeutic action. For example, aluminum and magnesium-based antacids can reduce the absorption of

antibiotics such as tetracyclines and fluoroquinolones, leading to decreased antibiotic effectiveness (Olawale *et al.,* 2024). Antacids can also interfere with the absorption of iron supplements and thyroid medications, making it necessary to space out their administration by at least two hours (Eze *et al.,* 2023).

### 1.6.6 Patient-Specific Conditions

Individual health conditions can influence how well an antacid works. Patients with chronic kidney disease (CKD) should avoid magnesium-based antacids because impaired kidney function can lead to magnesium accumulation, causing toxicity (Williams & Chukwudi, 2022). Similarly, individuals with cardiovascular conditions should limit sodium bicarbonate intake due to its high sodium content, which can contribute to hypertension and fluid retention (Adebayo & Yusuf, 2024). Pregnant women are often advised to use calcium- based antacids, as they provide additional calcium benefits, but excessive intake can lead to hypercalcemia and kidney stone formation (Chidiebere & Okafor, 2023).

## 1.7 ACID NEUTRALIZING CAPACITY (ANC)

Acid Neutralizing Capacity (ANC) is a critical parameter used to measure the effectiveness of antacids in counteracting gastric acid. It is defined as the amount of hydrochloric acid (HCl) that an antacid can neutralize per unit dose, usually expressed in milliequivalents (mEq) of acid neutralized (Okonkwo & Adeyemi, 2021). The ANC of an antacid determines its ability to relieve acid-related conditions such as heartburn, acid reflux, and indigestion. A higher ANC indicates greater potency, meaning that less of the antacid is required to achieve acid neutralization.

### 1.7.1 Factors Influencing ANC

Several factors influence the ANC of an antacid, including its chemical composition, solubility, and reaction kinetics. Magnesium hydroxide and calcium carbonate are known for their high ANC, making them effective in neutralizing large amounts of gastric acid within a short period

(Eze *et al.,* 2023). In contrast, aluminum hydroxide has a lower ANC but provides a prolonged buffering effect, making it suitable for sustained acid suppression (Williams & Chukwudi, 2022). Sodium bicarbonate, another commonly used antacid, has a very high ANC but can cause rapid $CO_2$ production, leading to bloating and belching (Ogunleye *et al.*, 2023).

### 1.7.2 Methods For Determining ANC

The ANC of an antacid is typically evaluated using back titration techniques, where a known excess of standardized hydrochloric acid is added to a sample of the antacid, and the remaining acid is titrated with a base such as sodium hydroxide (NaOH) (Adebayo & Yusuf, 2024). This method allows researchers to quantify the exact amount of acid neutralized by the antacid, providing an objective measure of its effectiveness. Additionally, pH-stat titration is used in advanced studies to continuously monitor pH changes in simulated gastric conditions, offering a real-time assessment of ANC (Chidiebere & Okafor, 2023).

### 1.7.3 Clinical Implications of ANC

Understanding the ANC of antacids is essential for ensuring appropriate dosing and maximizing therapeutic benefits. Patients with conditions such as gastroesophageal reflux disease (GERD) require antacids with a higher ANC to effectively counteract persistent acid exposure (Oluwaseun *et al.*, 2022). However, excessive ANC can lead to alkalosis, electrolyte imbalances, or rebound acid hypersecretion, where the stomach produces more acid in response to sudden pH changes (Emmanuel & Okechukwu, 2021).

### 1.7.4 Comparison of ANC Among Antacid Formulations

Different formulations, such as liquid, tablet, and effervescent antacids, exhibit varying ANC values. Liquid antacids generally have a higher ANC because they are already dissolved and can react with gastric acid immediately (Ogundipe & Williams, 2022). Chewable tablets may have slightly lower ANC due to the time required for dissolution. Effervescent formulations dissolve quickly in water, providing rapid acid neutralization but sometimes leading to gas- related side effects such as bloating (Okon & Bello, 2023).

Table 1.1: Comparation of Different forms of antacids available in Nigeria markets

| S/N | Antacids | Advantage | Disadvantage | Reference |
|---|---|---|---|---|
| 1 | Liquid | High ANC; already dissolved, acts quickly | Bulky to carry; may require refrigeration; may have unpleasant taste | Ogundipe & Williams, 2022 |
| 2 | Effervescent | Rapid dissolution in water; fast-acting; easy to ingest | May cause bloating due to gas release; not suitable for patients on low sodium diets | Okon & Bello, 2023 |
| 3 | Tablet | Convenient to use and store; longer shelf life | Slower onset of action due to need for dissolution; may have lower ANC | Ogundipe & Williams, 2022 |
| 4 | Suspension | Combines fast action with ease of swallowing; suitable for children and elderly | Requires shaking before use; may settle quickly; short shelf stability | Adebayo & Yusuf, 2024 |

## 1.8. Statement of the Problem

Gastric acidity and related gastrointestinal disorders remain a prevalent global health concern, especially in developing countries like Nigeria, where over-the-counter (OTC) access to antacid and anti-ulcer medications is widespread. However, many of these medications vary in formulation, efficacy, and therapeutic outcomes, often without clear guidance for consumers or adequate regulatory evaluation. Inconsistent or substandard performance in pH stabilization and acid neutralization can lead to inadequate symptom relief, prolonged discomfort, or potential adverse effects. The lack of comparative analysis and empirical data on the quality and performance of these formulations presents a gap in both clinical knowledge and consumer safety.

Therefore, a scientific evaluation of the acid neutralizing capacity and pH stability of these commonly used brands is necessary to ensure their efficacy and appropriate use.

## 1.9. Significance of the Study

This study provides valuable insight into the comparative effectiveness of popular antacid and anti-ulcer drug formulations available in the Nigerian pharmaceutical market. By analyzing their pH behavior and acid neutralizing capacities, the research offers evidence-based data to guide medical practitioners in prescribing appropriate therapies for acid-related disorders. Additionally, the findings help consumers make informed choices when purchasing over-the-counter remedies. On a broader scale, this research supports regulatory bodies in post-market surveillance and quality assurance efforts. It also serves as a reference for future pharmacological and pharmaceutical research on gastrointestinal medications.

## 1.10. Aims and Objectives

### 1.10.1 Aim.

The aim of this study is to evaluate and compare the pH stability and acid neutralizing capacity (ANC) of selected commercially available antacid and anti-ulcer drugs to determine their relative effectiveness in neutralizing gastric acid.

### 1.10.2 Objectives:

1. To measure the initial (0 minute) pH of each selected drug formulation.
2. To determine the pH variation of each drug after 15 minutes of preparation.
3. To calculate the acid neutralizing capacity (ANC) per standard dose of each formulation.
4. To compare the buffering capacities and therapeutic implications of the tested brands.
5. To provide data that can guide healthcare professionals and consumers in the rational selection of antacid and anti-ulcer products.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 MECHANISMS OF ANTACIDS

Antacids function primarily by neutralizing gastric acid (HCl) in the stomach, thereby increasing the pH and reducing acidity-related symptoms such as heartburn, indigestion, and acid reflux. These compounds are weak bases that react with hydrochloric acid to form salt and water, thereby lowering acidity (Okonkwo & Adeyemi, 2021). The efficiency of an antacid depends on its chemical composition, solubility, and rate of reaction with stomach acid.

### 2.1.1 Neutralization Reaction

The fundamental mechanism of antacids is the direct chemical neutralization of hydrochloric acid (HCl) in the stomach. Different antacids react with HCl in various ways:

#### 2.1.1.1 Magnesium hydroxide ($Mg(OH)_2$):

$$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$$

This reaction neutralizes acid effectively and has a fast onset of action (Eze *et al.*, 2023). However, magnesium-based antacids can cause diarrhea when used in excess.

#### 2.1.1.2 Aluminum hydroxide ($Al(OH)_3$):

$$Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$$

This reaction occurs more slowly, providing sustained acid suppression (Williams & Chukwudi, 2022). Aluminum hydroxide is often combined with magnesium hydroxide to balance their respective effects on bowel movements.

#### 2.1.1.3 Calcium carbonate ($CaCO_3$):

$$CaCO_3 + 2HCl \rightarrow CaCl_3 + CO_2 + H_2O$$

This reaction produces carbon dioxide ($CO_2$), which may cause bloating and belching. However, calcium carbonate has a high acid-neutralizing capacity (ANC), making it effective for rapid relief (Ogunleye *et al.*, 2023).

#### 2.1.1.4 Sodium bicarbonate ($NaHCO_3$):

$$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$$

While sodium bicarbonate provides immediate relief, it can lead to systemic alkalosis and sodium retention, making it unsuitable for long-term use, especially in patients with hypertension (Adebayo & Yusuf, 2024).

### 2.1.2 Buffering and Mucosal Protection

Apart from direct acid neutralization, some antacids act as buffers that help maintain a stable gastric pH over time. This reduces rebound acid secretion, a phenomenon where the stomach produces more acid in response to sudden pH changes (Chidiebere & Okafor, 2023). Additionally, some formulations contain alginates, which form a gel-like barrier that prevents acid reflux, particularly in conditions such as gastroesophageal reflux disease (GERD) (Oluwaseun *et al.*, 2022).

### 2.1.3 Interaction with Pepsin and Bile Acids

Some antacids inactivate pepsin, a digestive enzyme that contributes to mucosal damage when gastric pH is too low. Aluminum hydroxide and magnesium hydroxide have been found to reduce pepsin activity, providing additional protective effects for the stomach lining (Emmanuel & Okechukwu, 2021). Moreover, certain antacids help neutralize bile acids, reducing irritation in patients with bile reflux (Akinyemi *et al.*, 2023).

### 2.1.4 Effect on Gastric Emptying and Gastrointestinal Motility

Different antacids influence gastric emptying rates and gut motility. Magnesium-based antacids tend to promote faster bowel movements, potentially leading to diarrhea, while aluminum-based compounds slow gastric emptying, increasing the risk of constipation (Ogundipe & Williams, 2022). Combination formulations, such as magnesium-aluminum mixtures, help balance these effects, minimizing gastrointestinal side effects (Okon & Bello, 2023).

## 2.2 CHEMICAL NEUTRALIZATION

The primary mechanism through which antacids relieve acid-related disorders is chemical neutralization, a process in which weakly basic compounds react with gastric hydrochloric acid (HCl) to form salt and water (Okonkwo & Adeyemi, 2021). This neutralization reaction reduces stomach acidity, increasing the pH and alleviating symptoms such as heartburn, indigestion, and

acid reflux. The efficiency of an antacid's acid-neutralizing capacity (ANC) is determined by its chemical composition, solubility, and rate of reaction with gastric acid (Eze *et al.,* 2023).

## 2.3 METHODS OF EVALUATING ACID NEUTRALIZING CAPACITY

The acid neutralizing capacity (ANC) of an antacid refers to its ability to neutralize gastric acid and maintain an optimal pH level in the stomach. Evaluating ANC is crucial for determining the effectiveness of different antacid formulations, ensuring proper dosage recommendations, and comparing various commercial products (Okonkwo & Adeyemi, 2021). Several experimental methods have been developed to assess the ANC of antacids, with the most common techniques including titration methods, pH analysis, and in-vitro gastric acid simulation (Eze *et al.,* 2023).

### 2.3.1 TITRATION METHODS

One of the most widely used techniques for evaluating ANC is acid-base titration, which determines the amount of acid required to neutralize an antacid formulation. In this method, a known concentration of hydrochloric acid (HCl), usually 0.1 M, is added to a suspension of the antacid under controlled conditions. The reaction continues until the pH reaches a pre-defined endpoint, typically around 3–4, which mimics the acidic environment of the stomach (Williams & Chukwudi, 2022).

The volume of acid required to reach the endpoint provides a measure of the neutralizing power of the antacid. More effective antacids require less volume of HCl to reach the desired pH level, indicating a higher ANC (Ogunleye *et al.,* 2023). Back titration is also commonly used, where excess acid is added to the antacid, and the remaining unreacted acid is titrated with a strong base (NaOH) to determine ANC more precisely (Adebayo & Yusuf, 2024).

### 2.3.2 pH ANALYSIS AND PH-STAT METHODS

Another widely used method for assessing ANC involves monitoring real-time pH changes when an antacid is introduced into an acidic solution. The pH-stat method involves continuously measuring the pH of a gastric acid solution as antacid is added, ensuring that the pH remains within the physiologically relevant range (Chidiebere & Okafor, 2023).

The pH maintenance time—how long the antacid keeps the solution within an optimal pH range—is a critical factor in determining the duration of antacid action. Antacids that provide a longer duration of pH stability are generally considered more effective in controlling hyperacidity and acid reflux symptoms (Oluwaseun *et al.,* 2022).

### 2.3.3 In-Vitro Gastric Acid Simulation

To more accurately simulate real gastric conditions, in-vitro gastric models have been developed to test antacid effectiveness. These models involve synthetic gastric fluid, which mimics the composition and acidity of human stomach secretions. Antacids are added to the system, and their impact on pH stability and acid neutralization is assessed over time (Emmanuel & Okechukwu, 2021).

Some advanced gastric models include dynamic systems, which simulate gastric motility and food presence, providing a more realistic evaluation of how antacids function inside the stomach. These tests help predict how quickly an antacid dissolves, reacts, and provides symptom relief in real-world conditions (Akinyemi *et al.,* 2023).

### 2.3.4 Conductometric and Spectrophotometric Analysis

Modern techniques such as conductometric analysis and UV-visible spectrophotometry have also been employed in ANC evaluation. Conductometric analysis measures the change in electrical conductivity of the solution as the antacid reacts with acid, providing insights into the rate and extent of neutralization (Ogundipe & Williams, 2022).

Similarly, UV-visible spectrophotometry helps determine active ingredient concentration and reaction completion, making it a valuable tool for quality control in pharmaceutical formulations (Okon & Bello, 2023).

### 2.3.5 Clinical and Pharmacokinetic Studies

In addition to laboratory-based ANC evaluation, clinical studies assess the real-world effectiveness of antacids in managing symptoms like acid reflux and heartburn. Pharmacokinetic studies analyze how antacids interact with gastric secretions and their onset and duration of action

in human subjects (Olawale *et al.,* 2024). These studies help refine antacid formulations and improve treatment recommendations for acid-related disorders.

## 2.4 HEALTH IMPLICATIONS OF ANTACIDS

Antacids play a crucial role in managing acid-related disorders, including gastroesophageal reflux disease (GERD), peptic ulcers, and dyspepsia. They provide rapid relief by neutralizing stomach acid, improving patient comfort and quality of life (Okonkwo & Adeyemi, 2021). However, their prolonged or excessive use can lead to various health implications, including metabolic imbalances, drug interactions, and gastrointestinal disturbances (Williams & Chukwudi, 2022).

### 2.4.1 Electrolyte and Metabolic Imbalances

Frequent use of calcium-based antacids, such as calcium carbonate, can result in hypercalcemia, leading to kidney stone formation, altered heart rhythms, and muscle weakness (Ogunleye *et al.,* 2023). Similarly, excessive consumption of magnesium-based antacids may cause hypermagnesemia, characterized by symptoms such as hypotension, respiratory depression, and confusion (Adebayo & Yusuf, 2024).

Another common issue is metabolic alkalosis, which occurs due to the overconsumption of bicarbonate-containing antacids. This condition leads to symptoms such as nausea, muscle twitching, and electrolyte imbalances (Chidiebere & Okafor, 2023). Patients with renal insufficiency are particularly vulnerable, as their kidneys may struggle to excrete excess calcium, magnesium, or aluminum from prolonged antacid use (Oluwaseun *et al.,* 2022).

### 2.4.2 Gastrointestinal Side Effects

Antacids containing magnesium hydroxide can have a laxative effect, leading to diarrhea, while those with aluminum hydroxide may cause constipation (Emmanuel & Okechukwu, 2021). This alternating effect is why some formulations combine magnesium and aluminum compounds to balance their effects (Akinyemi *et al.,* 2023).

Long-term use of aluminum-based antacids has been associated with hypophosphatemia, a condition where phosphate absorption is reduced, leading to bone demineralization, muscle

weakness, and osteoporosis (Ogundipe & Williams, 2022). This effect is particularly concerning for elderly patients and individuals with chronic kidney disease.

### 2.4.3 Drug Interactions

Antacids can interfere with the absorption and effectiveness of various medications, leading to potential therapeutic failures. Aluminum hydroxide and magnesium hydroxide can bind to certain antibiotics, such as tetracyclines and fluoroquinolones, reducing their absorption and effectiveness (Okon & Bello, 2023). Similarly, antacids may alter the bioavailability of medications such as levothyroxine, digoxin, and bisphosphonates, making dosage adjustments necessary (Adebayo *et al.*, 2024).

Additionally, antacids increase gastric pH, which can affect the dissolution and absorption of pH-dependent drugs, such as ketoconazole and atazanavir (Eze *et al.*, 2023). Patients taking multiple medications should be advised to space antacid administration by at least two hours from other drugs to minimize interactions (Ogundipe & Williams, 2022).

### 2.4.4 Risk of Acid Rebound

A significant concern with prolonged antacid use is acid rebound, where gastric acid secretion increases after the medication is discontinued. This is particularly notable with calcium carbonate-based antacids, which stimulate gastrin release, leading to increased acid production once the antacid wears off (Ogunleye *et al.*, 2023). Acid rebound can worsen GERD symptoms, making long-term management challenging for patients (Adebayo & Yusuf, 2024).

### 2.4.5 Aluminum Toxicity and Neurological Effects

Long-term use of aluminum-containing antacids has been linked to aluminum accumulation in the body, particularly in patients with chronic kidney disease (CKD). Elevated aluminum levels have been associated with cognitive impairments, osteomalacia (soft bones), and anemia (Chidiebere & Okafor, 2023). Some studies suggest that chronic exposure to aluminum may contribute to neurodegenerative disorders, including Alzheimer's disease, though conclusive evidence is still debated (Oluwaseun *et al.*, 2022).

## 2.5 POSITIVE EFFECTS OF ANTACIDS

Antacids are widely used for the management of acid-related gastrointestinal disorders, offering rapid relief from symptoms such as heartburn, indigestion, and gastroesophageal reflux disease (GERD). Their mechanism of action involves neutralizing excess stomach acid, which helps protect the esophageal and gastric lining from irritation and damage (Okonkwo & Adeyemi, 2021). Apart from their primary role in acid neutralization, antacids also have several additional health benefits that contribute to improved gastrointestinal function and overall well-being.

### 2.5.1 Rapid Relief of Heartburn and Acid Reflux

One of the most significant benefits of antacids is their ability to quickly relieve heartburn and acid reflux symptoms by neutralizing gastric acid. Unlike proton pump inhibitors (PPIs) and H2-receptor antagonists, which take longer to act, antacids work within minutes, making them a preferred choice for individuals needing immediate relief (Williams & Chukwudi, 2022). This fast action is particularly beneficial for patients experiencing occasional acid reflux or those who consume acidic or spicy foods that trigger heartburn.

### 2.5.2 Prevention of Peptic Ulcer Complications

Peptic ulcers result from excess gastric acid secretion, often exacerbated by Helicobacter pylori infection or prolonged nonsteroidal anti-inflammatory drug (NSAID) use. Antacids buffer the stomach environment, reducing acidic irritation and promoting ulcer healing. Some formulations, such as magnesium-aluminum combinations, form a protective coating over ulcerated areas, shielding them from further damage (Ogunleye *et al.*, 2023).

Additionally, studies suggest that aluminum hydroxide-containing antacids can bind to bile acids, reducing their harmful effects on gastric mucosa, thus preventing ulcer aggravation (Adebayo & Yusuf, 2024).

### 2.5.3 Enhancing Esophageal and Stomach Mucosal Protection

Certain antacids, such as alginic acid formulations, provide physical protection in addition to acid neutralization. When combined with sodium bicarbonate, alginic acid forms a viscous gel-like barrier that floats on top of stomach contents, preventing acid from refluxing into the esophagus

(Chidiebere & Okafor, 2023). This effect is particularly useful for patients with GERD and laryngopharyngeal reflux (LPR).

Moreover, antacids containing calcium carbonate stimulate mucosal protective factors, including the secretion of prostaglandins and bicarbonate, which further reinforce the stomach lining (Oluwaseun *et al.,* 2022).

### 2.5.4 Support for Bone Health (Calcium-Based Antacids)

Antacids containing calcium carbonate serve as a supplemental source of calcium, which is essential for bone health and the prevention of osteoporosis. Studies indicate that calcium supplementation through diet or antacids can help reduce the risk of fractures in postmenopausal women and elderly individuals (Emmanuel & Okechukwu, 2021).

However, excessive consumption should be monitored to avoid hypercalcemia and kidney stone formation.

### 2.5.5 Reducing Phosphate Levels in Chronic Kidney Disease (CKD)

For individuals with chronic kidney disease (CKD), controlling serum phosphate levels is crucial to prevent complications such as vascular calcification and secondary hyperparathyroidism. Aluminum hydroxide and calcium carbonate-based antacids are frequently used as phosphate binders, reducing phosphate absorption in the intestines (Akinyemi *et al.,* 2023).

By lowering serum phosphate, these antacids help protect kidney function and bone metabolism, making them beneficial for patients undergoing dialysis or managing advanced CKD (Ogundipe & Williams, 2022).

## 2.6 NEGATIVE EFFECTS OF ANTACIDS

While antacids provide rapid relief from acid-related disorders, their prolonged or excessive use can result in adverse health effects. These negative effects range from electrolyte imbalances and metabolic disorders to gastrointestinal disturbances and drug interactions. The long-term implications of antacid misuse highlight the importance of appropriate dosing and medical supervision (Okonkwo & Adeyemi, 2021).

### 2.6.1 Electrolyte Imbalances and Metabolic Disorders

The use of calcium-based antacids, such as calcium carbonate, has been associated with hypercalcemia (excess calcium in the blood). This condition can lead to kidney stone formation, muscle weakness, and cardiac abnormalities (Williams & Chukwudi, 2022). Additionally, excessive consumption of bicarbonate-containing antacids may cause metabolic alkalosis, a condition characterized by symptoms such as nausea, muscle spasms, and confusion (Ogunleye *et al.*, 2023).

Similarly, magnesium-based antacids can cause hypermagnesemia, particularly in patients with kidney disease. Elevated magnesium levels can result in hypotension, drowsiness, and respiratory distress (Adebayo & Yusuf, 2024). In contrast, aluminum- based antacids have been linked to hypophosphatemia, which can weaken bones and lead to osteomalacia (Chidiebere & Okafor, 2023).

### 2.6.2 Gastrointestinal Side Effects

Different antacid formulations can have varying effects on gastrointestinal motility. For instance, magnesium-containing antacids are known to have a laxative effect, leading to diarrhea. On the other hand, aluminum hydroxide-based antacids tend to cause constipation due to their ability to slow down intestinal motility (Oluwaseun *et al.*, 2022).

Long-term use of aluminum-containing antacids has also been associated with bloating, nausea, and gastric discomfort. These effects can be particularly distressing for individuals with irritable bowel syndrome (IBS) or other functional gastrointestinal disorders (Emmanuel & Okechukwu, 2021).

### 2.6.3 Drug Interactions

Antacids can interfere with the absorption and bioavailability of several medications, potentially reducing their effectiveness. Aluminum hydroxide and magnesium hydroxide can bind to antibiotics like tetracyclines and fluoroquinolones, preventing their proper absorption (Akinyemi *et al.*, 2023). This interaction can lead to treatment failure in bacterial infections.

Additionally, antacids may impair the absorption of iron, calcium, and vitamin B12, leading to nutritional deficiencies over time. Individuals on levothyroxine, digoxin, or bisphosphonates

should avoid taking antacids simultaneously, as they can significantly reduce the efficacy of these medications (Ogundipe & Williams, 2022).

### 2.6.4 Rebound Acid Hypersecretion

Frequent use of calcium carbonate-based antacids can lead to acid rebound, where gastric acid production increases after the medication wears off. This is due to the stimulation of gastrin release, which causes the stomach to compensate by producing more acid (Okon & Bello, 2023). As a result, individuals may experience worsening acid reflux symptoms when they discontinue antacid use, creating a cycle of dependency (Adebayo *et al.,* 2024).

### 2.6.5 Aluminum Toxicity and Neurological Concerns

Long-term use of aluminum-containing antacids poses a risk of aluminum toxicity, particularly in individuals with chronic kidney disease (CKD). Because the kidneys play a crucial role in eliminating excess aluminum, patients with impaired renal function may experience aluminum accumulation in the bloodstream, leading to cognitive impairments, muscle weakness, and bone disorders (Eze *et al.,* 2023).

Some studies have suggested a possible link between chronic aluminum exposure and neurodegenerative conditions, such as Alzheimer's disease, although the evidence remains inconclusive (Ogunleye *et al.,* 2023). Nonetheless, individuals at risk should limit prolonged use of aluminum-based antacids to prevent potential complications.

## 2.7 RELIEF OF ACID REFLUX AND HEARTBURN

Acid reflux and heartburn are common gastrointestinal disorders caused by the backflow of stomach acid into the esophagus, leading to irritation and discomfort. Antacids are widely used for rapid symptomatic relief by neutralizing excess gastric acid and reducing esophageal irritation (Williams & Chukwudi, 2022). These over-the-counter (OTC) medications provide short-term relief, making them a first-line treatment for mild to moderate acid-related conditions (Ogunleye *et al.,* 2023).

### 2.7.1 Mechanism of Antacids in Acid Reflux Relief

Antacids work by chemically neutralizing gastric acid, raising the pH of the stomach contents and reducing acidity. This action helps to relieve the burning sensation in the chest and throat that characterizes heartburn. Common ingredients in antacids, such as calcium carbonate, magnesium hydroxide, and aluminum hydroxide, react with hydrochloric acid (HCl) in the stomach to form water and neutral salts, thereby reducing acidity (Adebayo & Yusuf, 2024).

For example, calcium carbonate ($CaCO_3$) reacts with gastric acid as follows:

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

This reaction neutralizes stomach acid and produces carbon dioxide gas, which may lead to belching or bloating in some individuals (Okonkwo & Adeyemi, 2021). Magnesium- based antacids tend to act more rapidly, while aluminum-containing antacids provide a longer- lasting effect but may cause constipation as a side effect (Oluwaseun *et al.,* 2022).

### 2.7.2 Comparing Antacids with Other Acid Suppressors

Although antacids provide quick relief, they do not address the underlying causes of acid reflux, such as lower esophageal sphincter (LES) dysfunction. Other classes of medications, such as H2-receptor antagonists (H2RAs) and proton pump inhibitors (PPIs), are often prescribed for more persistent or severe acid reflux cases (Chidiebere & Okafor, 2023). However, antacids remain a preferred option for occasional heartburn due to their rapid onset of action and minimal systemic side effects (Eze *et al.,* 2023).

### 2.7.3 Combination Antacids for Enhanced Efficacy

Some antacid formulations include alginates, which create a physical barrier against acid reflux by forming a gel-like raft that floats on top of stomach contents. These formulations, such as those containing sodium alginate and bicarbonates, are particularly effective for reducing nighttime reflux symptoms (Ogunleye *et al.,* 2023). Additionally, simethicone is sometimes added to reduce gas and bloating associated with acid reflux (Ogundipe & Williams, 2022).

### 2.7.4 Considerations and Precautions in Antacid Use

While antacids are generally safe for short-term use, excessive or prolonged consumption can lead to complications such as acid rebound, electrolyte imbalances, and drug interactions (Akinyemi *et al.,* 2023). For instance, calcium carbonate-based antacids may cause hypercalcemia, while aluminum-based antacids can contribute to phosphate depletion and bone demineralization (Okon & Bello, 2023).

Patients with chronic acid reflux (GERD) should consult healthcare providers for long- term management options, as antacids alone may not provide adequate symptom control (Emmanuel & Okechukwu, 2021). Lifestyle modifications, including dietary adjustments, weight management, and avoiding trigger foods, are crucial for sustained relief from acid reflux and heartburn (Adebayo *et al.,* 2024).

## 2.8 ANTACID USE IN SPECIAL POPULATIONS

The use of antacids varies across different population groups due to age, pre-existing medical conditions, pregnancy, and organ function. While antacids are generally considered safe, their effects can be altered in specific populations, necessitating caution and individualized medical advice (Williams & Chukwudi, 2022). Special populations, including pregnant women, the elderly, children, and patients with chronic diseases, may require dose adjustments or alternative treatments to prevent adverse effects (Ogunleye *et al.,* 2023).

### 2.8.1 Antacid Use in Pregnant Women

Acid reflux and gastroesophageal reflux disease (GERD) are common during pregnancy due to hormonal changes and increased intra-abdominal pressure. Many pregnant women turn to OTC antacids for symptom relief. Calcium carbonate-based antacids are considered safe and beneficial because they provide both acid neutralization and calcium supplementation, which is essential during pregnancy (Adebayo & Yusuf, 2024).

However, aluminum-containing antacids should be used with caution as they can lead to phosphate depletion, potentially affecting fetal bone development. Sodium bicarbonate- based antacids should also be avoided due to the risk of fluid retention and metabolic alkalosis (Okonkwo & Adeyemi, 2021). Healthcare providers often recommend dietary and lifestyle

modifications alongside safer antacid choices for managing acid reflux in pregnancy (Oluwaseun *et al.*, 2022).

### 2.8.2 Antacid Use in Elderly Individuals

Older adults often suffer from chronic acid-related disorders, requiring long-term antacid use. However, aging-related changes in renal function, bone density, and medication metabolism necessitate careful selection of antacids. Aluminum-based antacids can contribute to osteoporosis and cognitive decline, making them unsuitable for elderly patients, especially those at risk for Alzheimer's disease (Chidiebere & Okafor, 2023). Similarly, elderly individuals with chronic kidney disease (CKD) should avoid magnesium- containing antacids, as impaired kidney function can lead to magnesium accumulation (hypermagnesemia), resulting in cardiovascular and neuromuscular complications (Eze *et al.*, 2023). Instead, calcium carbonate-based or low-dose aluminum hydroxide antacids may be considered under medical supervision (Ogunleye *et al.*, 2023).

### 2.8.3 Antacid Use in Children

Children with acid reflux or peptic disorders may require antacid therapy, but dosing must be carefully adjusted. Pediatric guidelines recommend calcium carbonate-based antacids due to their safety profile and essential mineral benefits. However, excessive use can lead to hypercalcemia and milk-alkali syndrome (Ogundipe & Williams, 2022).

Prolonged use of aluminum-based antacids is discouraged in children due to the risk of neurotoxicity and bone mineralization issues. Instead, pediatricians may prescribe H2- receptor antagonists (H2RAs) or proton pump inhibitors (PPIs) for chronic reflux management (Akinyemi *et al.*, 2023). Additionally, dietary changes and postural adjustments are recommended to reduce acid reflux symptoms in infants and young children (Okon & Bello, 2023).

### 2.8.4 Antacid Use in Patients with Chronic Kidney Disease (CKD)

Patients with kidney dysfunction face challenges in eliminating excess minerals from their bodies. Magnesium- and aluminum-based antacids should be avoided in CKD patients due to the risk of

hypermagnesemia and aluminum toxicity, which can lead to neurological and skeletal complications (Emmanuel & Okechukwu, 2021).

Instead, calcium-based antacids are often used, but excessive calcium intake can lead to vascular calcification, which worsens cardiovascular risks in CKD patients (Adebayo *et al.*, 2024). Therefore, phosphate binders such as sevelamer and lanthanum carbonate may be preferable alternatives for acid regulation in CKD patients (Ogunleye *et al.*, 2023).

### 2.8.5 Antacid Use in Patients with Osteoporosis

Since calcium plays a crucial role in bone health, some individuals with osteoporosis may benefit from calcium carbonate-based antacids. However, excessive calcium intake can lead to the milk-alkali syndrome, characterized by hypercalcemia, kidney dysfunction, and metabolic alkalosis (Chidiebere & Okafor, 2023). Patients at risk of osteoporosis should balance calcium intake with vitamin D supplementation and consult a physician regarding the safest antacid options (Eze et al., 2023).

# CHAPTER THREE

# MATERIAL AND METHOD

## 3.1 EQUIPMENT AND REAGENT

### 4.1.1 Equipment:

1000ml Standard Flask, Filter Paper, Beaker, Pipette, Burette, Conical Flask, Funnel, PH Measurement, Magnetic Stir, Measuring Cylinder, Spatula, Weighing Balance.

### 4.1.2 Reagent:

Hydrochloric Acid (HCL), Distilled Water, Sodium Hydroxide (NaOH), Indicator (Bromocresol Green), Benzoic Acid, Indicator (Phenolphthalein), Tromethamine, Buffer Solution

### 4.1.3 Reagent 2 (Antacids):

**4 Suspension**, **5 Tablets, 2 Liquids**.

## 3.2 SAMPLE PREPARATION

The experimental procedure commenced with the thorough cleaning and setup of all required apparatus. Each tablet sample was carefully ground into fine powder using a mortar and pestle and labeled appropriately as follows: Specimen A, Specimen B, Specimen C, Specimen D, and Specimen E. After grinding, the powdered samples were wrapped in aluminum foil and properly labeled for identification. Precisely 2 g of each specimen was weighed using an analytical balance, and the weighing was performed in triplicates to ensure accuracy and repeatability (i.e., 2 g × 3 replicates). Subsequently, 400 mL of distilled water and 1000 mL of hydrochloric acid (HCl) were measured using a measuring cylinder and combined in a 1000 mL standard flask, with the acid carefully added to the water to prevent splashing or hazardous reactions, following the standard acid-to-water mixing protocol.

For the titration process, 2 g of Specimen A was transferred into a clean conical flask, followed by the addition of 25 mL of distilled water. The mixture was vigorously shaken

to ensure complete dissolution. A burette was mounted on a retort stand and filled with the acid solution prepared earlier. Three drops of methyl orange indicator were then added to the conical flask containing the specimen solution. While continuously swirling the flask, the acid solution from the burette was added dropwise until a clear and stable color change was observed, indicating the titration endpoint. The volume of acid used was recorded. This titration procedure was repeated three times for each of the five specimens (A to E) to ensure consistency and reliability of results.

### 3.3 ORGANOLEPTIC PROPERTIES OF ANTACID FORMULATIONS

**Table 3.1: organoleptic properties of antacid formulations**

| S/N | Brand Name | Country | Dosage Form | Package | Composition | Colour | Odour & Flavour |
|---|---|---|---|---|---|---|---|
| 1 | Kriscet | Nigeria | Chewable Tablet | 200 mg Sachet | Each uncoated tablet contains Cimetidine BP 200 mg. Excipients Q.S | White | Odorless and bitter |
| 2 | Pherix | India | Chewable Tablet | 10mg | Each enteric coated tablet contains Dexrabeprazole Sodium 10 mg. Excipients Q.S. | White | Mint |
| 3 | Krisnat Omeprazole | Nigeria | Chewable Tablet | 20 mg | Omeprazole (as enteric coated pellets) 20 mg. | White | Mint |
| 4 | Gestid | India | Chewable Tablet | 300 mg | Each chewable tablet contains: Dried Aluminium Hydroxide | Light yellow | Mint |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | BP 300 mg Magnesium Trisilicate BP 50 mg Magnesium Hydroxide USP 25 mg Simetilicone USP 10 mg. | | |
| 5 | Krisacid | Nigeria | Chewable Tablet | 250 mg | Each uncoated tablet contains: Magnesium Trisilicate BP 250 mg, Dried Aluminium Hydroxide BP 120 mg, pepper mint flavor Q.S. | White | Mint |

# CHAPTER FOUR

# RESULT AND DISCUSSION

## 4.1 RESULT

Table 4.1: **Comparative Analysis of pH Variation and Acid Neutralizing Capacity of Selected Antacid and Anti-Ulcer Drug Brands**

| S/N | Brand Name | pH at 0 min (Mean ± SD) | pH at 15 min (Mean ± SD) | ANC per Dose (mEq/10ml or 5gm/tab) |
|---|---|---|---|---|
| 1 | Specimen A | 6.39 ± (0.09) | 1.42 ± (0.06) | 12.15 |
| 2 | Specimen B | 6.94 ± (0.06) | 0.94 ± (0.03) | 11.55 |
| 3 | Specimen C | 8.35 ± (0.02) | 0.78 ± (0.02) | 10.95 |
| 4 | Specimen D | 6.89 ± (0.03) | 1.31 ± (0.01) | 13.80 |
| 5 | Specimen E | 6.35 ± (0.02) | 1.51 ± (0.08) | 13.25 |

**Parameters Tested for the Antacids (n = 3 ± SD)**

## 4.2 Discussion

The pH and Acid Neutralizing Capacity (ANC) of the five antacid and anti-ulcer drug samples evaluated in this study varied notably, reflecting differences in their chemical compositions and formulation efficiency. At baseline (0 minutes), all samples exhibited alkaline pH values, ranging from 6.35 ± 0.02 Specimen E to 8.35 ± 0.02 Specimen C. Specimen C showed the highest initial pH, indicating a stronger alkaline nature among the samples, which may be attributed to its proton pump inhibitor mechanism that acts more systemically compared to conventional antacids.

After 15 minutes of exposure, a significant drop in pH was observed in all samples, highlighting their interaction with acidic media. The extent of pH reduction serves as an indirect indicator of buffering action and acid resistance. Specimen B & C exhibited the most pronounced reductions, with final pH values of 0.94 ± 0.03 and 0.78 ± 0.02,

respectively. This sharp decline may reflect the limited duration of their surface-level neutralizing effects, suggesting that their sustained acid suppression likely depends on systemic absorption and delayed pharmacodynamics.

In contrast, Specimen E maintained the highest pH at 15 minutes (1.51 ± 0.08), suggesting better short-term acid neutralization or slower dissolution, which could prolong its effectiveness in immediate symptom relief. Specimen E also maintained relatively stable pH (1.31 ± 0.01), indicating a favorable buffering effect over time.

With regard to ANC, which quantifies the amount of acid neutralized per dose, Specimen D demonstrated the highest acid-neutralizing capacity (13.80 mEq/10 mL), followed closely by Specmen E (13.25 mEq/10 mL), while Specimen C had the lowest (10.95 mEq/10 mL). The higher ANC values of Specimen D & E align with their relatively stable pH at 15 minutes, implying a stronger neutralization potential. Despite Specimen C's high initial pH, its low ANC suggests that its mechanism of action may not rely heavily on direct acid neutralization, but rather on inhibition of gastric acid secretion at the cellular level.

Overall, the differences in pH stability and ANC among the tested brands emphasize the diverse pharmacological approaches and efficacy profiles of the formulations. Antacids like Specimen D & E appear to be more effective in immediate acid neutralization, making them potentially more suitable for quick symptomatic relief. In contrast, agents such as Specimen B & C may offer prolonged acid suppression through systemic mechanisms, despite lower ANC values.

## CONCLUSION AND RECOMMENDATION

The findings of this study reveal marked differences in the acid neutralizing capacity and pH stability of the selected antacid and anti-ulcer drug brands. While all samples exhibited alkaline properties at the point of preparation, their ability to maintain pH stability varied significantly. Gerdt and Krisacid showed superior buffering and neutralization performance, suggesting their suitability for rapid relief of gastric acidity. In contrast, drugs like Krisnat Omeprazole and Pherix, despite high initial alkalinity, demonstrated lower ANC values and greater pH reduction over time, reflecting systemic rather than immediate neutralizing effects. These results emphasize that the clinical effectiveness of antacid products is not solely dependent on pH but also on the extent and duration of acid neutralization, which varies with formulation type.

### RECOMMENDATION

Based on the findings of this study, the following recommendations are proposed:

1. **Clinical Selection**: Healthcare providers should consider both the acid neutralizing capacity and pH stability when prescribing antacids or anti-ulcer agents to ensure optimal therapeutic outcomes based on patient-specific needs.
2. **Public Awareness**: Consumers should be educated on the pharmacological differences between rapid-acting antacids and delayed systemic agents to avoid misuse and ensure effective symptom management.
3. **Regulatory Oversight**: Regulatory agencies such as NAFDAC should enforce routine testing of antacid formulations for quality assurance, ensuring that only products with proven efficacy are allowed into the market.
4. **Further Research**: Additional studies involving in vivo testing and broader sample sizes are recommended to corroborate these findings and explore long-term pharmacodynamic effects of these formulations.

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