AMELIORATIVE EFFECTS OF *Sida acuta* ON INDOMETHACIN-INDUCED ULCEROGENIC RATS

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SUPERVISED BY

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JULY, 2025

CERTIFICATION

This project work has been read and approved as meeting part of the requirements of the Department of Science Laboratory Technology (SLT) for the award of Higher National Diploma (HND) in Science Laboratory Technology (SLT).

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DEDICATION

This project is dedicated to Almighty God, the beneficent, the most merciful who has been supplying me with abundance wisdom, knowledge, understanding and for his love, kindness, favor, grace and mercy over me throughout this course of study and for giving me the privilege and strength to successfully complete this course.

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ABSTRACT

This study investigates the ameliorative effects of Sida acuta on indomethacin-induced ulcerogenic rats, focusing on its antiulcerogenic potential and underlying mechanisms. Ethanol extracts of Sida acuta were evaluated for their phytochemical composition, proximate and mineral contents, antioxidant properties, and effects on hematological and liver function indices in Wistar rats. Phytochemical analysis revealed the presence of bioactive compounds, including saponins, tannins, flavonoids, phenols, and glycosides, which contribute to its therapeutic properties. Proximate analysis indicated high crude protein (13.56–13.78%) and fiber (27.52–29.22%) contents, with moderate carbohydrates and low lipids, highlighting its nutritional value. Mineral analysis confirmed significant levels of iron, copper, potassium, magnesium, and calcium, supporting metabolic and cardiovascular health. In vivo experiments demonstrated that Sida acuta extract, particularly at moderate doses (100–400 mg/kg), reduced ulcerated areas, enhanced gastric mucosal healing, and improved hematological parameters such as red blood cell count and hemoglobin levels. Antioxidant assays (FRAP, ABTS, DPPH) confirmed the plant's ability to mitigate oxidative stress, while liver function indices suggested hepatoprotective effects. Compared to standard antiulcer drugs, Sida acuta showed promising efficacy with fewer side effects, supporting its potential as an alternative or adjunct therapy for peptic ulcer management. These findings validate the ethnomedicinal use of Sida acuta and underscore its nutritional and pharmacological significance in treating gastrointestinal disorders.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

The pharmacological properties of plants have been recognized for a long time. Herbal remedies have been used for centuries by indigenous cultures around the world to treat a variety of ailments. The pharmaceutical industry has grown significantly over the last century as a result of the identification and exploitation of chemicals with defined mechanisms of action (Zeouk and Bekhti, 2020). Plant-based products and their analogues are now widely used in clinical application due to the development of extremely effective medications (Máthé and Khan, 2022). Since the beginning of human civilization, medicinal plants have been used by mankind for their nutritional and therapeutic values. Nature has been a source of medicinal agents for thousands of years and an impressive number of modern drugs have been isolated from natural sources. Many of these isolations were based on the uses of these agents in traditional medicine.

Sida acuta (Malvaceae) is one of those plants currently used by indigenous people for the management of some health problems. This plant is an erect, branched small perennial herb or small shrub of about 1.5m height as shown in figure 1 (Mohideen *et al*., 2002). For thousands of years, plants and herbs have been a tremendous source of food and medicine. Various parts of *Sida acuta* have been reported in many studies to be used by indigenous people from tropical countries to manage some health problems: rheumatic affections, azoospermia, oligospermia and spermatorrhea, leucorrhoea, wounds, sciatica,

nervous and heart diseases, cold, cough, asthma, tuberculosis and respiratory diseases, disorders of the blood, bile and liver, elephantiasis, hemorrhoids, ulcers, gastric disorders and abdominal pain, headache, fever and malaria, skin diseases, worms, diarrhea and dysentery, venereal diseases, renal inflammation, toothache and snake bites (Tcheghebe *et al*., 2017). *Sida acuta* has been scientifically studied for its numerous pharmacological profiles such as: antioxidant, antimicrobial and antibacterial, antimalarial, cardiovascular, antiulcer, analgesic and anti-inflammatory, antipyretic, hepatoprotective, hypoglycemic, insecticidal and anticancer. Moreover, it has been proved that there was no mortality in rats administered with this plant extract up to a dose level of 2000 mg/Kg body weight. Bioactive constituents such as alkaloids, saponins, coumarins, steroids, tannins, phenolic compounds, cardiac glycosides, sesquiterpene and flavonoids, significantly present in the plant extract, account for its multiple properties and uses in traditional medicine (Tcheghebe *et al*., 2017).

Sida acuta otherwise known as broom weed is a shrub belonging to Malvaceae family (Ekwealor *et al*., 2020). The plant is widely distributed in the subtropical regions and has many traditional usages that varied from one region to another (Karou *et al*., 2007). All the plant parts exert various pharmacological properties which include antiplasmodial, antimicrobial, antioxidant and cytotoxic activities (Ekwealor *et al*., 2020). In Nigeria, *Sida acuta* known as Udo by the Igbos and Kayan Kuka in Hausa (Akaneme, 2008) and Iseketu by the Yorubas has been reported to be used in the treatment of malaria, ulcer, fever, gonorrhea, abortion, breast cancer, poisoning, inflammation, and

haemorrhage (Kayode, 2006). Different plant part of *Sida acuta* consists of complex phytochemicals, which are responsible for biological activity. The roots and seeds of this plant revealed the presence of pharmacologically active alkaloids, with a concentration of 0.066% and 0.26%, respectively (Khare, 2008). In this study, we provide an in-depth critical overview of *Sida acuta*'s traditional importance, pharmacological properties, and chemical constituents.

Figure 1: *Sida acuta* plant

Source: Srinivasan and Murali, (2022).

Phytochemicals are naturally occurring compounds found in plants with a variety of functions, including providing defences against diseases and environmental stressors. Some phytochemicals can also promote human health, and they are being studied for

their potential to prevent or treat various diseases. The medicinal plant *Sida acuta* consists of a variety of phytocompounds and the chemical structures are shown in Figure 2. An analysis of ethanol extracts from *Sida acuta* leaves revealed the presence of alkaloids, flavonoids, steroids, tannins, terpenoids, and cardiac glycosides (Adeniyi *et al*., 2010). Vitamins and minerals present in *Sida acuta* leaves include ascorbic acid, niacin, thiamine, riboflavin, and β-carotene, as well as calcium, iron, phosphorus, sodium, and magnesium (Raimi *et al*., 2014).

Gastric ulcers, commonly known as peptic ulcers, are lesions in the stomach lining or the upper part of the small intestine that occur due to excessive gastric acid secretion and an imbalance between aggressive and defensive factors in the gastrointestinal tract (Li *et al*., 2020). The condition affects millions worldwide, leading to significant morbidity and economic burdens. Common causes of gastric ulcers include *Helicobacter pylori* infection, excessive use of nonsteroidal anti-inflammatory drugs (NSAIDs), alcohol consumption, and stress (Suerbaum and Michetti, 2002). Conventional antiulcer medications such as proton pump inhibitors (PPIs), H2-receptor antagonists, and antacids are commonly used for managing ulcers (Brunton *et al*., 2017). However, their long-term use is associated with several side effects, including increased risk of fractures, kidney disease, and microbial imbalances (Moayyedi *et al*., 2019).

As a result, there is growing interest in exploring alternative and complementary medicines, particularly plant-based remedies, which have been traditionally used for ulcer

treatment with minimal side effects. *Sida acuta* (Malvaceae) is a widely distributed medicinal plant recognized for its pharmacological properties, including antimicrobial, antioxidant, anti-inflammatory, and antiulcer activities (Ekwealor *et al*., 2020). Indigenous communities in tropical regions have used *Sida acuta* for treating various ailments, including ulcers, fever, malaria, wounds, and gastrointestinal disorders (Tcheghebe *et al*., 2017). Given its rich phytochemical composition, including alkaloids, flavonoids, tannins, and phenolic compounds, *Sida acuta* exhibits promising bioactivities that could be beneficial in ulcer treatment (Adeniyi *et al*., 2010).

Gastric ulcer development is influenced by an imbalance between protective and aggressive factors in the gastrointestinal tract. Protective factors include mucus secretion, bicarbonate production, and adequate blood flow to the gastric mucosa, while aggressive factors include gastric acid, pepsin, and reactive oxygen species (Wallace, 2008). Ulcer formation typically occurs when the mucosal defenses are weakened or overwhelmed by aggressive factors, leading to tissue damage and inflammation (Malfertheiner *et al*., 2017).

Medicinal plants have been widely explored as potential antiulcer agents due to their natural bioactive compounds that offer gastroprotective effects (Balogun *et al*., 2019). Many plant extracts contain flavonoids, tannins, alkaloids, and terpenoids, which exhibit antioxidant, anti-inflammatory, and cytoprotective properties that enhance gastric mucosal defenses (Borrelli and Izzo, 2000). These natural compounds help in reducing

acid secretion, promoting mucus production, and improving gastric tissue repair (Jaiswal *et al*., 2016).

Sida acuta has been reported to possess multiple pharmacological activities, including antimicrobial, anti-inflammatory, hepatoprotective, hypoglycemic, and antioxidant effects (Karou *et al*., 2007). The plant's traditional use in treating ulcers is supported by scientific evidence demonstrating its gastroprotective and healing potential (Ekwealor *et al*., 2020). Studies indicate that *Sida acuta* contains significant levels of flavonoids, tannins, saponins, and other phytochemicals known for their antiulcer activity (Tcheghebe *et al*., 2017). Phytochemical analysis of *Sida acuta* reveals the presence of alkaloids, flavonoids, steroids, tannins, terpenoids, and cardiac glycosides, which contribute to its therapeutic properties (Adeniyi *et al*., 2010). These compounds are known to enhance mucosal protection, reduce inflammation, and scavenge free radicals that contribute to ulcer pathogenesis (Raimi *et al*., 2014). Moreover, *Sida acuta* has demonstrated significant antioxidant activity, which may help in alleviating oxidative stress-induced gastric mucosal damage (Mohideen *et al*., 2002).

1.2 Statement of the Problem

Peptic ulcers are a prevalent gastrointestinal disorder that significantly impacts human health, causing symptoms such as pain, indigestion, and discomfort. The pathogenesis of peptic ulcers is often linked to factors such as the imbalance between aggressive and defensive factors in the gastrointestinal tract, including excessive gastric

acid secretion, impaired mucosal defense mechanisms, and *Helicobacter pylori* infection. While various pharmacological agents are available for ulcer management, their side effects and the potential for drug resistance remain a concern. *Sida acuta*, a medicinal plant traditionally used in folk medicine for its purported therapeutic properties, has been suggested to possess anti-inflammatory, analgesic, and antioxidant effects.

However, its potential role in treating peptic ulcers, particularly through in vivo models, remains underexplored. This study aims to investigate the in vivo antiulcer activity of *Sida acuta* in a rat model induced with peptic ulcers, assessing its effectiveness in reducing ulceration, healing gastric mucosal damage, and its possible mechanisms of action. Understanding the pharmacological potential of *Sida acuta* may provide valuable insights into its use as an alternative or adjunct therapy in the management of peptic ulcers. By conducting this study, we hope to contribute to the growing body of knowledge on natural therapeutic agents and their efficacy in treating gastrointestinal disorders, potentially offering a safer and more accessible option for ulcer management

1.2 Justification for the Study

Peptic ulcers are a common gastrointestinal disorder that continues to affect a large population worldwide, leading to significant morbidity and healthcare costs (Sung et al., 2009). Despite the availability of several pharmaceutical treatments, many of these drugs are associated with undesirable side effects such as gastrointestinal irritation, renal

toxicity, and drug resistance (Lanas and Chan, 2017). Moreover, the over-reliance on synthetic drugs has raised concerns about their long-term effectiveness and safety, emphasizing the need for alternative, natural, and safer therapeutic options (Kambe *et al*., 2019).

Sida acuta, a plant known for its traditional medicinal uses, has shown potential as an effective therapeutic agent in managing various ailments (Akinmoladun *et al*., 2020). Preliminary studies indicate that *Sida acuta* possesses bioactive compounds with anti-inflammatory, antioxidant, and antimicrobial properties, which could play a significant role in managing peptic ulcers (Ugwu *et al*., 2020; Oyedemi *et al.*, 2015). However, there is a lack of extensive scientific evidence and detailed studies evaluating its effectiveness specifically in ulcer healing and its underlying mechanisms. Given the increasing interest in phytotherapeutic approaches to gastrointestinal disorders, it is essential to validate the medicinal properties of *Sida acuta* through rigorous scientific investigation. This study, focusing on the in vivo antiulcer activity of *Sida acuta* in an induced rat model (Oyedemi *et al.*, 2015), will contribute to the understanding of its pharmacological potential and support the exploration of plant-based alternatives to conventional antiulcer treatments.

1.3 Aim and objectives of the study

The primary aim of this study is to evaluate the in vivo antiulcerogenic activity of *Sida acuta* in a rat model of induced ulcers, with a focus on assessing its ulcer-healing potential and possible mechanisms of action.

Objectives of the Study

The specific objectives were:

i. To extract *Sida acuta* plant using ethanol

ii. To determine phytochemicals present in *Sida acuta*

iii. To assess the effect of *Sida acuta* on ulcer formation in rats induced with gastric ulcers by using an indomethacin.

iv. To evaluate the healing properties of *Sida acuta* on gastric mucosal damage, measuring parameters such as ulcer index, gastric pH, and histopathological changes in the gastric tissues.

v. To determine the proximate composition of *Sida acuta extract*

vi. To investigate the antioxidant potential of *Sida acuta* by evaluating oxidative stress markers

vii. To compare the effectiveness of *Sida acuta* to conventional antiulcer medications

CHAPTER TWO

2.0 LITERATURE REVIEW

Ulcers have been a significant medical concern for centuries, with extensive research dedicated to understanding their etiology, pathophysiology, and treatment. The most studied ulcers are peptic ulcers, which affect the gastrointestinal tract, primarily due to the involvement of *Helicobacter pylori* infection and the prolonged use of nonsteroidal anti-inflammatory drugs (NSAIDs) (Malfertheiner *et al*., 2017). Research indicates that an imbalance between aggressive factors, such as gastric acid secretion and pepsin activity, and protective mucosal defense mechanisms contributes to ulcer formation (Laine *et al*., 2021). The role of stress and dietary habits has also been explored in ulcer pathogenesis, although their direct causation remains debated (Lanas and Chan, 2017).

Over the years, various treatment modalities have evolved, ranging from traditional remedies to modern pharmacological interventions. The advent of proton pump inhibitors (PPIs) revolutionized ulcer management by effectively reducing gastric acid production and promoting mucosal healing (Sung *et al*., 2020). Histamine Type 2 Receptor antagonists, such as ranitidine, were previously popular but have been largely replaced due to the superior efficacy of PPIs (Laine *et al*., 2021). The discovery of *H. pylori* as a key factor in peptic ulcer disease led to the introduction of antibiotic therapy, significantly improving treatment outcomes (Malfertheiner *et al*., 2017).

However, antibiotic resistance poses a growing challenge, necessitating ongoing research into alternative therapeutic strategies (Sung *et al*., 2020). Recent studies have

focused on the role of the gut microbiome in ulcer pathophysiology, suggesting that microbial composition influences disease progression and healing (Lanas and Chan, 2017). may offer complementary therapeutic benefits (Malfertheiner *et al*., 2017).

Despite advancements in treatment, ulcers remain a global health concern, particularly in developing countries where access to healthcare and eradication programs for *H. pylori* are limited. Further research is needed to address these disparities and develop more effective, accessible treatment options (Sung *et al*., 2020). Ulcers have been a significant medical concern for centuries, with extensive research dedicated to understanding their etiology, pathophysiology, and treatment. The most studied ulcers are peptic ulcers, which affect the gastrointestinal tract, primarily due to the involvement of *Helicobacter pylori* infection and the prolonged use of nonsteroidal anti-inflammatory drugs (NSAIDs) (Malfertheiner *et al*., 2017). The role of stress and dietary habits has also been explored in ulcer pathogenesis, although their direct causation remains debated (Lanas and Chan, 2017).

2.1 Ulcer

Ulcers are defined as open sores or lesions that develop on the skin or mucous membranes due to various etiological factors, including infections, chronic diseases, and medication-induced damage (Lanas and Chan, 2017). Ulcers can occur in different parts of the body, including the gastrointestinal tract (gastric and duodenal ulcers), the skin (pressure ulcers), and the mouth (aphthous ulcers). Among these, peptic ulcers, particularly gastric and duodenal ulcers, have been widely studied due to their significant

impact on global health (Sung *et al*., 2020). The prevalence of ulcers varies globally, influenced by dietary habits, healthcare accessibility, and infection rates of *H. pylori*. Developing countries report higher incidences of peptic ulcers due to poor sanitation and high transmission of *H. pylori* (Sung *et al*., 2020).

On the other hand, industrialized nations have seen a decline in ulcer cases due to improved healthcare and the widespread use of proton pump inhibitors (PPIs) (Lanas and Chan, 2017). However, the increasing use of NSAIDs among the elderly population continues to pose a significant risk for ulcer development (Laine *et al*., 2021). Over the years, various treatment modalities have evolved, ranging from traditional remedies to modern pharmacological interventions. The advent of PPIs revolutionized ulcer management by effectively reducing gastric acid production and promoting mucosal healing (Sung *et al*., 2020). H2-receptor antagonists, such as ranitidine, were previously popular but have been largely replaced due to the superior efficacy of PPIs (Laine *et al*., 2021).

2.2 Types of Ulcer

2.2.1 Peptic Ulcer

Peptic ulcer disease is a problem of the gastrointestinal tract characterized by mucosal damage secondary to pepsin and gastric acid secretion. It usually occurs in the stomach and proximal duodenum; less commonly, it occurs in the lower esophagus, the distal duodenum, or the jejunum, as in unopposed hypersecretory states such as Zollinger-Ellison syndrome, in hiatal hernias (Cameron ulcers), or in ectopic gastric

mucosa (e.g., in Meckel's diverticulum) (Kalyanakrishnan *et al*., 2007). Peptic ulcer disease affects 1-2 per 1000 people annually as per a systematic review with data from the USA, UK, and Europe (Sung *et al.,* 2009). The incidence is declining, possibly due to decreasing prevalence of *Helicobacter pylori* infection (Agréus *et al*., 2016).

Previous studies suggest that 90% of duodenal ulcers and 70% of gastric ulcers are associated with *Helicobacter pylori* infection. Although these percentages are now considered to be lower, *Helicobacter pylori* is also an important risk factor for gastric cancer, which further emphasises the importance of its eradication (Ford *et al*., 2017). *Helicobacter pylori* infection and the use of nonsteroidal anti-inflammatory drugs (NSAIDs) are the predominant causes of peptic ulcer disease (Kurata and Nogawa, 1997). Although *Helicobacter pylori* is present in the gastroduodenal mucosa in most patients with duodenal ulcers, only a minority (10 to 15 percent) of patients with *H. pylori* infection develop peptic ulcer disease. *Helicobacter pylori* bacteria adhere to the gastric mucosa as shown in figure 2; the presence of an outer inflammatory protein and a functional cytotoxin-associated gene island in the bacterial chromosome increases virulence and probably ulcerogenic potential (Nilsson *et al*., 2003).

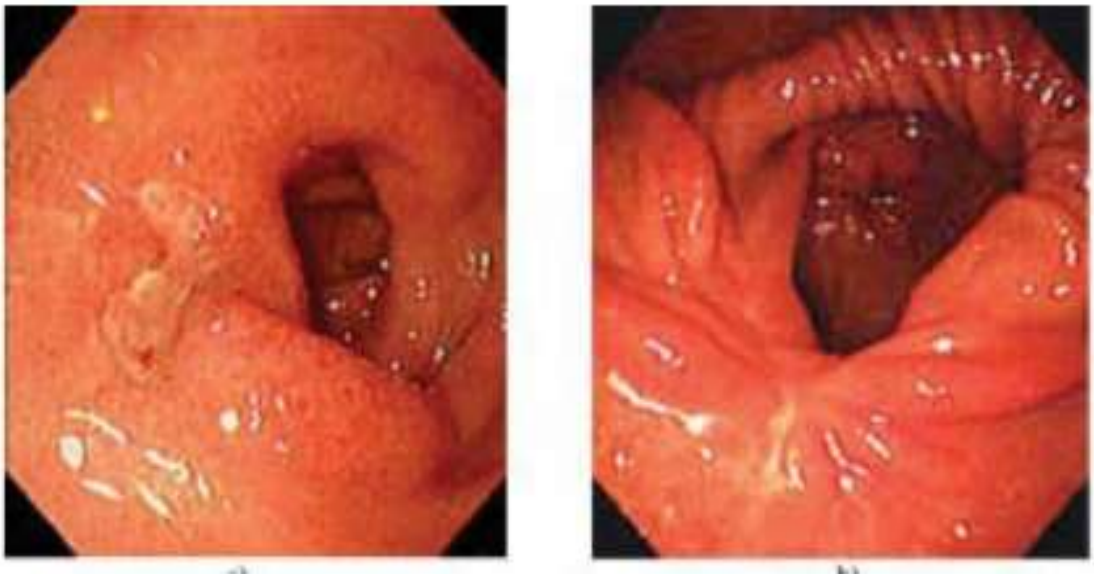


Figure 2: Peptic Ulcer infection

Source: Lauret (2015).

2.2.2 Skin Ulcer

A skin ulcer is a localized defect or excavation of the skin surface that results from the progressive disintegration and necrosis of epidermal and dermal tissues, often extending into the subcutaneous layers (Gupta *et al*., 2020). These ulcers are caused by various underlying conditions, including poor circulation, prolonged pressure, infections, and metabolic disorders. Skin ulcers are classified based on their etiology, such as pressure ulcers, venous ulcers, arterial ulcers, neuropathic ulcers, and infectious ulcers (Bergstrom *et al*., 2018).

Skin ulcers are a significant health concern globally, affecting individuals across various age groups and socioeconomic backgrounds. These chronic wounds result from

multiple underlying conditions, including vascular insufficiency, prolonged pressure, infection, and systemic diseases (Sen *et al*., 2009). Skin ulcers are characterized by the loss of epidermal and dermal integrity as shown in figure 3 below, leading to exposure of underlying tissues, which can predispose affected individuals to infections and prolonged healing processes (Guo and DiPietro, 2010). The burden of skin ulcers is extensive, with epidemiological studies indicating their high prevalence, particularly among elderly individuals and those with chronic illnesses such as diabetes and peripheral vascular diseases (Nussbaum *et al*., 2018). Studies have shown that factors such as persistent inflammation, excessive protease activity, and reduced cellular migration contribute to the delayed healing seen in ulcerative conditions (Eming *et al*., 2014).

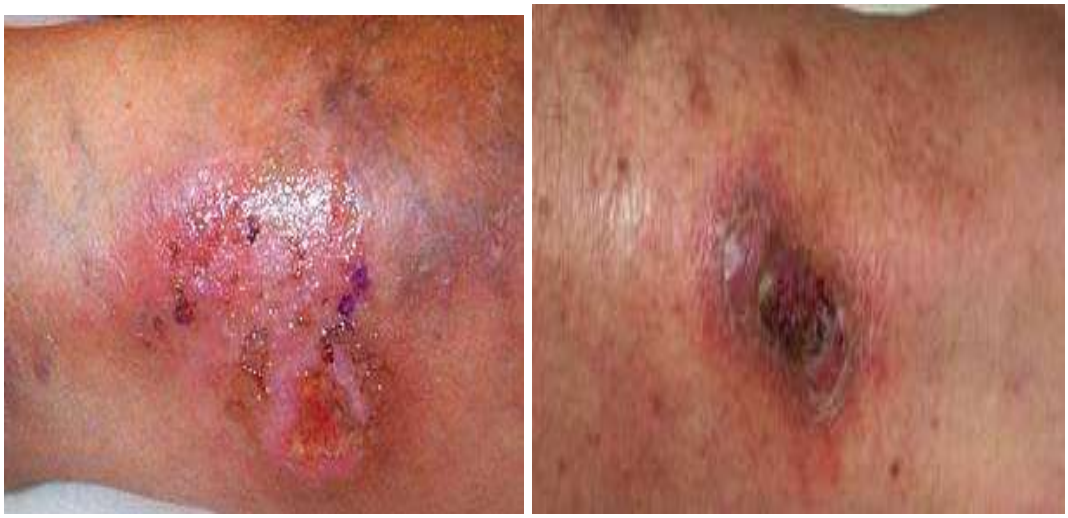


Figure 3: Skin Ulcer

Source: Kumar, (2004).

Skin ulcers are also associated with substantial economic burdens, as their treatment often involves prolonged hospitalization, use of advanced wound care products, and surgical interventions (Sen *et al*., 2009). A study by Guest *et al*. (2015) highlighted the financial implications of managing chronic wounds, emphasizing the need for cost-effective and innovative wound care solutions. An ulcer is a sore on the skin or a mucous membrane, accompanied by the disintegration of tissue. Ulcers can result in complete loss of the epidermis and often portions of the dermis and even subcutaneous fat. Ulcers are most common on the skin of the lower extremities and in the gastrointestinal tract (Kumar *et al*., 2004). An ulcer that appears on the skin is often visible as an inflamed tissue with area of reddened skin. Pressure ulcers, also known as decubitus ulcers or bedsores, occur due to prolonged pressure on the skin, leading to tissue ischemia and necrosis (Stern and Neuman, 2019). These ulcers typically develop over bony prominences such as the sacrum, heels, and hips as shown in figure 3. Risk factors include immobility, malnutrition, moisture, and impaired sensory perception (Jaul *et al*., 2018).

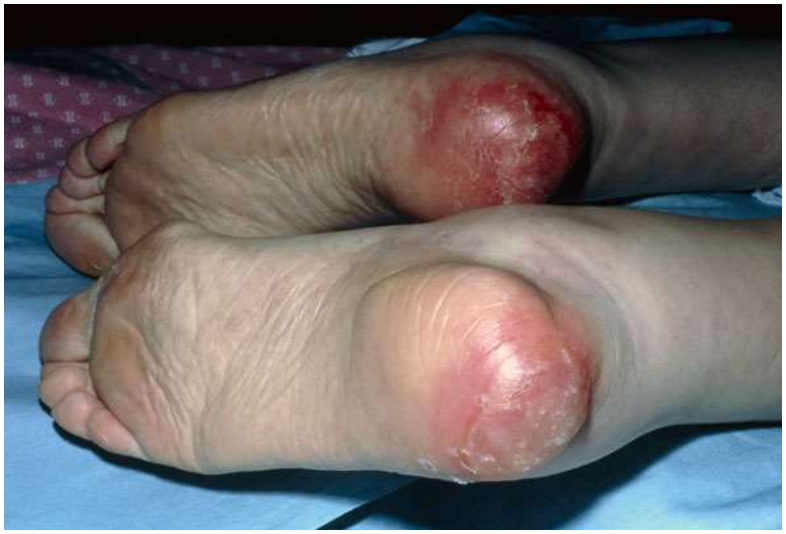


Figure 3: Pressure Ulcer

Source: Kumar, (2004).

Venous ulcers are the most common type of chronic lower extremity ulcers and result from venous insufficiency due to dysfunctional venous valves (Armstrong *et al*., 2019). These ulcers are usually found around the medial malleolus, Figure 4 below shows Venous ulcer effect on human skin, alwaysw presenting with irregular borders, edema, and hyperpigmentation due to hemosiderin deposition (O'Donnell *et al*., 2020).

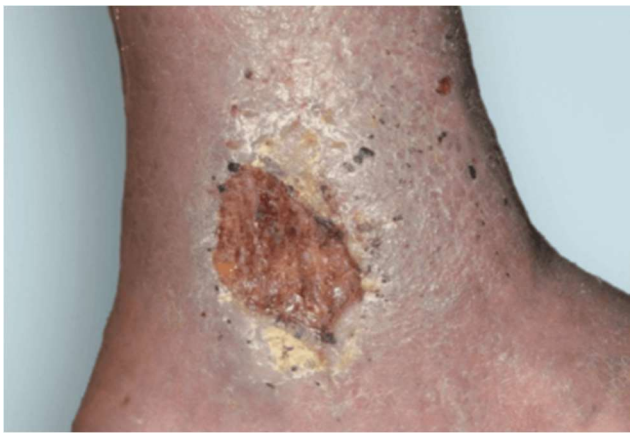


Figure 4: Venus Ulcer

Source: Kumar, (2004).

Arterial ulcers develop due to inadequate blood supply from peripheral arterial disease (PAD), leading to ischemia and tissue necrosis (Fowkes *et al*., 2020). These ulcers are usually located on the toes, feet, (see figure 5) or lateral malleolus and have a punched-out appearance with a pale wound bed and minimal exudate (Conte *et al*., 2019).

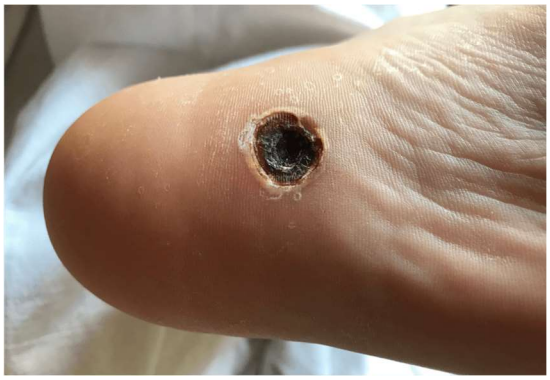


Figure 5: Arterial ulcers

Source: Fowkes *et al*. (2020).

Neuropathic ulcers are common in diabetic patients and result from peripheral neuropathy, leading to loss of sensation and repeated trauma (Armstrong *et al*., 2021). These ulcers are typically found on weight-bearing areas of the feet (figure 6), and are often associated with osteomyelitis and poor healing (Lazzarini *et al*., 2019). Skin ulcers can also arise due to bacterial, viral, or fungal infections. Examples include

Mycobacterium ulcerans infections (Buruli ulcer), Treponema pallidum (syphilitic ulcers), and Leishmania species (cutaneous leishmaniasis) (Sadeghian *et al*., 2020).

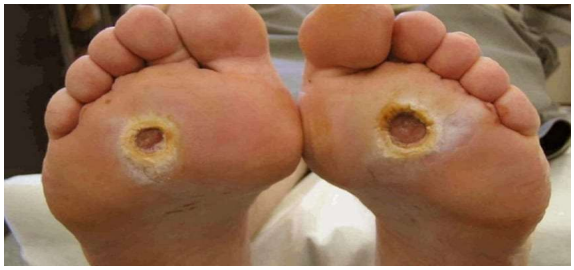


Figure 6: Arterial ulcers

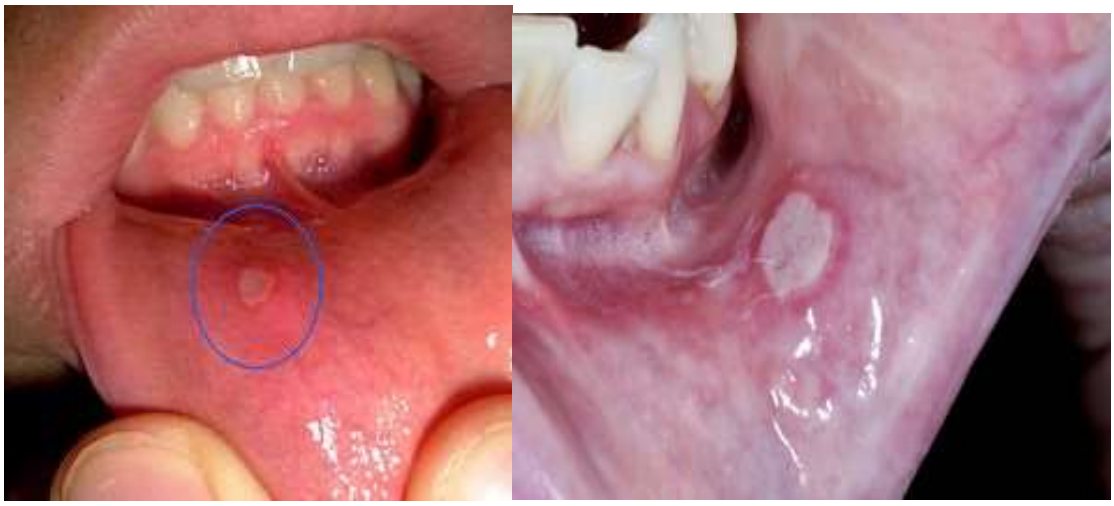
2.2.3 Mouth Ulcer

The oral cavity is lined by epithelia, extending from the inner aspect of the lips to the oropharynx. Keratinized mucosa includes the dorsal tongue, gingivae and hard palate, while non keratinized mucosa involves the labial mucosa, buccal mucosa, ventral tongue, floor of the mouth and soft palate. Abnormalities of the oral mucosa can be manifestations of systemic disease and the initial signs of an undiagnosed underlying condition (Yogarajah and Setterfield, 2021). Oral ulcers are common and although most are caused by trauma or are recurrent aphthae, some may be the manifestation of an underlying systemic disease or may be due to malignant disease, mainly oral cancer (Scully and Felix, 2005). Ulceration is a commonly presenting sign of a wide spectrum of diseases of the oral cavity involving many etiologic factors (Fitzpatrick *et al*., 2019).

These lesions may pose a unique diagnostic challenge for clinicians due to overlap of clinical and histologic features between different types of ulcerated lesions. Most ulcerative lesions of the oral mucosa fall into one of four categories: infection,

immune related, traumatic, or neoplastic (Fitzpatrick *et al*., 2019). The precise aetiology of the mucositis remains unclear, although most likely reflects a loss of basal cell proliferation5 rather than a reaction to changes in the local oral microflora (e.g. rises in Gram-negative bacteria, particularly Enterobacteriaceae) (Stokman *et al*., 2003).

This mucositis, akin to that of the bowel, is difficult to manage specifically. Benzydamine hydrochloride mouth rinse or spray may provide symptomatic relief, but often effective analgesia requires opioids. The clinical feature of oral mucositis does not significantly improve with topical chlorhexidine gluconate, although this is commonly used in clinical practice. Novel regimes for the treatment of mucositis include granulocyte-macrophage colony-stimulating factor (GM-CSF) and protegrins, although these are presently in the early stages of clinical trial (Chen *et al*., 2000; Mantovani *et al*., 2003).



(a) **(b)**

Figure 7: (a) Aphthous Ulcerations (b) Herpetiform ulceration

Source: Crispian and Rosemary (2000).

2.2.4 Corneal Ulcer

The cornea serves as the eye's primary refracting surface and plays an indispensable role in transmitting and focusing light on the retina. Given its anterior location, it is vulnerable to injuries, infections, and various inflammatory conditions, one of the most severe being the corneal ulcer. Defined as a defect in the corneal epithelium with underlying inflammation, a corneal ulcer, or keratitis, can have a profound impact on vision if not swiftly and adequately addressed. While corneal ulcers may arise from various etiologies, the majority are infectious in origin. Bacteria are often the most common causative agents, especially in contact lens wearers. However, fungi, viruses, and parasites can also be implicated, particularly in certain environmental or clinical scenarios (Mohan *et al*., 2003).

Corneal ulcers are serious vision-threatening conditions characterized by defects in the corneal epithelium with underlying inflammation, often due to microbial invasion by bacteria, fungi, viruses, or Acanthamoeba. These ulcers can be initiated by mechanical trauma or nutritional deficiencies and, if left untreated, can lead to severe complications such as corneal perforation and vision loss. Corneal ulcers are primarily categorized into infectious and noninfectious causes. Infectious causes include bacterial, viral, fungal, and amoebic infections (see figure 8 below). Noninfectious causes may involve trauma, contact lens use, and systemic conditions. Risk factors for developing corneal ulcers include contact lens wear, especially improper use or hygiene, and conditions that

compromise the corneal surface, such as dry eye or previous eye surgery (Johnson, 2023). Corneal ulcers are a significant cause of visual impairment globally, often resulting from microbial infections or trauma. A study conducted at the University of Ilorin Teaching Hospital in Nigeria highlighted the prevalence of corneal ulcers as a major cause of avoidable blindness, with microbial keratitis being the most common cause (Adepoju *et al*., 2023).

The World Health Organization guidelines also underscore the challenges in managing corneal ulcers across different health systems, highlighting the need for standardized treatment protocols (WHO, 2015). Diagnosis and management of corneal ulcers involve detailed clinical examinations and microbial studies to identify the causative agent. A study published in the PMC highlighted the importance of thorough clinical evaluation and appropriate antimicrobial therapy to improve outcomes (PMC, 2007).

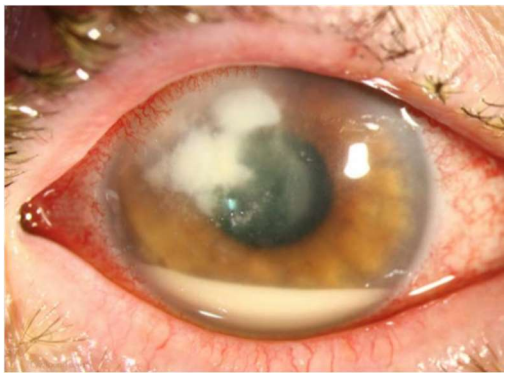


Figure 8: The Fungal keratitis

Source: WHO (2015)

2.2.5 Diabetic Ulcer

Diabetes mellitus affects approximately 422 million people worldwide and is responsible for an estimated 2 million deaths per year. It affects 11.3% of the United States population (Raja *et al*., 2023). Diabetic ulcer (DU) is a debilitating and severe manifestation of uncontrolled and prolonged diabetes that presents as an ulceration, usually located at the plantar aspect of the foot. Approximately 15% of individuals with diabetes will eventually develop one of these ulcers, and out of these individuals, 14%-24% of them will require amputation of the ulcerated foot due to bone infection or other ulcer-related complications. With such a high level of morbidity stemming from debilitating osteomyelitis and amputation in patients with DU, it is of the utmost importance to properly address and treat the underlying causes of DU. In this paper, we review the current literature with focus on the pathophysiology, preventive options, and definitive management of DU (Raja *et al*., 2023).

Diabetic ulcer comprises a full-thickness wound involving the dermis, located in the weight-bearing or exposed area below the ankle. The Wagner system aids in categorizing the severity of the ulcer, ranking it on a scale of 1 to 5 (figure 9). The pathologic mechanisms of DFU are described in terms of a triad. This triad includes neuropathy, vascular insufficiency, and secondary infection due to trauma of the foot (Raja *et al*., 2023).

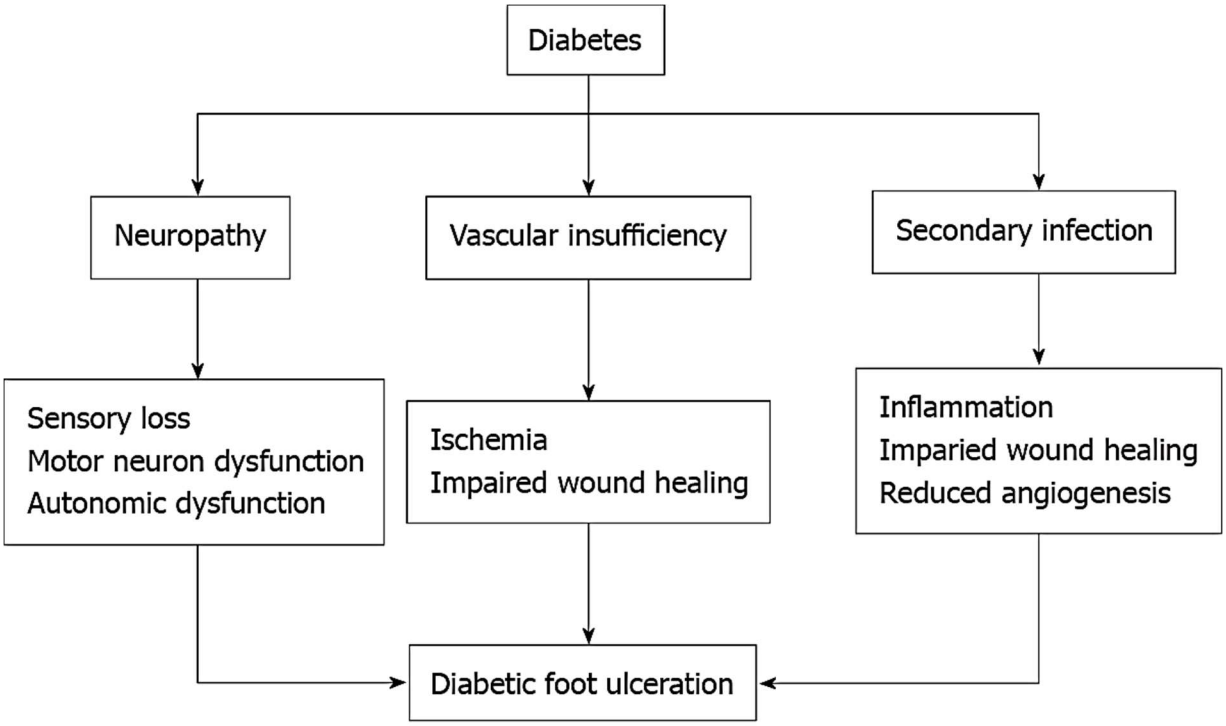


Figure 9: The pathophysiology of Diabetic Ulcer

Source: Raja *et al*. (2023)

2.2.6 Stomach Ulcer

Digestion and the role of the stomach in maintaining health have interested man since early times (Modlin, 1995). Stomach ulcers are a significant gastrointestinal disorder that affects millions of people worldwide. They occur when the mucosal lining of the stomach is eroded due to excessive gastric acid secretion, infection with *Helicobacter pylori*, or the chronic use of non-steroidal anti-inflammatory drugs (NSAIDs) (Sung *et al*., 2020). The primary cause of stomach ulcers is *H. pylori* infection, which induces inflammation and disrupts the mucosal barrier, making it more susceptible

to acid damage (Malfertheiner *et al*., 2017). NSAIDs also contribute to ulcer formation by inhibiting cyclooxygenase (COX) enzymes, reducing the production of protective prostaglandins, and increasing gastric acidity (Lanas and Chan, 2017).

Research indicates that *H. pylori* infection is responsible for the majority of stomach ulcer cases. *Helicobacter pylori* colonizes the gastric epithelium, triggering inflammatory responses and damaging the protective mucosal barrier, image shown in figure 10. This results in increased susceptibility to acid-induced injury (Malfertheiner *et al*., 2017). The bacterium produces virulence factors such as cytotoxin-associated gene A (CagA) and vacuolating cytotoxin A (VacA), which further contribute to epithelial damage and ulcer formation (Sugano *et al*., 2021).

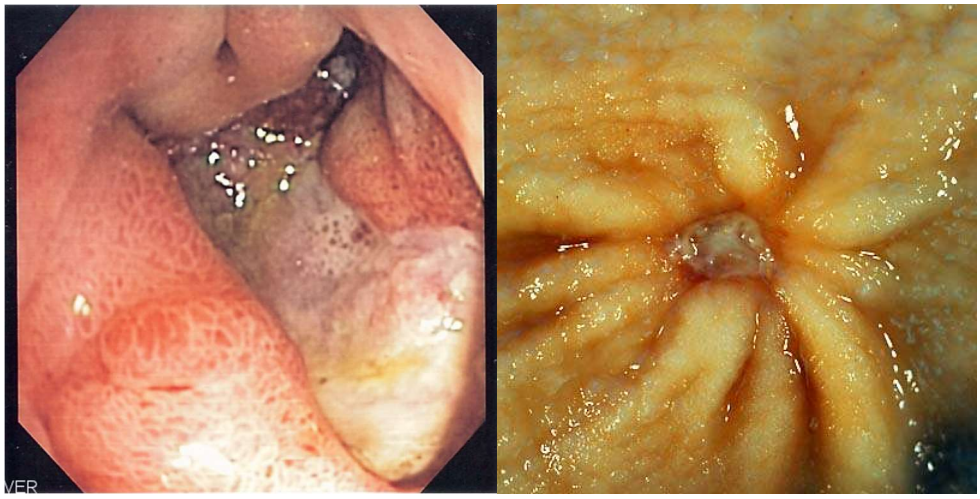


Figure 10: Stomach Ulcer

Source: Najm, (2011).

Gastric cancer is a multifaceted disease with different aetiologies, genetic changes and phenotypes. *Helicobacter pylori* infection is considered as the single most important risk factor leading to gastric cancer, (IARC, 2012) through chronic inflammatory changes in the gastric mucosa, followed by preneoplastic changes such as atrophy and IM, as in the Correa cascade (Stearns *et al*., 2011).

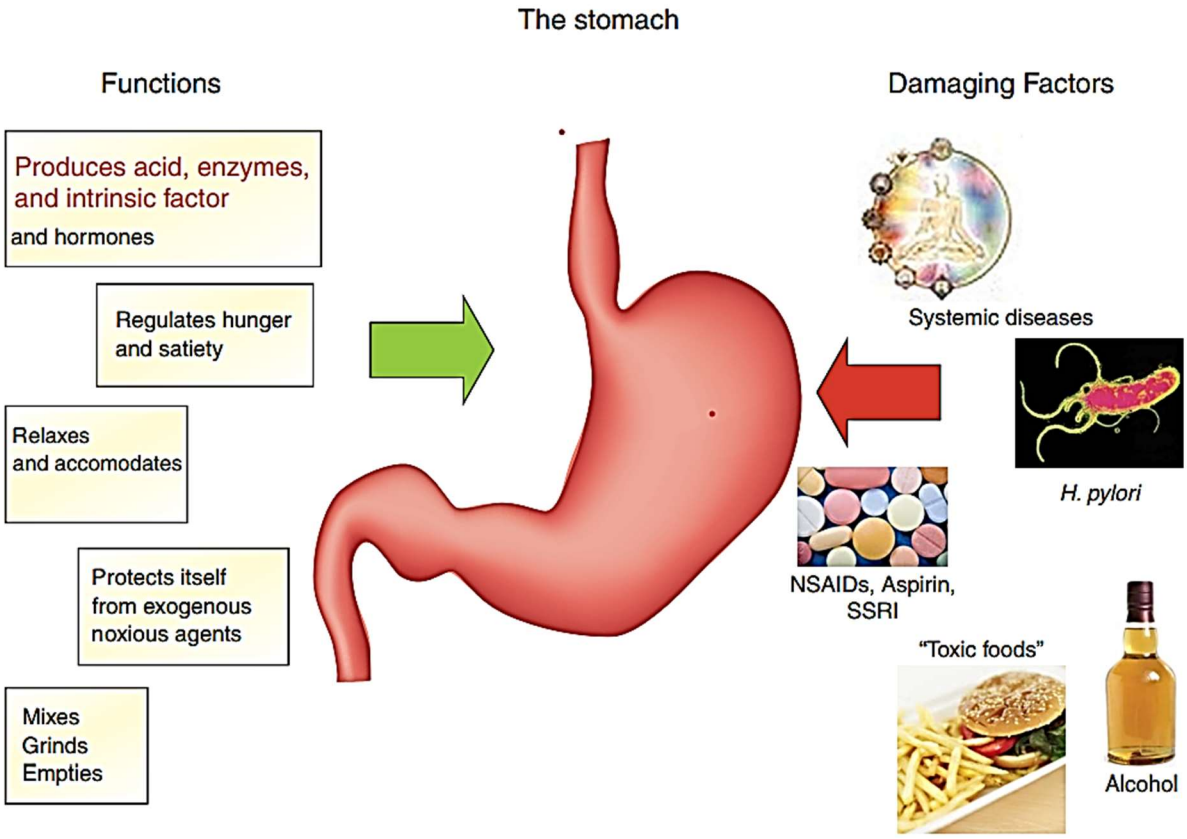


Figure 11: Key functions of the stomach and common harmful and noxious agents that affect gastric mucosal, secretory and motor functions

Source: Stearns *et al*. (2011).

2.3 Causes of Ulcer

2.3.1 Psychological Causes

Over the generations clinicians have been intrigued by the relationships between physical disorders and psychologic states. Observations of the role of psychologic processes in the pathogenesis and course of medical diseases have been shown by many researchers. Some illnesses, recognized as the classic psychosomatic disorders in the 1930s, appear to be directly affected by the impact of psychosocial factors. Peptic ulcer disease is regarded as one of the psychosomatic disorders. Alexander's initial psychologic constructs, based on retrospective data, were elaborated by the prospective studies of Mirsky and Weiner (NIasiry and Piper, 1985).

More recently, it has become increasingly clear that peptic duodenal ulcer is a heterogeneous illness. Patients with peptic duodenal ulcer may have elevated or normal pepsinogen levels inherited as an autosomal dominant trait. Two-thirds of duodenal ulcer patients have elevated levels, whereas the remaining one-third have normal levels. Elevated serum levels have been found in peptic ulcer disease patients with increased psychopathology, especially poor coping ability, hostility, and hypersensitivity. There may be additional genetic markers such as blood type 0 or absence of blood group antigens ABH in the saliva and gastric juice. Although the genetic and physiologic heterogeneity of peptic ulcer has become increasingly evident, it has not been possible to define equally refined psychologic characteristics for possible subgroups of peptic ulcer patients (Magni *et al*., 1987).

Recent attempts to delineate the psychogenic £actors in the etiology of peptic ulcer disease have utilized advanced behavioral research methodology. Three independent lines of research have evolved: (1) personality and other psychologic factors; (2) stressful life events; and (3) biopsychological interactions. Personality and Psychologic Factors Many psychoanalytically oriented researchers have hypothesized the existence of a psychosomatic personality structure distinct from neurotic or psychotic patterns. This type of individual lacks imagination and displays poverty of interpretative functions and symbolization. He has difficulty verbalizing feelings and has a decreased capacity for fantasy (Barbara, 1991).

Recent research in psychoneuroimmunology and psychoneurophysioloogy has elucidated potential mediating mechanisms that link the psyche and soma, particularly the effect of stressful events in the evolution of physical illness. Complex direct and indirect interactions and feed-back loops between the central nervous system, the immune systems, and the neuroendocrine systems have been identified. In peptic ulcer disease, catecholamines, corticosteroids, pepsinogen I and 11, as well as direct vagal stimulation, are viewed as mediators between stressful events and ulcer formation (Barbara *et al*., 1991).

2.3.2 Medication

Ulcers due to drugs are clinically classified into two types. The first is widespread mucositis and ulceration, mainly caused by cytotoxic drugs used for anti-tumor chemotherapy. Widespread sloughing and ulceration arise within days of commencing

therapy, with the associated pain often requiring opioid therapy and alteration or cessation of chemotherapy. Such cytotoxic drugs include 5-fluorouracil, methotrexate, bleomycin, and cisplatin. Immunosuppressive agents may also cause oral ulceration through opportunistic secondary infections involving organisms such as Gram-negative bacteria and fungi. The second type is fixed drug eruption, showing repeated development of treatment-resistant ulcers (Ozkaya, 2013). Single or multiple large ulcerations are seen on every site of the oral mucosa. Generally, the ulceration is larger than aphthous ulceration, with a flat surface showing slightly white appear ance (Ozkaya, 2013).

The margin of the ulcer is clear and often slightly raised; however, the ulcers are unaccompanied by any induration. Topical steroids are ineffective for these forms of ulceration. Histopathological examination usually reveals non-specific ulcer formation with marked infiltration of inflammatory cells. The molecular mechanisms involved with these types of oral ulceration have yet to be clarified, but immunological reactions may play some role in the process (Field and Allan, 2003).

Many kinds of drugs cause oral ulcerations, including some b blockers, immunosuppressants, anticholinergic bronchodila tors, platelet aggregation inhibitors, vasodilators, protease inhibitors, antibiotics, non-steroidal anti-inflammatory drugs (NSAIDs), antiretrovirals, and antihypertensives, table 1 below shows drug inducing ulceration (Scully and Bagan, 2003).

Table 1: Drugs inducing oral ulceration.

Antibiotics	Gastric ulcer treatments
Anticholinergic bronchodilators	Hypoglycemic agents
Anti-hypertensives	Immunosuppressants
Antiretrovirals	Interferons
Anti-rheumatic drug	Non-steroidal anti-inflammatory drugs (NSAIDs)
Anti-septics	Platelet aggregation inhibitors
Bisphosphonate	Potassium-channel activators
b-Blockers	Protease inhibitors
Corticosteroids	Vasodilators

Source: Jinbu and Demitsu (2014).

Alendronate (bisphosphonate). Alendronate is a drug belonging to the diphosphonate family that has recently been used in the treatment of osteoporosis and other bone diseases. This drug has been demonstrated to induce progressive and significant increases in bone mineral density in women with osteoporosis. Bisphosphonate-related osteonecrosis of the jaw is a well-established adverse effect of bisphosphonates, but oral ulceration as a result of taking alendronate has also recently been reported. These oral ulcerations are induced by incorrect use of the drugs and are caused by the drugs causing direct irritation as shown in figure 12 and 13 Jinbu and Demitsu, (2014).

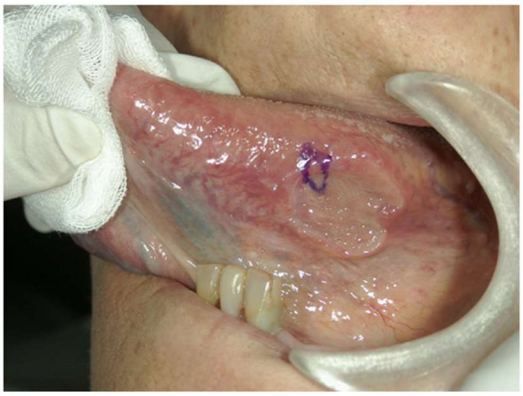


Figure 12: Indomethacin-induced oral ulceration. Ulceration on the left tongue margin with no induration. Line shows the biopsy site.

Source: Jinbu and Demitsu, (2014).

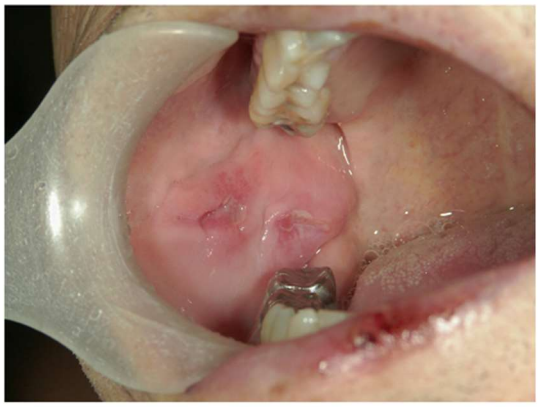


Figure 13: Oral ulcerations due to nicorandil. Multiple ulcers on bilateral buccal mucosa and bilateral tongue margins.

Jinbu and Demitsu, (2014).

The use of dopamine and the use of corticosteroids8 have been reported as risk factors for the development of pressure ulcer. Few reports have investigated the effect of prescription medications on pressure ulcer after it has developed. In addition, certain

medications have been reported to delay wound healing, but the effect of medications on pressure ulcer remains unclear. Non-steroidal anti-inflammatory drugs (NSAIDs) ongoing use of this class of medications is the second most common cause of ulcers (Arai *et al*., 2020).These drugs (which include aspirin, ibuprofen, naproxen, diclofenac, tolmetin, piroxicam, fenoprofen, indomethacin, oxaprozin, ketoprofen, sulindac, nabumetone, etodolac, and salsalate) are acidic (Debjit *et al*., 2010).

2.3.3 Dietary Factors

Various factors contribute to ulcer development, including Helicobacter pylori infection, nonsteroidal anti-inflammatory drug (NSAID) use, and lifestyle factors such as diet (Lanas and Chan, 2017). Spicy foods, particularly those containing capsaicin, have been controversially linked to ulcer development. Some studies suggest that excessive consumption of spicy foods can exacerbate gastric mucosal irritation and increase acid secretion (Zhu *et al*., 2019). However, other research indicates that capsaicin may have protective effects by stimulating mucus secretion and promoting gastric mucosal blood flow (Satyanarayana *et al*., 2021). Despite these conflicting findings, individuals with existing ulcers are often advised to limit spicy food intake.

A diet high in sodium has been implicated in gastric mucosal damage and increased susceptibility to H. pylori infection, which is a major risk factor for ulcers (Huang *et al*., 2017). High salt intake may alter gastric mucus composition and impair its protective functions, thereby making the stomach lining more vulnerable to acid-induced

injury (Gaddy *et al*., 2019). Excessive alcohol consumption has been shown to contribute to ulcer formation by weakening the gastric mucosal barrier and increasing acid production (Jiang *et al*., 2021). Alcohol can also stimulate inflammatory responses and delay ulcer healing by interfering with prostaglandin synthesis (Matsuhashi *et al*., 2018).

Diets rich in processed foods containing artificial additives, preservatives, and high levels of unhealthy fats have been associated with increased ulcer risk (Zhang *et al*., 2019). These foods may promote inflammation and oxidative stress, which can weaken the mucosal defense system and contribute to ulcerogenesis (Patel and Shah, 2022). While certain dietary habits contribute to ulcer formation, others may offer protection. Diets rich in fiber, particularly from fruits, vegetables, and whole grains, have been shown to reduce ulcer risk by promoting healthy gut microbiota and enhancing mucosal integrity (Song *et al*., 2018).

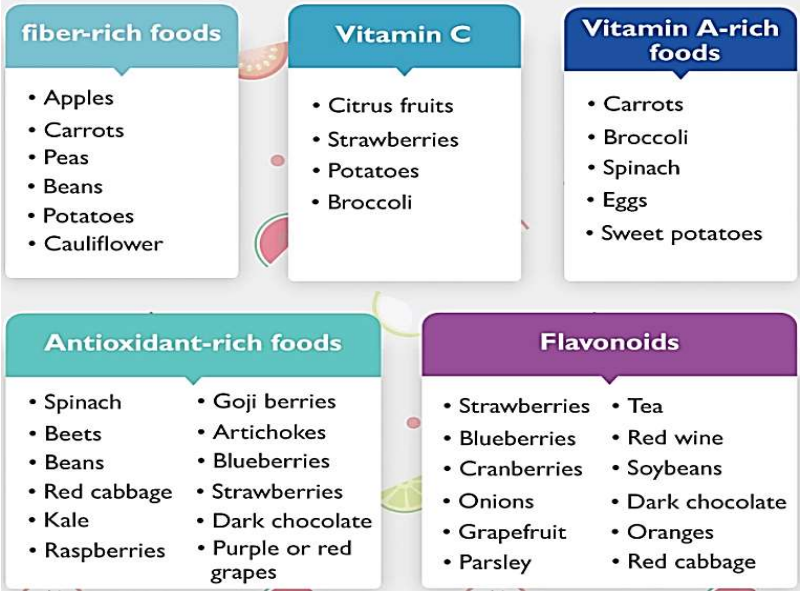


Figure 14: Stomach ulcer Diet

Source: www.sprintmedical.in

2.4 Pathophysiology of Ulcer

In recent years the hospitalization rate for duodenal ulcer (DU) has decreased by 43%, that for gastric ulcer (GU) by 8% and mortality by ca. 62%. At first sight these figures might suggest that the disease as such is dying out. This is an illusion based to some extent on improvements in diagnosis, therapy and control of complications. Gastric acid (HCl) and pepsin play a crucial role in digestion but can also contribute to mucosal injury when unregulated. The parietal cells of the stomach secrete acid under the influence of histamine, gastrin, and acetylcholine (Kumar *et al*., 2021). Excessive acid production leads to mucosal erosion and ulcer formation, especially in conditions such as

Zollinger-Ellison syndrome (Sundaram and Sitaraman, 2018). Pepsin, a proteolytic enzyme, further degrades the mucosal proteins, worsening ulceration (Wang *et al*., 2019).

The majority of the Helicobacter pylori bacteria live freely in colonized hosts, but ~20% are believed to bind gastric epithelial cells. The bacteria colonize the gastric mucosa, producing urease, which converts urea into ammonia, neutralizing stomach acid and allowing bacterial survival (Hooi *et al*., 2017). Additionally, H. pylori releases cytotoxins such as CagA (cytotoxin-associated gene A) and VacA (vacuolating cytotoxin A), leading to epithelial cell damage, inflammation, and disruption of gastric mucosal integrity (Chey and Leontiadis, 2018).

This colonization is highly specific in vivo when it overlays islands of gastric metaplasia (Peek and Crabtree, 2006). *Helicobacter pylori* is well characterized as determining the 'cag' pathogenicity island (cag PAI), a multigene locus. It induces gastritis augmenting the risk for atrophie gastritis and distal gastric cancer. In most people, however, it remains asymptomatic. It would be useful to identify a few people with high risk, because they could serve as a paradigm for the chronie role of inflammation in the genesis of malignancies that arise in the gastrointestinal tract. Helicobacter pylori is not the only organism that is believed to cause active chronie gastritis in man. Other infections with spiral organisms have been described (Israel and Peek, 2006).

The bacillus is sensitive to penicillin, erythromycin, cephalosporins, gentamycin, tetracycline and bismuth citrate. Ranitidine has been combined with bismuth citrate

(RBC), clarithromycin or amoxycillin. In 70% of patients the peptic ulcer healed within 4 weeks, but only 41-48% of the Helicobacter organism were eradicated. In a randomized study of 900 patients with peptic complaints an average of 75% of those given the combination of omeprazole plus clarithromycin, had Helicobacter eradication, but at 6 months 30% in one study and 52% in another had ulcer recurrence. In a third study at final analyses after 4-6 weeks 50-70% of ulcers had not healed (Bamett, 1995).

2.5 *Sida acuta*

The important of plants of various types cannot be over emphasized. Since the time immemorial, plant has been taking so important in various approaches. Several plant leaves are delicacy in the preparation of stew in some tribes, which when its number and types is not complete the stew look awkward and unacceptable to them. The belief is that different plant contributes different nutrient to the stew which make it delicious and nutritional. Therefore plenty plants of proven nutritional/ medicinal quality are of important to many pharmaceutical companies manufacturing a wide range of allopathic medicines, due to their phytochemical properties. This has caused increasing consideration of natural drug to an individual and most companies producing most synthetic drug (Shittu and Alagbe, 2020).

Sida acuta (broom weed) is one of the plants with medicinal potential qualities and present in abundance in the tropics. It is drought resistance tropical weeds that are common in almost everywhere. *Sida acuta* is an erect, branched and perennial shrub with a woody tap root, hairy branded up to 1 m high and is reproduced from their seeds. The

stem is woody, rounded and slender, and is fibrous and hairy especially when young. The leaves are simple and alternate while the inflorescence is solitary and axillary with stalks up to 1.3 cm long jointed about half of the length. The flowers are yellow with five petals and the fruit is capsuled with 5-6 carpels (Ekpo and Etim, 2009).

As shown in figure 15, the bark of *Sida acuta* is smooth, greenish, the root is thin, long, cylindrical and very rough; leaves are lanceolate, the flowers are yellow, solitary or in pairs; seeds are smooth and black. In Indian traditional medicine, the root of *Sida acuta* is extensively used as a stomachic, diaphoretic and antipyretic. It is regarded as cooling, astringent, tonic and useful in treating nervous and urinary diseases and also disorders of the blood, bile and liver (Khare *et al*., 2002).The ethanol extract of *Sida acuta* whole plant exhibited moderate anti-ulcer activity in ulcer models in rats (Malairajan *et al*., 2006). The ethanol extract of *S. acuta* leaf also exhibited antiulcer activity in ulcer models in rats (Akilandeswari *et al*., 2010).

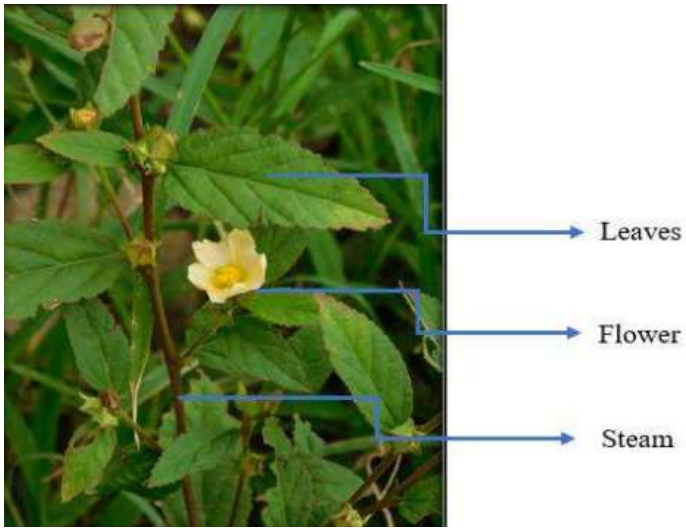


Figure 20: *Sida acuta* Plant with arrow indicating different parts

Source: Tejas *et al*. (2024)

Table 2: Taxonomical Hierarchy

Kingdom	Plantae
Phylum	Anthophyta
Class	Dicotyledonae
Order	Malvales
Family	Malvaceae
Genius	*Sida*
Species	*Sida acuta*
Scientific Name	*Sida acuta Burm f.*

Tejas, *et al.* (2024).

Sida acuta Burm. f. (*Malvaceae*) is a widely distributed medicinal plant found in tropical and subtropical regions. It is traditionally used in various cultures for its therapeutic properties, including antibacterial, anti-inflammatory, antidiabetic, antioxidant, and anti-ulcer activities (Okokon *et al*., 2018). Studies have identified a variety of bioactive compounds in *Sida acuta*, including alkaloids, flavonoids, tannins, saponins, terpenoids, and phenolic compounds (Ogunyemi *et al*., 2019). These secondary metabolites are responsible for its medicinal properties. The presence of flavonoids and

polyphenols contributes significantly to its antioxidant activity, which plays a crucial role in neutralizing free radicals (Edeoga *et al*., 2020).

The antimicrobial efficacy of *Sida acuta* has been widely reported. Studies indicate that extracts from the plant exhibit strong antibacterial properties against Gram-positive and Gram-negative bacteria, including *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* (Adegboye *et al*., 2021). Oxidative stress is a major contributor to various diseases, including cancer and cardiovascular disorders. Extracts of *Sida acuta* have been shown to possess potent antioxidant properties, which help in reducing oxidative damage and protecting cells from lipid peroxidation (Uche *et al*., 2020). Animal studies have demonstrated that *Sida acuta* extracts can significantly reduce blood glucose levels in diabetic rats (Akinpelu *et al*., 2021). These effects make it a promising candidate for ulcer management. Despite its numerous pharmacological benefits, toxicological assessments are necessary to determine the safety of *Sida acuta* (Ajayi *et al*., 2022).

2.5.1 Saponin

Saponins are bioactive glycosides with a characteristic foaming property, widely studied for their medicinal benefits (Ogunyemi *et al*., 2019). Saponin in *Sida acuta* are a class of triterpenoid or steroidal glycosides known for their amphiphilic nature (Edeoga *et al*., 2020). Phytochemical screening has confirmed the presence of these compounds in various parts of the plant, including leaves, stems, and roots (Adegboye *et al*., 2021).

Their structural diversity contributes to various biological activities, including antimicrobial, anti-inflammatory, and antioxidant effects (Olajide *et al*., 2019). The extraction of saponins from *Sida acuta* is typically performed using aqueous or alcoholic solvents, with ethanol and methanol being the most effective (Mbagwu and Okoro, 2017). Chromatographic techniques such as High-Performance Liquid Chromatography (HPLC) and Gas Chromatography-Mass Spectrometry (GC-MS) have been utilized to characterize these bioactive compounds (Uche *et al*., 2020).

2.5.2 Tannins

Tannins are a class of polyphenolic compounds widely distributed in plants, and *Sida acuta* has been reported to contain significant amounts of these compounds. Tannins exhibit strong astringent properties and have been associated with various pharmacological activities, including antimicrobial, antioxidant, anti-inflammatory, and gastroprotective effects (Bennett and Wallsgrove, 2019). Tannins in *Sida acuta* contribute significantly to its antioxidant properties. These compounds can scavenge free radicals and chelate metal ions, thereby preventing oxidative damage to cells (Hagerman and Butler, 2020). The antioxidant potential of *Sida acuta* tannins has been linked to its effectiveness in preventing lipid peroxidation and oxidative stress-related diseases (Uche *et al*., 2020). Tannins play a crucial role in the gastroprotective activity of *Sida acuta*. They enhance mucus secretion, reduce gastric acid production, and strengthen the mucosal barrier, thereby preventing ulcer formation (Ezekwesili *et al*., 2018).

2.5.3 Flavonoids

Sida acuta is a medicinal plant rich in flavonoids, which are polyphenolic compounds known for their diverse biological activities. Flavonoids play a critical role in the pharmacological potential of *Sida acuta*, exhibiting antioxidant, antimicrobial, anti-inflammatory, and other health benefits (Ogunyemi *et al*., 2019). The presence of these bioactive compounds in the plant contributes significantly to its traditional and therapeutic uses in managing various diseases. These compounds act as potent free radical scavengers, reducing oxidative stress and preventing cellular damage (Edeoga *et al*., 2020). Oxidative stress is a major contributor to aging and various chronic diseases, including cardiovascular diseases, neurodegenerative disorders, and cancer. Flavonoids neutralize reactive oxygen species (ROS) and enhance the activity of endogenous antioxidant enzymes, thus protecting cells from oxidative damage (Uche *et al*., 2020).

Sida acuta flavonoids exhibit strong antimicrobial effects. Studies have demonstrated their efficacy against various bacterial and fungal pathogens, including *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* (Adegboye *et al*., 2021). The antimicrobial mechanism involves disruption of microbial cell membranes, inhibition of bacterial enzyme systems, and interference with biofilm formation (Olajide *et al*., 2019). This makes *Sida acuta* extracts a promising alternative for combating antibiotic-resistant infections. Flavonoids from *Sida acuta* also possess significant anti-inflammatory properties (Mbagwu and Okoro, 2017).

Research suggests that *Sida acuta* flavonoids have anticancer properties. They exhibit cytotoxic effects against tumor cells by inducing apoptosis, inhibiting proliferation, and modulating key signaling pathways involved in cancer progression (Fraga *et al*., 2019). These properties make *Sida acuta* a promising candidate for further investigation in cancer prevention and treatment (Ezekwesili *et al*., 2018).

2.5.4 Phenols

Sida acuta phenols play a crucial role in neutralizing free radicals and reducing oxidative stress, which is linked to chronic diseases such as cancer, cardiovascular disorders, and neurodegenerative conditions (Edeoga *et al*., 2020). Phenolic compounds exhibit strong radical-scavenging abilities by donating hydrogen atoms to reactive oxygen species (ROS), thereby preventing cellular damage and enhancing the body's defense mechanisms (Uche *et al*., 2020). Phenols display significant antimicrobial activity against various bacterial and fungal pathogens. Studies have shown that these compounds inhibit the growth of *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans*, making them effective agents in combating infectious diseases (Adegboye *et al*., 2021). The antimicrobial mechanism involves disrupting microbial cell membranes, inhibiting essential enzymes, and interfering with microbial DNA synthesis (Olajide *et al*., 2019). This highlights the potential of *Sida acuta* as a natural source for developing antimicrobial drugs.

The phenolic content of *Sida acuta* makes it a promising candidate for further studies in cancer prevention and treatment. However, additional research is required to

establish the full molecular mechanisms and therapeutic potential of these bioactive molecules. Phenols contribute to gastroprotection by reducing gastric acid secretion, enhancing mucosal defense, and promoting ulcer healing (Ezekwesili *et al*., 2018).

2.6 Mineral composition

The diverse mineral profile of *Sida acuta* enhances its pharmacological relevance, supporting its traditional applications in treating mineral deficiencies and metabolic disorders. Continued research is necessary to quantify the bioavailability of these minerals and their precise roles in human health. The potential for *Sida acuta* as a nutraceutical or functional food supplement remains promising, warranting further investigation into its therapeutic benefits and clinical applications (Fraga *et al*., 2019). Trace elements such as iron (Fe), zinc (Zn), and copper (Cu) are also present in *Sida acuta* and are essential for various biological processes. Iron is crucial for hemoglobin formation and oxygen transport, making *Sida acuta* beneficial in addressing iron deficiency anemia (Mbagwu and Okoro, 2017).

2.6.1 Calcium

Among the macrominerals found in *Sida acuta*, calcium (Ca) is one of the most abundant. Calcium is essential for bone health, nerve transmission, and muscle function. The presence of calcium in *Sida acuta* suggests its potential role in preventing osteoporosis and maintaining skeletal integrity (Edeoga *et al*., 2020). According to Enin (2015), the calcium content in *Sida acuta* leaves is approximately 185 mg per 100 grams of dried sample. This level is relatively high when compared with other wild leafy

vegetables and highlights the plant's potential to support calcium requirements, especially in plant-based or low-income diets. Shittu and Alagbe (2020) similarly observed a significant calcium presence in their analysis of the plant's mineral profile, further supporting its nutritional relevance.

2.6.2 Potassium

Potassium (K) is another vital mineral present in *Sida acuta*, playing an essential role in maintaining electrolyte balance, nerve signaling, and cardiovascular function. A potassium-rich diet has been linked to reduced blood pressure and a lower risk of stroke (Adegboye *et al*., 2021). The presence of potassium in *Sida acuta* suggests its potential contribution to heart health and blood pressure regulation. Furthermore, sodium (Na) is present in trace amounts, ensuring proper fluid balance and nerve function without contributing to hypertension (Olajide *et al*., 2019).

2.6.3 Sodium

Sida acuta, commonly referred to as broom weed, is a medicinal plant widely utilized in traditional medicine across tropical regions. One of its lesser-discussed but important attributes is its mineral composition particularly sodium. Sodium, a key electrolyte in human physiology, plays essential roles in fluid regulation, nerve transmission, and muscle function. Although many dietary sources provide sodium, the relevance of its presence in medicinal plants like *Sida acuta* is significant, especially for populations relying on herbal remedies for both nutrition and therapy. Recent analyses have revealed that *Sida acuta* leaves contain appreciable amounts of sodium. According

to Shittu and Alagbe (2020), the sodium content in *Sida acuta* leaf extract was recorded at 0.222 mg per gram. This indicates that even in small servings, the plant contributes measurable sodium to the diet. Similarly, Enin (2015) found that the leaves contain approximately 110 mg of sodium per 100 grams of dried plant material, further confirming the plant's role as a potential sodium source.

2.6.4 Phosphorus

Phosphorus is a critical mineral required for various physiological processes, including energy metabolism, bone mineralization, and cellular signaling. While commonly obtained through animal products and cereals, some medicinal plants like *Sida acuta* also contribute to dietary phosphorus intake, especially in regions where plant-based diets are predominant. The phosphorus content in *Sida acuta* has been analyzed in several nutritional studies.

According to Enin (2015), the leaves of *Sida acuta* contain approximately 18.6 mg of phosphorus per 100 grams of dried plant material. This level, though modest compared to animal-based sources, is notable for a wild leafy plant often used in herbal infusions or as a supplementary food source. Shittu and Alagbe (2020) similarly reported the presence of phosphorus in the leaf extract, suggesting its contribution to the mineral profile of the plant.

2.6.5 Iron and copper

Iron is crucial for the formation of hemoglobin, the protein responsible for transporting oxygen in the blood, and plays a role in cellular respiration and immune

function. Copper, on the other hand, assists in iron metabolism, supports antioxidant activity, and is necessary for the development of connective tissue and the nervous system. When found together in a plant like *Sida acuta*, these minerals suggest that the plant may serve as a valuable dietary supplement, especially in areas where iron-deficiency anemia is common.

According to Shittu and Alagbe (2020), the iron content in *Sida acuta* leaf extract was reported to be approximately 1.02 mg per gram. This relatively high value indicates a promising potential for combating iron deficiency through traditional herbal consumption. Enin (2015) also reported a comparable iron concentration, further supporting the idea that *Sida acuta* could be an effective natural source of dietary iron. In terms of copper, *Sida acuta* also shows a meaningful mineral profile. Enin (2015) documented the presence of about 0.35 mg of copper per 100 grams of dried leaf sample. Although the copper content is lower compared to iron, it remains within a beneficial range for human nutrition. This trace amount contributes to several physiological functions, including the formation of red blood cells and maintenance of healthy bones and blood vessels.

2.6.6 Aluminum

Aluminium, although not considered an essential nutrient for human physiology, is a naturally occurring element that can be found in various plants, soils, and water sources. In recent years, the presence of aluminium in medicinal plants such as *Sida acuta* has sparked interest, especially due to growing concerns about its potential health

effects when consumed in large quantities or over extended periods. *Sida acuta*, known for its medicinal versatility, has been examined for its elemental composition, including trace amounts of aluminium. According to Enin (2015), the leaves of *Sida acuta* were found to contain approximately 3.08 mg of aluminium per 100 grams of dried sample. This value indicates that while aluminium is present in the plant, it is within a relatively low concentration compared to other essential minerals like iron or calcium.

2.7 Proximate composition

Proximate analysis is used to estimate the relative amounts of protein, lipid, water, ash and carbohydrate in any sample. Proximate composition is the term usually used in the field of feed/food and means the components of moisture, crude protein, ether extract, crude fibre, crude ash and nitrogen-free extracts, which are expressed as the content (%) in the sample, respectively. Protein, lipid and carbohydrate each contribute to the total energy content of an organism, while water and ash only contribute mass (Parimelazhagan and Thangaraj, 2016).

2.7.1 Moisture content

Moisture content is an essential factor in determining the storage and preservation characteristics of plant materials. It directly affects the stability and nutritional quality of plants, influencing their shelf life and susceptibility to microbial spoilage. For *Sida acuta*, a plant commonly utilized in traditional medicine and as a food supplement, understanding its moisture content is crucial for effective post-harvest handling and processing.

The moisture content in *Sida acuta* leaves has been reported to be relatively high, a study by Moti *et al*. (2020) found that the fresh leaves of *Sida acuta* contained approximately 75.2% moisture, which is typical of many leafy plants. This high moisture content makes the plant vulnerable to rapid spoilage if not properly dried or stored. Adequate drying is critical to preserving the plant's bioactive compounds and extending its shelf life for both medicinal and nutritional purposes (Akinmoladun *et al*., 2016).

2.7.2 Crude protein

Crude protein is an essential component in the nutritional evaluation of plant materials, as it reflects the total protein content, including both true proteins and non-protein nitrogen compounds. As an important macronutrient, protein plays a vital role in tissue repair, enzyme activity, immune function, and overall growth. Research on the crude protein content of *Sida acuta* indicates that it is a reasonable source of plant-based protein. According to Moti *et al*. (2020), the crude protein content in *Sida acuta* leaves was found to be approximately 12.3% on a dry weight basis. This value places *Sida acuta* among moderate protein-containing leafy vegetables, which is important for supporting protein intake in plant-based diets.

Similarly, Akinmoladun *et al*. (2016) found that the leaves of *Sida acuta* contained 11.5% crude protein, which is consistent with the general range found in other leafy plants commonly used in herbal medicine and traditional food. The presence of crude protein in *Sida acuta* highlights its potential as a supplementary protein source, especially in regions where animal protein is scarce or expensive. Although the protein

content in *Sida acuta* may not be as high as in legumes or animal-based sources, it still contributes meaningfully to the protein intake of individuals consuming it regularly. Additionally, the plant's protein is complemented by other essential nutrients, making it a valuable part of a balanced diet or herbal remedy (Akinmoladun *et al*., 2016; Moti *et al*., 2020).

2.7.3 Crude ash

Crude ash content is a key indicator of the total mineral content in a plant material. It represents the inorganic residue left after the combustion of the plant material, and it includes essential minerals such as calcium, magnesium, potassium, phosphorus, and trace elements. While high crude ash content is often linked with a rich mineral composition, For *Sida acuta*, crude ash content has been studied to evaluate its mineral composition and overall nutritional profile. According to Singh *et al*. (2019), the crude ash content of *Sida acuta* leaves was found to be 7.1% on a dry weight basis. This value indicates that the plant contains a significant proportion of minerals, which could contribute to its nutritional and medicinal properties. In a similar study, Oyetayo *et al*. (2018) reported that *Sida acuta* leaves contained 6.3% crude ash, further supporting its status as a plant rich in essential minerals. The presence of a relatively high crude ash content in *Sida acuta* suggests that it may be a useful source of minerals, particularly for individuals seeking to supplement their mineral intake through plant-based foods. (Singh *et al*., 2019; Oyetayo *et al*., 2018).

2.7.4 Lipid

Lipids are an essential class of biomolecules that play key roles in energy storage, cellular structure, and signaling processes within the human body. In plants, lipids are primarily found in the form of oils and fats, which are important for their role in cellular function and energy storage. Research on the lipid content of *Sida acuta* indicates that while the plant does contain lipids, the levels are generally moderate. According to Oyeleke *et al*. (2021), the crude lipid content of *Sida acuta* leaves was found to be around 3.2% on a dry weight basis. This is relatively low compared to oil-rich plants like soybean or sunflower, which have lipid contents above 20%. However, this level of lipids is still significant for a plant traditionally consumed as a leafy green or used in herbal medicine.

Crude fat is the term used to refer the crude mixture of fat-soluble material present in a sample. Crude fat also known as the ether extract or the free lipid content is the traditional measure of fat in food products. The lipid materials may include triglycerides, diglycerides, monoglycerides, phospholipids, steroids, free fatty acids, fat-soluble vitamins, carotene pigments and chlorophylls. The common approach for total crude fat determination is based on the solubility of lipids in non-polar organic solvents such as hexanes, petroleum ether or supercritical liquid carbon dioxide with or without a solvent modifier (Arunachalam *et al*., 2011).

2.7.5 Crude fibre

Crude fibre, or dietary fibre, refers to the indigestible parts of plant materials, including cellulose, hemicellulose, and lignin, which are essential for digestive health. Fibre plays an important role in maintaining gastrointestinal function, regulating blood sugar levels, and supporting cardiovascular health. The crude fibre content in *Sida acuta* has been examined in several studies, revealing notable levels of dietary fibre. According to Akinmoladun *et al*. (2017), the crude fibre content in the leaves of *Sida acuta* was found to be approximately 14.4% on a dry weight basis. This value indicates that *Sida acuta* is a moderate source of fibre, which is beneficial for promoting healthy digestion and preventing constipation. Additionally, dietary fibre is known to play a role in weight management by promoting satiety, which could enhance *Sida acuta*'s role as part of a balanced diet.

In a similar study, Oyeleke *et al*. (2021) reported that the crude fibre content of *Sida acuta* was 13.8%, further supporting its relevance as a plant-based source of fibre. Given the plant's use in traditional medicine and as a food supplement, its moderate fibre content could be advantageous for individuals seeking to improve their digestive health or regulate their cholesterol levels. Fibre-rich plants such as *Sida acuta* are also thought to contribute to overall gut health by supporting the growth of beneficial gut bacteria (Oyeleke *et al*., 2021).

2.8 Non enzymatic antioxidant

2.8.1 Total phenolic content

Non-enzymatic antioxidants play a vital role in protecting biological systems from oxidative stress, which arises when there's an imbalance between the production of free radicals and the body's ability to detoxify them. Among the most important non-enzymatic antioxidants are phenolic compounds, which are naturally found in plants and known for their strong radical-scavenging abilities. The cumulative measure of these compounds in a sample is referred to as the Total Phenolic Content (TPC), and it is a widely accepted indicator of a plant's antioxidant potential. In recent years, medicinal plants like *Sida acuta* have gained attention for their high TPC and associated health benefits (Ogunmoyole *et al*., 2015).

A high Total Phenolic Content in *Sida acuta* signifies a rich presence of bioactive phytochemicals such as flavonoids, tannins, and phenolic acids, which contribute to its therapeutic properties, including anti-ulcer, anti-inflammatory, and antioxidant effects (Ogunmoyole *et al*., 2015). Phenolic compounds work by directly scavenging reactive oxygen species (ROS) and reactive nitrogen species (RNS), thereby preventing the oxidative damage of cell membranes, proteins, and DNA. In the context of peptic ulcer disease, oxidative stress plays a major role in gastric mucosal injury, often triggered by factors such as *Helicobacter pylori* infection, NSAID use, or ethanol-induced gastric irritation. The phenolic-rich extracts of *Sida acuta* have been shown to mitigate such

damage by reducing lipid peroxidation and enhancing mucosal protection (Akinmoladun *et al*., 2020).

2.8.2 Total flavonoid content

Flavonoids are a large class of naturally occurring polyphenolic compounds that serve as powerful non-enzymatic antioxidants. They are known for their capacity to scavenge free radicals, inhibit oxidative damage, and modulate inflammatory responses, making them central to the prevention and management of numerous health conditions, including peptic ulcer disease. The Total Flavonoid Content (TFC) of a plant extract is a quantifiable measure of its flavonoid richness, often used as a marker of its antioxidant potential. In medicinal plants like *Sida acuta*, TFC plays a crucial role in its gastroprotective, anti-inflammatory, and wound-healing properties. The Total Flavonoid Content is typically determined using the aluminium chloride colorimetric method and results are expressed in quercetin equivalents (QE) (Ogunmoyole *et al*., 2015).

Studies on *Sida acuta* have revealed that it contains a high flavonoid content, particularly in its ethanolic and aqueous leaf extracts, which correlates with its notable antioxidant activity (Ogunmoyole *et al*., 2015). Flavonoids in *Sida acuta* contribute to ulcer prevention through several biological mechanisms. Firstly, they neutralise reactive oxygen species (ROS) and reduce lipid peroxidation, which is a major cause of gastric mucosal damage in ulcer formation. Secondly, flavonoids enhance gastric mucosal defense by stimulating prostaglandin synthesis and increasing mucus secretion, both of

which are essential for protecting the stomach lining from irritants such as ethanol, NSAIDs, or *Helicobacter pylori* (Ezekwesili *et al*., 2014).

2.8.3 Ferric reducing antioxidant power (FRAP)

The Ferric Reducing Antioxidant Power (FRAP) assay is a well-established analytical method used to evaluate the antioxidant potential of plant extracts. It measures the ability of a sample to reduce ferric ions (Fe^{3+}) to ferrous ions (Fe^{2+}) under acidic conditions. The higher the reducing capacity, the stronger the antioxidant activity, which is crucial in preventing oxidative damage implicated in several pathological conditions, particularly peptic ulcers. In this context, *Sida acuta*, a medicinal plant long used in traditional systems for treating stomach-related disorders, has demonstrated notable FRAP activity, especially in its leaf extracts. The antioxidant power exhibited is primarily attributed to its abundance of polyphenolic compounds, especially flavonoids and phenolic acids, which are known for their electron-donating capacity (Sharma *et al*., 2022). Oxidative stress plays a central role in ulcerogenesis, contributing to mucosal erosion through the generation of free radicals that damage cell membranes, proteins, and DNA. Substances with high FRAP values like *Sida acuta* can interrupt this process by donating electrons to unstable radicals, thus halting their damaging cascade. Such antioxidant activity enhances gastric mucosal protection and supports healing of existing lesions (Mehta *et al*., 2021). Additionally, the FRAP assay reflects the total antioxidant effect of all compounds present in the extract. In *Sida acuta*, these include flavonoids, tannins, and saponins, which may act synergistically to neutralise free radicals and reduce

inflammation. This synergistic action contributes to the plant's broader therapeutic roles, including its gastroprotective and anti-inflammatory effects (Kumar *et al*., 2020).

2.8.4 2,2-azino-bis C3 ethylbenzothiazoline-b-sulphonic acid (ABTS)

The ABTS [2,2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)] assay is a reliable method for determining the antioxidant capacity of natural compounds and plant extracts. It evaluates the ability of antioxidants to quench the $ABTS^{+\bullet}$ radical cation, producing a measurable reduction in absorbance. The higher the antioxidant activity, the more effectively the extract neutralises free radicals, making this assay especially relevant in studies exploring the gastroprotective potential of medicinal plants like *Sida acuta*. *Sida acuta*, a plant traditionally used to treat inflammation and gastrointestinal discomfort, has been shown to possess strong ABTS radical scavenging activity, particularly in its methanolic and aqueous extracts (Adepoju *et al*., 2021). This activity is directly linked to the presence of flavonoids, tannins, and polyphenolic compounds, which are known to donate hydrogen atoms or electrons to stabilise free radicals and prevent cellular damage.

The antioxidant effect measured by the ABTS assay is important in the context of peptic ulcer disease, as oxidative stress plays a significant role in the breakdown of gastric mucosa. Excessive generation of reactive oxygen species (ROS) during stress, NSAID use, or *Helicobacter pylori* infection can lead to mucosal injury. The ability of *Sida acuta* extracts to scavenge ABTS radicals suggests that the plant can protect gastric

tissue by neutralising free radicals, thereby preventing or reducing ulcer formation (Nwanya *et al*., 2020).

2.8.5 2,2-diphenyl-1-pycrylhydraxyl (DPPH)

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay is a widely used and simple method for evaluating the free radical scavenging activity of plant extracts. It measures the ability of antioxidants in a sample to reduce the DPPH radical, a stable purple-colored compound, into a yellow-colored non-radical form. The reduction in absorbance is directly proportional to the antioxidant strength of the sample, offering valuable insight into its potential biological protective effects (Olasehinde *et al*., 2022).

In the context of peptic ulcer disease, oxidative stress is one of the main culprits in mucosal injury, particularly when triggered by ethanol, NSAIDs, or *Helicobacter pylori*. Antioxidants that effectively quench radicals like DPPH can significantly mitigate gastric epithelial cell damage, promote tissue repair, and improve mucosal defense mechanisms. Extracts of *Sida acuta* with high DPPH scavenging capacity have been found to reduce oxidative stress markers, thereby supporting their gastroprotective potential (Iroanya and Onajobi, 2020). Compared to other assays, DPPH is particularly useful for evaluating lipophilic antioxidants, making it an ideal method for investigating the total antioxidant capacity of plant-based remedies (Ajiboye *et al*., 2021).

2.9 Organ studied

2.9.1 Stomach

The stomach is the primary organ affected in gastric ulceration, which results from a complex interplay of acid secretion, enzyme activity, and oxidative stress. Ulcers often arise due to the breakdown of the gastric mucosal barrier, exposing the underlying tissue to damaging factors such as gastric acid and reactive oxygen species (ROS). Antioxidants from plant sources, including *Sida acuta*, are known to offer protection by neutralising free radicals and enhancing the gastric mucosal defense mechanisms. Several studies have shown that *Sida acuta* extracts exhibit significant gastroprotective effects, primarily by scavenging free radicals and promoting the synthesis of prostaglandins, which increase mucus secretion and help maintain mucosal integrity (Ezekwesili *et al*., 2014). These effects are particularly important in combating the damage caused by excessive alcohol consumption, NSAIDs, and *Helicobacter pylori* infection, all of which are associated with gastric ulcers. Furthermore, antioxidants from *Sida acuta* have been found to reduce oxidative markers in the stomach, supporting the idea that oxidative stress is a central factor in ulcer pathogenesis (Akinmoladun *et al*., 2020).

2.9.2 Liver

The liver plays a pivotal role in metabolising nutrients, detoxifying harmful substances, and regulating antioxidant systems. It is also a key organ in responding to oxidative stress, which can be exacerbated in conditions such as gastritis or peptic ulcers. While ulcers primarily affect the stomach and duodenum, liver function can be indirectly

impacted due to systemic inflammation and oxidative damage caused by chronic ulcers. Studies have shown that the hepatoprotective effects of *Sida acuta* can be attributed to its antioxidant properties, which help reduce liver damage induced by toxic substances or oxidative stress (Ogunmoyole *et al*., 2015).

2.9.3 Duodenum

The duodenum, the first section of the small intestine, is another critical site in the pathophysiology of peptic ulcers, particularly duodenal ulcers, which are often linked to Helicobacter pylori infection and excessive acid secretion. The duodenum plays a key role in digestion and nutrient absorption and is highly susceptible to oxidative damage and inflammation during ulceration. In preclinical studies, *Sida acuta* has shown the ability to reduce ulcer formation in the duodenum by scavenging ROS and reducing pro-inflammatory cytokines, thus supporting its traditional use as a gastroprotective herb. The plant's high antioxidant capacity, as demonstrated in DPPH, FRAP, and ABTS assays, directly contributes to its ability to protect the duodenal mucosa (Ajiboye *et al*., 2021).

2.10 Hematological indices

Hematological indices refer to a set of measures obtained from blood tests that provide insights into an individual's overall health and specific conditions. These indices include parameters such as red blood cell count, hemoglobin concentration, hematocrit, white blood cell count, and platelet count. One of the primary hematological indices affected by ulcers is hemoglobin. Chronic blood loss from ulcers can result in a condition known as iron-deficiency anemia. As blood loss occurs over time, there is a decrease in

red blood cells and hemoglobin concentration, which can lead to symptoms such as fatigue, weakness, and pallor (Fitzgerald and McCarthy, 2019). Hematocrit, which reflects the proportion of red blood cells in the blood, is also often reduced in individuals with active ulcers, especially if there is ongoing bleeding. A decreased hematocrit can indicate anemia resulting from blood loss, further exacerbating the symptoms of the ulcer and complicating recovery (Zhao *et al*., 2018).

2.10.1 Red blood cell count

The red blood cell count (RBC) is an important hematological index that reflects the number of red blood cells circulating in the bloodstream. These cells are responsible for transporting oxygen from the lungs to the tissues and organs and carrying carbon dioxide back to the lungs for exhalation. A decrease in RBC count can lead to anemia, which is characterized by fatigue, weakness, pallor, and impaired oxygen delivery to tissues. In the context of ulcer conditions, particularly peptic ulcers, changes in RBC count are significant as they can indicate underlying complications such as bleeding, nutritional deficiencies, and the overall severity of the disease. Peptic ulcers, which are open sores that form in the stomach lining or small intestine, can cause chronic blood loss, either through overt bleeding or slow, insidious blood loss. This prolonged blood loss can lead to a reduced RBC count, which is commonly associated with iron-deficiency anemia. Anemia in ulcer patients often results from the continuous loss of small amounts of blood, which is common in individuals with ulcers, especially if the ulceration is not properly managed or treated (Fitzgerald and McCarthy, 2019).

A decreased RBC count in individuals with ulcers is a key indicator of blood loss, often accompanied by a reduction in hemoglobin (Hb) and hematocrit (Hct) levels. As blood loss continues, the body's ability to maintain an adequate supply of red blood cells diminishes, leading to a drop in RBC count. This condition can be exacerbated if the ulcer is caused by *Helicobacter pylori* infection, as this bacterium not only contributes to ulcer formation but can also cause gastric bleeding, further depleting the body's RBC reserves (Zhao *et al*., 2018). Blood loss, ulcers can also affect the body's ability to absorb nutrients, including iron, which is vital for the production of hemoglobin and red blood cells. This is particularly true in cases where ulcers affect the duodenum or the small intestine, where iron absorption predominantly occurs. (Siddiqui *et al*., 2017).

The RBC count is an essential parameter to monitor in individuals with ulcers, as a low RBC count can signal both the presence of chronic blood loss and the body's struggle to compensate for it. Regular monitoring of RBC levels in ulcer patients helps in assessing the extent of blood loss, the severity of anemia, and the effectiveness of treatment strategies, which may include iron supplementation, ulcer healing, or more advanced interventions such as blood transfusions or surgical procedures (Fitzgerald and McCarthy, 2019).

2.10.2 Hemoglobin

Hemoglobin (Hb) is a vital protein found in red blood cells, responsible for transporting oxygen from the lungs to the tissues and returning carbon dioxide back to the lungs for exhalation. It is composed of heme groups that contain iron, which binds to

oxygen. Hemoglobin levels are a key hematological index used to assess an individual's overall health, with abnormal levels indicating various health conditions, such as anemia, bleeding, or chronic illness. In the context of ulcers, hemoglobin levels are closely related to the severity of blood loss, inflammation, and nutritional status, making it an important marker for diagnosis and treatment monitoring. Peptic ulcers, which are sores that form in the stomach lining or small intestine, can cause chronic bleeding that leads to a gradual decrease in hemoglobin levels. In patients with active or recurrent ulcers, especially those caused by *Helicobacter pylori* infection, the ulceration can lead to small but persistent blood loss over time. This chronic loss of blood reduces the body's supply of red blood cells, thereby lowering hemoglobin levels (Zhao *et al*., 2018).

Decreased hemoglobin levels in ulcer patients are an important clinical sign of both active ulceration and the body's reduced capacity to carry oxygen effectively. A low hemoglobin concentration can result in symptoms such as fatigue, weakness, dizziness, and pale skin. These symptoms are a direct consequence of the reduced oxygen-carrying capacity of the blood, which can affect organ function and overall health (Fitzgerald and McCarthy, 2019).

2.10.3 Hematocrit

Hematocrit (Hct) is a critical hematological index that measures the proportion of red blood cells (RBCs) in a blood sample. It is typically expressed as a percentage and is an essential indicator of the body's ability to transport oxygen via red blood cells. Hematocrit levels are influenced by factors such as hydration status, blood loss, and the

body's production of red blood cells. A decreased hematocrit level can indicate anemia, dehydration, or significant blood loss, whereas an elevated hematocrit can suggest conditions like polycythemia or dehydration. In the context of ulcers, hematocrit is especially useful in assessing the degree of blood loss and the impact of gastrointestinal bleeding, which can occur in individuals with peptic ulcers. Peptic ulcers, which are lesions in the stomach or duodenal lining, often cause blood loss through erosion of blood vessels in the gastrointestinal tract. The bleeding can be either overt (visible to the patient) or occult (hidden), and it may lead to a gradual reduction in hematocrit levels. In patients with active or untreated ulcers, ongoing blood loss can significantly decrease the number of red blood cells, leading to a reduction in hematocrit. A low hematocrit level reflects a diminished blood volume of red blood cells, a condition commonly associated with iron-deficiency anemia due to chronic blood loss (Fitzgerald and McCarthy, 2019).

2.10.4 White blood cell count

White blood cells (WBCs) are a crucial component of the immune system, playing a vital role in defending the body against infections, inflammation, and injury. The white blood cell count is a key hematological index used to assess an individual's immune response. An elevated WBC count is typically associated with infection or inflammation, as the body produces more white blood cells to fight off pathogens or heal damaged tissues. Peptic ulcers are painful sores that develop on the lining of the stomach or small intestine, often caused by *Helicobacter pylori* infection, the long-term use of nonsteroidal anti-inflammatory drugs (NSAIDs), or excessive alcohol consumption. *H.*

pylori infection, in particular, is a major contributor to the development of gastric and duodenal ulcers. When an ulcer becomes infected or inflamed, the body mounts an immune response, which can lead to an increase in the WBC count (Zhao *et al*., 2020).

2.10.5 Platelet count

Platelets, also known as thrombocytes, are essential components of the blood responsible for initiating blood clotting and promoting wound healing. The platelet count is an important hematological index used to evaluate the body's ability to form blood clots and prevent excessive bleeding. Platelet count may be altered in various conditions, including peptic ulcers, which are lesions that form in the lining of the stomach or duodenum. Ulcers can lead to blood loss and influence platelet production and activity, either by increasing platelet count due to inflammation and bleeding or decreasing it due to complications such as disseminated intravascular coagulation (DIC). In individuals with peptic ulcers, especially those complicated by bleeding, the platelet count may be elevated as a compensatory mechanism to control blood loss. The damage to blood vessels from the ulceration causes platelet aggregation at the site of injury, initiating the clotting process. When an ulcer causes significant bleeding, either overt or occult, the bone marrow may release more platelets into the bloodstream to help mitigate further blood loss (Ali *et al*., 2018).

2.11 Total protein

Total protein refers to the combined levels of all proteins found in blood plasma, which are vital for cellular structure, enzyme activity, and immune function. In the

context of liver function, total protein levels are a critical reflection of the liver's synthetic capacity, as the liver is primarily responsible for producing most of the proteins found in the bloodstream, including albumin and globulins. A decrease in total protein levels can indicate liver damage, impaired synthesis, or malnutrition (Liverani *et al*., 2020). The gastroprotective and antioxidant properties of plants like *Sida acuta* can help stabilize protein levels by reducing liver damage. Studies have shown that *Sida acuta* extracts may increase serum total protein levels in liver-damaged animal models, indicating its protective effect on liver function (Sharma *et al*., 2020).

2.11.1 Liver function indices

Liver function indices are a set of blood tests that assess the health and functionality of the liver. These tests measure the levels of enzymes and proteins produced by the liver, which are released into the bloodstream during liver damage or disease. Some of the key liver function indices include:

- Alanine aminotransferase (ALT): An enzyme primarily found in the liver. Elevated ALT levels often indicate liver cell damage.
- Aspartate aminotransferase (AST): Another enzyme found in the liver, elevated levels suggest liver injury or muscle damage.
- Alkaline phosphatase (ALP): An enzyme related to bile ducts and liver. Increased levels may point to cholestasis or liver disease.

- Total Bilirubin: The liver processes bilirubin, a breakdown product of red blood cells. Elevated bilirubin levels can indicate liver dysfunction or bile duct obstruction.
- Albumin: A protein produced by the liver, often used as a marker of liver function. Low albumin levels may indicate chronic liver disease.

2.11.2 Alanine amino transferase

Aminotransferases (also called transaminases) are ubiquitous pyridoxal-5'-phosphate-dependent enzymes that catalyze reversible transfer of amino group from amino acids to α-keto acids. These enzymes play a key role in the metabolism of amino acids in all species (Ndrepepa, 2021).

Aspartate aminotransferase (AST, EC 2.6.1.1) and alanine aminotransferase (ALT, EC 2.6.1.2) are enzymes found mainly in the liver, but also found in red blood cells, heart cells, muscle tissue and other organs, such as the pancreas and kidneys (Mayer *et al*., 2005). AST and ALT formerly are called serum glutamic oxaloacetic transaminase (GOT) and serum glutamic pyruvic transaminase (GPT), respectively. AST or ALT levels are a valuable aid primarily in the diagnosis of liver disease. Although not specific for liver disease, it can be used in combination with other enzymes to monitor the course of various liver disorders (Schumann *et al*., 2003).

2.11.3 Aspartate amino transferase

In humans, AST exists as two genetically and immunologically distinct isoenzymes: cytoplasmic AST (cAST or GOT1) and mitochondrial AST (mAST or

GOT2). Both isoenzymes catalyze the same reaction albeit with different kinetics, share a sequence homology of ~45% and are thought to have evolved from a common ancestral gene (via gene duplication). The enzyme consists of two identical dimers where each dimer consists of a large and a small domain (McGill, 2016). Each monomer of cytoplasmic AST represents a polypeptide chain of 413 amino acid residues with a secondary structure consisting of α-helices and β-strands and a molecular weight of approximately 45 kD. Each dimer has an identical binding site for pyridoxal-5'-phosphate which is located in the dimer interface. Pyridoxal-5'-phosphate is stabilized by a number of surrounding amino acid residues (Ndrepepa, 2021).

2.11.4 Alkaline phosphatase

Alkaline phosphatases [ALP; orthophosphoric monoester phosphohydrolase (alkaline optimum) EC 3.1.3.1] are plasma membrane-bound glycoproteins (Tsai *et al*., 2000). These enzymes are widely distributed in nature, including prokaryotes and higher eukaryotes (Sadeghirishi *et al*., 2007), with the exception of some higher plants. Alkaline phosphatase forms a large family of dimeric enzymes, usually confined to the cell surface hydrolyzes various monophosphate esters at a high pH optimum with release of inorganic phosphate (Mornet *et al*., 2001). Mammalian alkaline phosphatases (ALPs) are zinccontaining metalloenzymes encoded by a multigene family and function as dimeric molecules (Sharma *et al*., 2012).

Alkaline phosphatase (ALP) is an ubiquitous membrane-bound glycoprotein that catalyzes the hydrolysis of phosphate monoesters at basic pH values. Alkaline

phosphatase is divided into four isozymes depending upon the site of tissue expression that are Intestinal ALP, Placental ALP, Germ cell ALP and tissue nonspecific alkaline phosphatase or liver/bone/kidney (L/B/K) ALP. The intestinal and placental ALP loci are located near the end of long arm of chromosome 2 and L/B/K ALP is located near the end of the short arm of chromosome 1 (Sharma *et al*., 2014)

2.11.5 Albumin

Albumin (ALB) is a multifunctional protein, which demonstrates numerous physiological functions. The primary role of ALB is to regulate osmotic pressure and distribute fluids between different body compartments. It also takes part in transporting bile pigments, cholesterol, fatty acids and drugs. The latest research shows that plasma ALB is the major extracellular antioxidant (Taverna *et al*., 2013). Human ALB is composed of 585 amino acids. It shows affinity to bind many types of molecules and ions. Free ferrous and cupric ions are catalyst in the Fenton reaction, in which hydroxyl radicals are generated (Plantier *et al*., 2016).

The antioxidant properties of albumin derive also from its indirect effect, associated with binding of bilirubin and unsaturated fatty acids, which prevents oxidation of these compounds (Roche *et al*., 2008). The antioxidative function of albumin results from its free radical-trapping capacities and various ligand-binding properties. Both functions are closely related to the ALB structure (Taverna *et al*., 2013).

2.11.6 Bilirubin

Bilirubin (BIL) is a degradation product of hemoglobin and other heme proteins by the mononuclear phagocyte system. After the dissolution of erythrocytes, the heme residue of hemoglobin is enzymatically decomposed to biliverdin by heme oxygenase (HO), and subsequently biliverdin is reduced to BIL by biliverdin reductase (BVR). This process is reversible and the oxidation of BIL results in the formation of biliverdin. Indirect (unconjugated) BIL (uBIL) circulates in plasma bound to albumin, from where it is taken up by the liver. In the liver, uBIL is conjugated with glucuronic acid and in this form, it is excreted in bile into the intestine. In some diseases of the liver, the excretion of bile is obstructed and the level of bilirubin in the blood increases (Bhutani *et al*., 2016),

2.12 Antioxidant and lipid peroxidation parameters

Antioxidants are a very heterogeneous class of compounds, small molecules and enzymes that share the task of protecting oxidizable molecules or materials from oxidative transformation. In the biological context, the reference oxidative process is lipid peroxidation (LP); therefore, antioxidants are typically defined and discussed on the basis of their ability to prevent, slow down or block LP (Valgimigli *et al*., 2012). Based on where and how they interfere with the LP radical chain, antioxidants are classified as preventive, if they impair the initiation process, and chain-breaking if they block or slow down the propagation, while a new category, the termination-enhancing antioxidants, was recently introduced by our group, to include those molecules, such as some terpenes and

terpenoids from essential oils, which act by favoring the radical-chain termination without actually impairing propagation (Amorati and Valgimigli, 2018).

2.12.1 Superoxide dismutase

Superoxide dismutase (SOD) is among the most potent antioxidants known in nature and is an important constituent of cellular defense against oxidative stress. The enzyme shows several interesting properties like very high catalytic rate of reaction and high stability to physiochemical stress. It has also attracted widespread interest due to its therapeutic potential. Oxidative stress is known to be involved in pathophysiology of several diseases and SOD supplementation has been shown to be beneficial in treatment or prevention of such diseases (Bafana *et al*., 2011)

SOD is ubiquitous to all forms of life. Four different types of metal centers have been detected in SOD, dividing this family into Cu,Zn-, Fe-, Mn- and Ni-SODs. The evolution of SOD and other antioxidant enzymes was probably triggered by production of O2 by photosynthetic organisms about 2 billion years ago. Two major kinds of SOD appeared independently in prokaryotes at that time, Cu,Zn SODs and Fe SODs/Mn SODs. Fe/Mn SODs then evolved into Fe and Mn SODs by gene duplication. This may be the reason why Fe and Mn SODs are closely related with regard to three-dimensional structure and amino acid sequence. However, their crystal structures and catalytic mechanism are completely different as compared to Cu, Zn SOD, supporting the hypothesis of independent evolution (Shin *et al*., 2009).

2.12.2 Catalase

Catalase is a vital antioxidant enzyme present in nearly all aerobic organisms, where it plays a key role in cellular defense against oxidative stress. Its primary function is to decompose hydrogen peroxide (H_2O_2), a reactive oxygen species (ROS), into water and molecular oxygen, thus preventing the accumulation of H_2O_2 and subsequent oxidative damage (Chelikani, Fita, and Loewen, 2004). Hydrogen peroxide is produced as a by-product of various metabolic processes, and if not efficiently removed, it can participate in the Fenton reaction to generate hydroxyl radicals, which are highly reactive and capable of initiating lipid peroxidation (Halliwell and Gutteridge, 2015).

Catalase plays a protective role by limiting the availability of H_2O_2, thereby reducing the potential for hydroxyl radical formation and subsequent lipid peroxidation. In tissues with high catalase activity, ROS are more effectively neutralized, resulting in lower levels of lipid peroxidation products. Conversely, a decrease in catalase activity can lead to elevated oxidative stress and increased lipid peroxidation, contributing to the pathogenesis of several diseases, including neurodegenerative disorders, cardiovascular diseases, diabetes, and cancer (Zhang *et al*., 2016).

2.12.3 Glutathione transferase

Glutathione (GSH) is a low molecular weight compound composed of three amino acids: glycine, cysteine and glutamic acid. GSH is present in all plant and animal cells. In physiological conditions it is synthesized in many different tissues (Forman *et al*., 2009), but the most intense GSH synthesis occurs in hepatocytes (Lu, 2013).

Glutathione in the human body is present in several redox forms, among which the most important are reduced glutathione (GSH) and oxidized glutathione (GSSG). Blood plasma, for example, contains only about 20mM of glutathione and the dominant form there is oxidized glutathione (GSSG) (Lushchak *et al*., 2012).

Glutathione transferases (GSTs) are a family of multifunctional enzymes that play a central role in cellular detoxification and antioxidant defense. These enzymes catalyze the conjugation of reduced glutathione (GSH) to a wide range of electrophilic and hydrophobic compounds, including products of oxidative stress such as lipid peroxides, xenobiotics, and environmental toxins (Hayes, Flanagan, and Jowsey, 2005). By facilitating the conjugation of GSH, GSTs help increase the solubility of toxic compounds, making them easier to excrete from the cell. This function is crucial for maintaining redox homeostasis and protecting cellular macromolecules from damage.

GST activity is often used as a biomarker of oxidative stress and cellular response to toxic insult. Elevated or suppressed GST activity has been reported in various pathological conditions, including cancer, neurodegenerative diseases, and cardiovascular disorders (Board and Menon, 2013). Moreover, polymorphisms in GST genes can affect individual susceptibility to environmental toxins and disease risk, highlighting their importance in toxicology and pharmacogenomics (Board and Menon, 2013).

2.12.4 Glutathione peroxidase

Glutathione Peroxidase and Its Role in Antioxidant Defense

Glutathione peroxidase (GPx) is a family of selenium-dependent antioxidant enzymes that play a critical role in protecting cells from oxidative damage. These enzymes catalyze the reduction of hydrogen peroxide (H_2O_2) and organic hydroperoxides into water and corresponding alcohols using reduced glutathione (GSH) as a substrate, thereby preventing the formation of reactive oxygen species (ROS)-induced damage (Brigelius-Flohé and Maiorino, 2013). The general reaction catalyzed by GPx is as follows: $2GSH+H_2O_2 \rightarrow GSSG+2H_2O$

This process helps maintain redox balance in cells by detoxifying harmful peroxides and regenerating reduced forms of critical molecules. Among the GPx isoforms, GPx1 is the most abundant and ubiquitously expressed in the cytoplasm of nearly all mammalian tissues, while other isoforms such as GPx4 are involved in reducing lipid hydroperoxides within membranes and lipoproteins (Lubos, Loscalzo, and Handy, 2011).

2.12.5 Glutathione reductase

Glutathione reductase (GR) is a flavoprotein enzyme essential for maintaining the cellular redox balance by regenerating reduced glutathione (GSH) from its oxidized form (GSSG). This reaction is vital for sustaining high intracellular levels of GSH, a major antioxidant that protects cells from oxidative damage by neutralizing reactive oxygen species (ROS) and detoxifying peroxides (Couto *et al*., 2016). Under conditions of

oxidative stress, GR activity becomes particularly important. Without adequate GR function, GSSG accumulates, depleting GSH levels and impairing the cell's ability to neutralize peroxides. This dysfunction has been associated with the pathogenesis of various diseases, including cancer, neurodegenerative disorders, and cardiovascular diseases (Franco and Cidlowski, 2012).

2.12.6 Reduced glutathione

In typical cells, in normal conditions, the predominant form of glutathione is its reduced form (GSH) in a ratio of 100:1. Under normal conditions, for instance, reduced GSH is the most prevalent form of GSH, constituting up to 98% of the total GSH pool. Glutathione molecules can also be bound to proteins (Samuelsson *et al*., 2011). GSH is a soluble antioxidant, which in high cellular concentrations (1–10 mM) is present in the cytoplasm, mitochondria and nucleus. As an antioxidant, GSH reduces ROS during the enzymatic and non-enzymatic reactions. It regenerates other oxidized small molecule antioxidants, for example vitamin C and vitamin E (Rahman *et al*., 2007), is involved in the repair of protein molecules, nucleic acids and lipids damaged in peroxidation processes, and in the maintenance of sulphydryl groups of protein in the reduced state (Alli *et al*., 2014).

2.12.7 Malondialdehyde

Lipid peroxidation is one of known indices of oxidative stress and contributing factor in degenerative diseases, cardiovascular disease, Parkinson's disease, Alzheimer's disease,4 and psychiatric disorders, including schizophrenia. Assesment of primary lipid

peroxidation products (hydroperoxides) is usually unstable due to its reactive nature.6 Therefore, measurement of secondary oxidation products such as malondialdehyde (MDA) is commonly conducted to observe lipid peroxidation (Fauziah *et al*., 2018).

Malondialdehyde (MDA) is a product of lipid peroxidation that appears to be produced in a relatively constant proportion of the breakdown of polyunsaturated fatty acids. The MDA count is a good indicator of lipid peroxidation especially in vitro (Yekti, *et al*., 2018). The chemical analysis of MDA began by measuring a component called thiobarbituric acidreactive substances (TBARS) to estimate lipid peroxidation with spectrophotometry (Biri *et al*., 2006).

2.12.8 Mycloperoxidase

Myeloperoxidase (MPO) is a heme-containing enzyme predominantly found in the azurophilic granules of neutrophils and, to a lesser extent, in monocytes. It plays a crucial role in the innate immune response by catalyzing the formation of hypochlorous acid (HOCl) from hydrogen peroxide (H_2O_2) and chloride ions (Cl^-) during the respiratory burst of activated phagocytes (Klebanoff, 2005). Hypochlorous acid is a potent antimicrobial agent capable of killing bacteria, viruses, and fungi, thus contributing to host defense. However, excessive or dysregulated MPO activity can contribute to tissue damage due to the high reactivity of HOCl and other oxidants produced, which can oxidize proteins, lipids, DNA, and other cellular components (Winterbourn *et al*., 2016).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Plant Materials

Fresh *Sida acuta* is collected at Kwara State Polytechnic main campus around the lecture rooms that led to Akuo Village on 12th of March 2025.

3.1.2 Animal Materials

52 Wistar Albino rats (*Rattus norvegicus*) obtained from the Animal Laboratory House, Kwara State Polytechnic, Ilorin Kwara State, Nigeria.

3.1.3 Chemicals and Reagents

The chemicals and reagents used in this study were carefully chosen for their high purity, availability, and suitability for the experimental protocols. All substances were of analytical grade. Below is a detailed list of the chemicals and reagents utilized in this project research:

DMSO (Dimethyl sulfoxide) by Thermo Fisher Scientific, Indomethacin by Thermo Fisher Scientific, Omeprazole by Sigma-Aldrich, Acetate buffer (300 mM, pH 3.6) by Sigma-Aldrich, TPTZ solution (10 mM in 40 mM HCl) by Sigma-Aldrich, $FeCl_3 \cdot 6H_2O$ (20 mM) by Sigma-Aldrich, FRAP reagent (prepared by mixing acetate buffer, TPTZ, and $FeCl_3$ in 10:1:1 ratio) by Sigma-Aldrich, ABTS (7 mM) by Sigma-Aldrich, Potassium persulfate (2.45 mM) by Fisher Scientific, DPPH solution (0.1 mM in methanol) by Cayman Chemical, 2% Aluminum chloride in methanol by Cayman

Chemical, Potassium acetate (optional) by Fisher Scientific, Folin–Ciocalteu reagent (diluted 1:10) by Thermo Fisher, Sodium carbonate (7.5%) by Thermo Fisher.

3.2 Methods

3.2.1 Preparation of Plant Extract

Fresh *Sida Acuta* was collected and thoroughly washed, the plant sample was dried at room low temperature for a week to avoid damage of active compounds present in *Sida Acuta.* 500g of dried *Sida Acuta* are blended into a fine powder using blender. The powdered *Sida Acuta* was weighed into a suitable bowl and dissolved with 2.5mL of ethanol and the powdered *Sida Acuta* was completely submerged in the ethanol. The mixture was macerate for a specific duration of 72 hours and the mixture was filtered using Whatman filter paper to remove the plant material.

500g of blended stubborn grass was weighed into a bowl and dissolved with 2.5mL of ethanol. The mixture was left for 72 hours, then the solution was filtered and left for concentration

3.2.2 Determination of the weight of the Albino Rats .

We divided fifty-two Wistar albino rats into seven groups to investigate the effects of *Sida Acuta* on indomethacin-induced ulcerogenic rats. The groups consisted of a normal control group that received no treatment, an indomethacin only group serving as the ulcer control, and five treatment groups administered indomethacin followed by *Sida Acuta* extract at doses ranging from 100 to 800 milligrams per kilogram of body weight.

We ensured the groups had similar average weights at the start of the experiment to eliminate initial weight disparities as a confounding factor. we recorded each rat's weight weekly throughout the study to monitor changes over time and we compared the weights of the different groups over time to analyze differences in weight changes between groups. We recorded the results and documented the average weight for each group at various time points to assess the impact of the treatments.

3.2.3 Determination of Phytochemicals

3.2.3.1 Determination of Saponins

Gravimetric Method

One gram (1g) of dry extract was weighed and boil in 100 mL of 20% ethanol for 30 minutes. Filter and re-extract the residue twice using 20% ethanol. The filtrates were combined and evaporate to dryness. Dry residue in a desiccator and weigh. The weight corresponds to total saponin content.

3.2.3.2 Determination of Tannins

The extract (1g) was weighed and boiled in 100 mL of 20% ethanol for 30 minutes. The solution was filtered and the residue was re-extracted twice using 20% ethanol. The filtrates were evaporated to dryness in a desiccator and weighed. The weight is corresponded to Total Saponin content present in the sample. This method is Folin-Denis method.

3.2.3.3 Determination of Flavonoids

The procedure stated that 1 mL of extract should be mixed with 1 mL of 2% $AlCl_3$ in methanol, followed by incubation for 10 minutes at room temperature. Absorbance was then to be measured at 415 nm, using a quercetin standard curve for quantification. It was noted that this method is based on the Folin-Ciocalteu Method.

3.2.3.4 Determination of Phenols

The method described that 1 mL of the sample was to be mixed with 5 mL of Folin–Ciocalteu reagent diluted at a ratio of 1:10. After 5 minutes, 4 mL of 7.5% sodium carbonate was to be added. The mixture was then incubated for 30 minutes at room temperature, and the absorbance was measured at 765 nm. Gallic acid was used as the standard for quantification. It was noted that this procedure followed the Folin-Ciocalteu method.

3.2.3.5 Determination of Glucosides

The procedure stated that 2 mL of glacial acetic acid containing a drop of $FeCl_3$ was to be added to 1 mL of the extract. Then, 1 mL of concentrated H_2SO_4 was to be carefully added down the side of the test tube. It was noted that the formation of a brown ring at the interface indicated the presence of deoxysugars in cardiac glycosides.

3.2.4 Proximate analysis

3.2.4.1 Determination of Moisture Content

Moisture is determined by the loss in weight that occurs when a sample is dried to a constant weight in an oven.

About 2g of a *Sida Acuta* sample was weighed into a silica dish previously dried and weighed. The sample was then dried in an oven for 65°C for 36 hours, cool in a desiccator and weighed. The drying and weighing continued until a constant weight was achieved.

$$\%\text{Moisture} = \frac{\text{Wt of sample + dish before drying} - \text{wt of sample + dish after drying}}{Wt\ of\ sample\ taken} \text{x}100$$

Since the water content of feed varied widely, ingredients and feed are usually compared for their nutrient content on moisture free or dry matter (DM)

basis.

%DM=100 - %Moisture.

3.2.4.2 Determination of crude protein

Crude protein was determined by measuring the nitrogen content of the feed and multiplying it by a factor of 6.25. This factor is based on the fact that most protein contains 16% nitrogen. Crude protein is determined by kjeldahl method. The method involves: Digestion, Distillation and Titration.

Digestion: About 2 g of the sample was weighed into kjeldahl flask and 25 ml of concentrated sulphuric acid, 0.5g of copper sulphate 5 g of sodium sulphate and a speck of selenium tablet were added. Heat in a fume cupboard was applied slowly at first to prevent undue frothing, digestion continued for 45 minutes until the digester became clear pale green. It was left until completely cooled and 250 ml of distilled water was rapidly added. The digestion flask was rinsed 2-3

times and the rinsing was added to the bulk.

Distillation: "Markham distillation apparathus was used for distillation. The distillation apparatus was steamed up and about 10 ml of the digest was added

into, the apparatus via a funnel and allowed to boil. 10 ml of sodium hydroxide was added from the measuring cylinder so that ammonia was not lost. It

was distilled into 50 ml of 2% boric acid containing screened methyl red indicator.

Titration: the alkaline ammonium borate formed was titrated directly with O. IN HCI. The titre value which was the volume of acid used was recorded. The

volume of acid used was fitted into the formula which became:

$$\%N = \frac{14\times VA \times 0.1 \times w \times 100}{1000 \times 100}$$

%crude protein = %N x 6.25

Where;

VA= volume of acid used,

w= weight of sample,

3.2.4.3 Determination of crude ash

Determination of Ash content of the samples: Ash is the inorganic residue obtained by burning off the organic matter of feedstuff at 400-600°C in muffle furnace for 4 hours. 2 g of the sample was weighed into a pre-heated crucible. The crucible was placed into muffle furnace at 400-600°C for 4 hours or until whitish-grey ash was obtained. The crucible was then placed in the desiccator and weighed.

$$\%ASH = \frac{wt.of\ crucible+ash \quad .of\ crucible}{wt\ of\ sample} \times 100$$

3.2.4.4 Determination of lipid

Determination of Fat content: The ether extract of a *Sida Acuta* represents the fat and oil in the cheese. Soxhlet apparatus is the equipment used for the determination of ether extract. It consists of 3 major components. An extractor: comprising the thimble which holes the sample, Condenser for cooling and condensing the ether vapor and 250 ml flask. About 150 ml of an anhydrous diethyl ether (petroleum ether) of boiling point of 40°-60°C was placed in the flask. 2-5 g of the sample was

%Ether extract = weighed into a thimble and the thimble was plugged with cotton wool. The thimble with content was placed into the extractor; the ether in the flask was then heated. As the ether vapour reached the condenser through the side arm of the extractor, it condensed to liquid form and drop back into the sample in the thimble, the ether soluble substances were dissolved and were carried into solution through the siphon tube back into the flask. The extraction continued for at least 4 hours. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was then disconnected and placed in an oven at 65°C for 4 hours, cooled in a desiccator and weighed.

% ether extract $\frac{\text{weight of flask + extract} - \text{tare weight of flask}}{Wt\ of\ sample}$ x100

3.2.4.5 Determination of Fibre

The organic residue left after sequential extraction ether can be used to determine the crude fibre, however if a fresh sample was used, the fat in it could be extracted by adding petroleum ether, stirred and allowed to settle and decanted. This was done three times.

The fat-free material was then transferred into a flask/beaker and 200 ml of pre-heated 1.25% H_2SO_4 was added and the solution was gently boiled for about 30 minutes, maintaining constant volume of acid by the addition of hot water. The Buckner flask funnel fitted with Whatman filter was pre-heated by pouring hot water into the funnel. The boiled acid sample mixture was then filtered hot through the funnel under sufficient suction. The residue was then washed several times with boiling water (until the residue was neutral to litmus paper) and transferred back into the NaOH beaker. Then 200 ml of pre-heated 1.25% NaSO was added and boiled for another 30 minutes.

Filtered under suction and washed thoroughly with hot water and twice with ethanol. The residue was dried at 65°C for about 24 hours and weighed. The residue was transferred into a crucible and placed in muffle furnace (400-600°C) and ashed for 4 hours, then cooled in desiccator and weighed.

3.2.5 Mineral Analysis

3.2.5.2 Determination of Sodium Content

The Procedure described by Tietz (1983) was used to assay for presence of sodium.

Procedure:

Sodium reagent (1000µl) was added to 10µl of the sample and standard in a test tube. The solution was incubated at 37^0C for five (5) minutes. The absorbance value was read at 630 nm.

Calculation:

Sodium ion concentration (mmol/L) = $\frac{A_{sample} \times \text{Concentration of standard}}{A_{standard}}$

Note; Sodium reagent contains Tris buffer, proclin 300 and Chromogen.

3.2.5.3 Determination of Potassium Content

The method described by Tietz, (1995) was used to assay for the Potassium Content.

Principle:

Sodium tetraphenylboron reacts with potassium in an alkaline medium to produce a turbid suspension of potassium tetraphenylboron. Thus, the turbidity produced is directly proportional to the concentration of potassium in the serum tested.

Procedure:

Sodium tetraphenylboron (1.0 ml) reagent was added to 10µl of sample and standard in a test tube. The mixture was then incubated for five (5) minutes at $37^{\theta}C$. The absorbance value was taken at 578 nm.

NB;Tetraphenylboron reagent contains 0.6 mol/L NaOH and 250 mmol/L sodium tetraphenylboron.

Calculation:

Potassium ion concentration (mmol/L) = $\frac{A_{sample} \times \text{Concentration of standard}}{A_{standard}}$

3.2.5.3 Determination of Phosphorus Content

The powder *sida acuta* is mix with solution hydrogen peroxide (H_2O_2) The phosphorus concentration is determined by comparing the absorbance with a standard calibration curve prepared using known concentrations of KH_2PO_4.

3.2.5.4 Determination of Iron Content

Iron (Fe)

The method described by Tietz, (1995) was used to assay for iron Content.

Principle

Ferric iron is dissociated from its carrier protein transferrin in an acid medium and simultaneously reduced to the ferrous iron. The ferrous iron is then complexed with the chromogen to produce a blue chromophore. In the measurement of unsaturated iron binding capacity (UIBC) a known amount of ferrous iron is added in excess to the serum at alkaline Ph. This saturates the UIBC sites on the transferrin. The amount of free iron is then measured and subtracted from the total amount added to calculate the UIBC.

Proceedure

Sample and standard (0.5ml) was dispensed into a test tube, 2 ml buffer, 0.1 ml of reductant and 0.5 ml of iron-free water was subsequently added to it. The initial absorbance was immediately taken after which the 0.1 ml of chromogen was added to the mixture. The mixture was then incubated for 5 minutes at 37^0C after which the final absorbance value was taken. The absorbance values were read at 590 nm.

Calculation

$$Fe = \frac{\text{Abs Sample}}{\text{Abs Standard}} \times \text{Concentration Cal/std}$$

3.2.5.5 Determination of Copper Contents

Copper (Cu)

The method described by Kasper *et al,* (2012) was used to assayed for the presence of Copper.

Principle

At pH 4.7 (acid buffer), copper, which is bound to ceruloplasmin is released by a reducing agent. It then react with a specific colour reagent, 3.5-Di-Br-PAESA, to form a stable, colored chelate. The intensity of the colour, photometrically measurable at 570 nm, is directly proportional to the amount of copper present in the sample.

Procedure

Working reagent (1000µl) was added to 50µl of the sample and standard in a cuvette. The mixture was incubated for 5minutes at 37^0C. The absorbance value was immediately taken after the incubation at 570nm.

Calculation

$$Cu = \frac{\text{Abs Sample}}{\text{Abs Standard}} \times \text{Concentration Cal/std}$$

Conversion factor: Copper [µg/dl] ×0.1573=Copper [µmol/l]

3.2.6 Determination of Antioxidant properties

3.2.6.1 Determination of Ferric Reducing Antioxidant Power

This method evaluates the antioxidant effect of a substance in reducing Fe^{3+} to Fe^{2+} in the presence of TPTZ (2,4,6-tripyridyl-s-triazine), forming a blue complex measurable at 593 nm.

Procedure:

The procedure indicated that 100 µL of plant extract was to be added to 3 mL of freshly prepared FRAP reagent. The mixture was then incubated at 37°C for 4 to 6 minutes. Absorbance was measured at 593 nm using a spectrophotometer. It was stated that $FeSO_4$ was used as a standard for calibration, and the results were expressed as µmol Fe^{2+} equivalents.

3.2.6.2 Determination of 2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)

ABTS is oxidized to its radical cation ($ABTS^{+}$•), which is blue-green and absorbs at 734 nm. Antioxidants reduce the $ABTS^{+}$•, leading to decolorization.

Procedure:

The method stated that $ABTS^{+}$ was prepared by mixing ABTS with potassium persulfate and incubating the mixture in the dark for 12 to 16 hours. The resulting $ABTS^{+}$ solution was then diluted with ethanol to an absorbance of approximately 0.700 at 734 nm. Afterward, 100 µL of the extract was added to 3.9 mL of the diluted $ABTS^{+}$ solution.

Absorbance was measured at 734 nm after 6 minutes. It was noted that the results were compared with a Trolox standard and expressed as µmol Trolox equivalents.

3.2.6.3 Determination of 2,2-Diphenyl-1-picrylhydrazyl

Principle:

DPPH is a stable free radical that changes color (deep violet to yellow) upon reduction by an antioxidant.

Procedure:

The procedure stated that 1 mL of DPPH solution was to be mixed with 1 mL of the extract and incubated in the dark for 30 minutes at room temperature. Absorbance was then measured at 517 nm.

Calculate percentage inhibition using:

$$\%\text{Inhibition} = \frac{A_0 - A_1}{A_0} \times 100$$

.

where A_0= control absorbance, A_1= sample absorbance.

Express results as IC_{50} or µmol Trolox equivalents.

3.2.6.4 Determination of Total Flavonoid Content

Principle:

Flavonoids react with aluminum chloride to form a yellow complex, measurable at 415 nm.

Procedure:

The procedure indicated that 0.5 mL of the extract was to be mixed with 0.5 mL of 2% $AlCl_3$ and incubated for 30 minutes at room temperature. Absorbance was then measured at 415 nm. It was noted that quercetin was used as the standard, and the results were expressed in mg quercetin equivalents (QE) per gram of extract.

3.2.6.5 Determination of Total Phenolic Content

Principle:

The Folin–Ciocalteu reagent reacts with phenolics to produce a blue complex detectable at 765 nm.

Procedure:

The procedure stated that 0.5 mL of the sample was to be mixed with 2.5 mL of Folin–Ciocalteu reagent. After 5 minutes, 2 mL of sodium carbonate was to be added. The mixture was then incubated for 30 minutes at room temperature, after which absorbance was measured at 765 nm. It was noted that gallic acid was used as the

standard, and the results were expressed as mg gallic acid equivalents (GAE) per gram of extract.

3.3 Experimental design

The study included 52 white Albino rats (*Rattus norvegicus*) of the Wistar breed, clinically healthy, females, weighed an average of 169 g obtained from the Animal House, Kwara State Polytechnic, Ilorin Kwara State, Nigeria. On the first day of the study, the subjects were randomly assigned to 7 homogeneous groups, 8 individuals each. The animals were hosted in the institutional biobase, in favourable conditions, adapted to their physiological needs. The environment was strictly controlled to avoid any external influence on the host. Experienced staff performed the care of the animals. The procedures were reduced to the minimum necessary to fulfil the purpose of the experiment.

Table 4: Group of experimental animals according to treatment method

Group	Treatment
Group 1	Control vector group
Group 2	Untreated group
Group 3	Treated with standard drug
Group 4	100 mg / kg of the extract
Group 5	200 mg / kg of the extract

Group 6	400 mg / kg of the extract
Group 7	800 mg / kg of the extract

3.4 Determination of Ulcerated Albino Rats

We used adult Wistar albino rats, each weighing between 150 to 200 grams. Before starting, we let them get used to their new home for about a week (7 days) so they wouldn't be stressed during the experiment. All the rats were fasted for 24 hours before we started, but they still had access to water so they didn't dehydrate. We divided the rats into 7 groups:

Group 1: Normal control, no ulcer, no treatment.

Group 2: Ulcer control, we gave them ulcers but didn't treat them.

Group 3: Ulcer, treatment with a standard anti-ulcer drug (Omeprazole).

Group 4: Ulcer, treated with 100 mg/kg of the plant extract.

Group 5: Ulcer, treated with 200 mg/kg of the extract.

Group 6: Ulcer, treated with 400 mg/kg of the extract.

Group 7: Ulcer, treated with 800 mg/kg of the extract.

Preparing the Indomethacin Solution: We measured out the indomethacin, then mixed it into 54 ml of distilled water along with 2 ml of DMSO (dimethyl sulfoxide) to help it dissolve properly. For the extracts (Groups 4–7), each dose (100–800 mg/kg) was mixed with 2 ml of DMSO and 18 ml of distilled water to make the treatment solutions. We gave 1 ml of the indomethacin solution to each rat (except Group 1) to cause ulcers in their stomach lining and after 30 minutes we gave each group their treatment 1ml of the treatment Group 3 for the standard drug and 4-7 the extraction solution prepared for each group which was done 7 days. Once the experiment was done 7 days, we humanely euthanized the rats, Then we opened their stomachs along the greater curvature, rinsed everything with saline, and checked for ulcers.

3.5 Hematological of Albino Rats

Blood collection was said to have been carried out after the completion of the experimental treatment period, typically after 14 days. According to the procedures followed, blood was collected using the retro-orbital puncture technique under light anesthesia. A volume of 1 to 2 milliliters of blood was collected from each rat into EDTA-containing tubes, which were designated for hematological analysis.

The researchers confirmed that ethical approval was obtained from the Institutional Animal Ethics Committee (IAEC) or its equivalent. All experimental procedures adhered strictly to institutional and international guidelines for the humane treatment and care of laboratory animals.

CHAPTER FOUR

4.0 RESULTS

4.1 Body Weight Gain in Experimental Animals

The initial and final average weights of the experimental groups are presented in Table 4.1. All groups showed an increase in body weight over the experimental period, except Group 3, which recorded a slight reduction. Group 1 had the highest increase in average weight, rising from 131.25 g to 153 g. Group 6 and Group 4 also recorded appreciable weight gains, from 121.5 g to 136.75 g, and from 110.63 g to 124 g, respectively. Group 7 maintained relatively stable weight, with a minimal decrease from 144.63 g to 143.5 g. Data for the initial weight of Group 5 was not recorded, but the final average weight was 128.38 g.

Table 4.1: Weight gain by the experimental animals during the treatment (14 days)

Group	Initial Average Weight	Final Average Weight
Group 1	131.25	153
Group 2	105.38	120.5
Group 3	115.63	114.5
Group 4	110.63	124
Group 5	_____	128.38
Group 6	121.5	136.75

Group 7	144.63	143.5

4.2: Phytochemical Present in the Sample

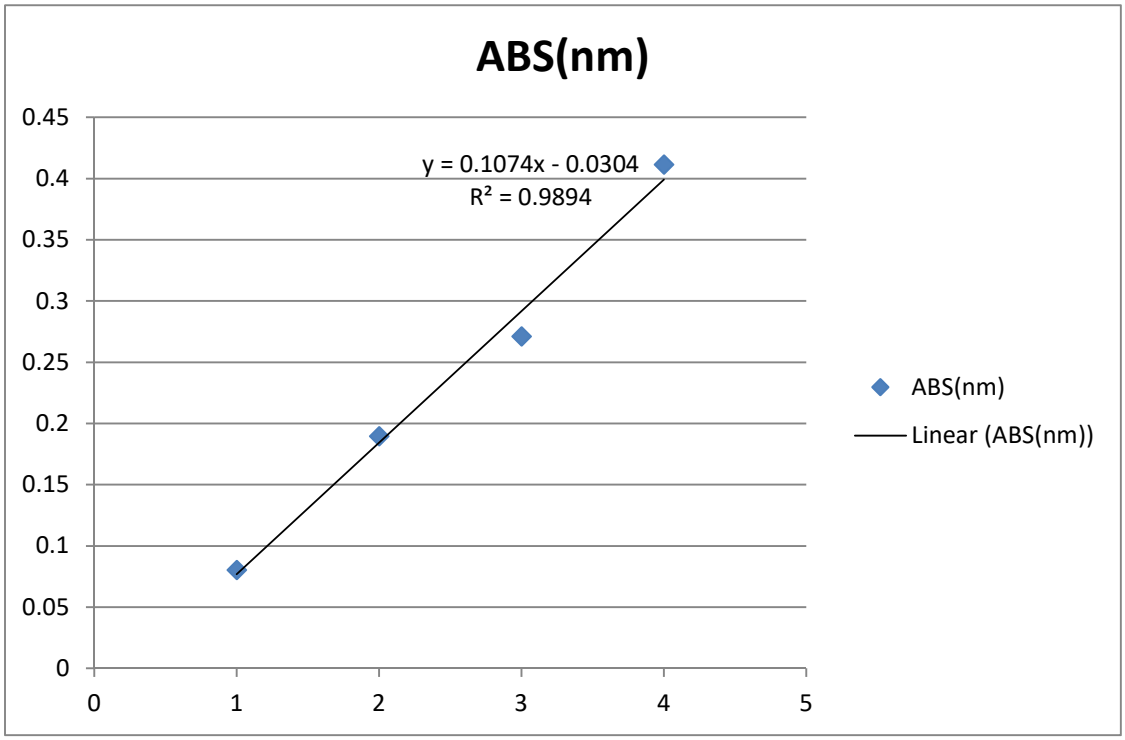
Table 4.2 presents the results of the phytochemical analysis of the sample, highlighting the presence or absence of several bioactive compounds with potential therapeutic benefits. The sample contains phenols, saponins, tannins, alkaloids, triterpenoids,.

Table 4.2: Phytochemical present in *Sida Acuta*

Sample Code	Saponin	Tannins	Flavonoid	Phenol	Glycosides
A_1	+	+	+	+	+

+ = Present, - = Absent.

Total Tannin Result Using Uv Spectrophotometer



Conc(ppm)	**ABS(nm)**
	1
	2
	3
	4
Sample	**ABS**
EX TAIL LIVER	0.9116, 0.9113, 0.9113
Group 1	1.3847, 1.3845, 1.3843

4.3. Proximate Composition of *Sida Acuta*

The proximate composition of the two samples was analyzed in table 4.3 to determine their nutritional quality. The key components analyzed include crude protein, crude lipid, moisture content, total ash, crude fibre, and carbohydrate content. Crude Protein Content: The crude protein content of both samples is relatively high, This suggests that both samples can serve as good sources of protein. However, which may make it more suitable for applications where protein content is a critical factor, such as in animal feeds or human diets requiring higher nitrogen intake.

Crude Lipid Content: The lipid content, which is important for providing energy and essential fatty acids, was 7.14%. The higher energy density due to its higher fat content. Sample have relatively low lipid contents, suggesting that they are not overly rich in fats, which could be desirable depending on the intended use.

Moisture Content: Moisture content in both samples is low, which is ideal for preserving the quality and shelf life of the samples. the higher moisture content in *Sida acuta* may slightly reduce its shelf life, although both values are within a similar range that would not significantly impact preservation.

Total Ash Content: of sample show similar moderate ash contents, This indicates that the inorganic mineral content in the sample.

Crude Fibre Content: Crude fibre, which plays a crucial role in digestion and overall gastrointestinal health, was found to be significantly higher, which contained 27.52%. The higher fibre content in *Sida acuta* suggests that it may be more indigestible, potentially limiting its utility in high-efficiency feeding systems where digestibility is a key consideration. A2, with its slightly lower fibre content, may be more easily digestible and could be preferable for applications where digestibility is paramount.

Carbohydrate Content: Both samples contain substantial amounts of carbohydrates, which are the primary energy source for both human and animal nutrition. *Sida acuta* contains 30.68% carbohydrates, This that *Sida acuta* might provide slightly more energy, making it a more efficient energy source.

Table 4.3: Proximate Composition of *Sida acuta*

S/N	Sample	Crude Protein (%)	Crude Lipid (%)	Moisture Content (%)	Total Ash (%)	Crude Fibre (%)	Carbohydrate (%)
1	*Sida acuta*	13.57	7.14	8.24	11.42	28.37	31.16

S/N	Sample	Crude Protein (%)	Crude Lipid (%)	Moisture Content (%)	Total Ash (%)	Crude Fibre (%)	Carbohydrate (%)

4.4. Mineral Composition of *Sida acuta*

The mineral composition analysis of *Sida acuta* is shown in table 4.4 where the plant possesses appreciable amounts of essential minerals that are important. The iron (Fe) content was found to be 2.023 mg/100g. Iron is critical for the synthesis of hemoglobin1 and the prevention of anemia, suggesting that *Sida acuta* could serve as a beneficial dietary component in combating iron deficiency. Copper (Cu) was present at 1.0948 mg/100g. Copper plays a vital role in iron metabolism and supports the proper functioning of the cardiovascular and nervous systems. The zinc (Zn) content, recorded at 0.570 mg/100g.

The sodium (Na) content was relatively low at 2.962 mg/100g. This low sodium level is noteworthy because diets high in sodium are associated with hypertension and cardiovascular diseases; thus, the consumption of *Sida acuta* may not pose such risks. Conversely, the potassium (K) level was relatively high at 5.833 mg/100g. Potassium is known for its role in maintaining electrolyte balance, nerve transmission, and regulating

blood pressure. The high potassium-to-sodium ratio observed in *Sida acuta* further highlights its potential cardiovascular benefits.

Magnesium (Mg) content was measured at 5.376 mg/100g. Magnesium is indispensable for neuromuscular transmission, energy production, and bone development. Manganese (Mn) was detected at 0.476 mg/100g. Calcium (Ca) content was found to be 4.031 mg/100g. Calcium is essential for the development and maintenance of strong bones and teeth, as well as for muscular function and nerve signaling.

Table 4.4: Mineral Composition of *Sida acuta*

S/N	Sample Name	Fe	Cu	Zn	Na	K	Mg	Mn	Ca
1	*Sida acuta*	2.023	1.0948	0.570	2.962	5.833	5.376	0.476	4.031

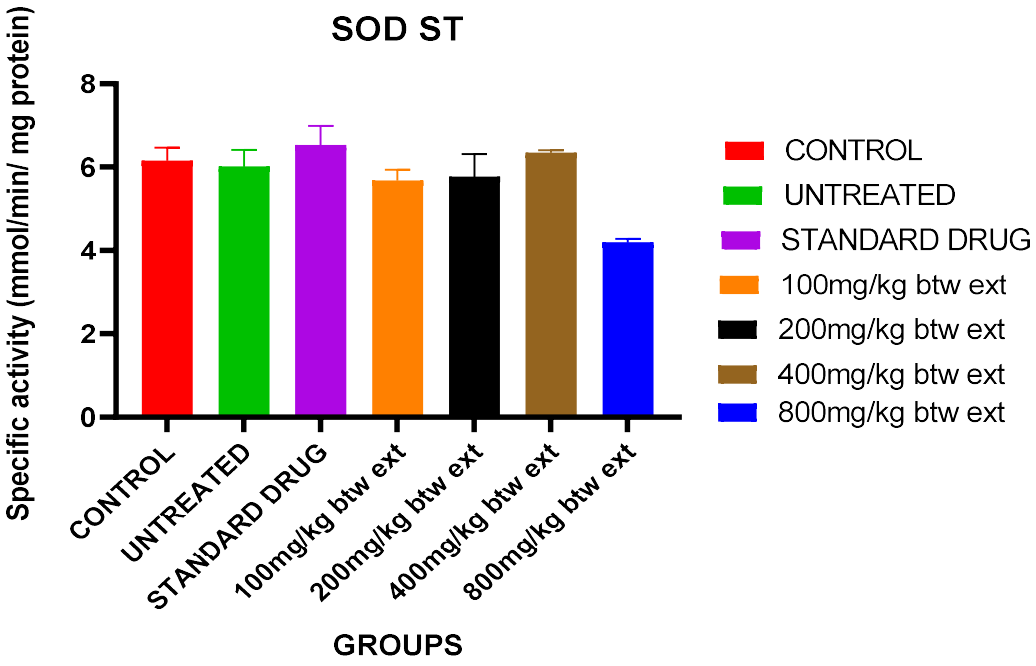
Key: iron (Fe), copper (Cu), zinc (Zn), sodium (Na), potassium (K), and Magnesium (Mg).

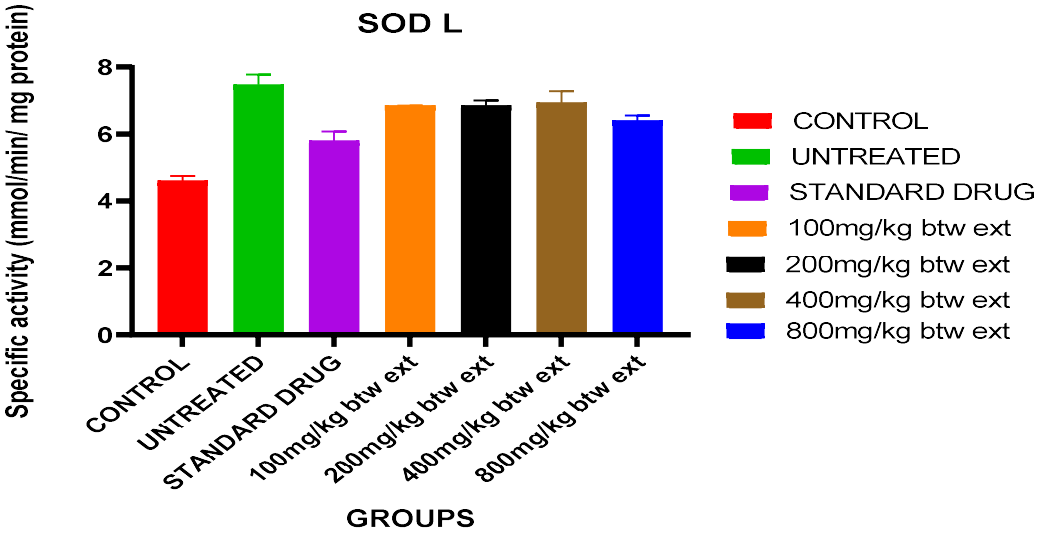
Table 4.5: Antioxidants and Liver Function Index

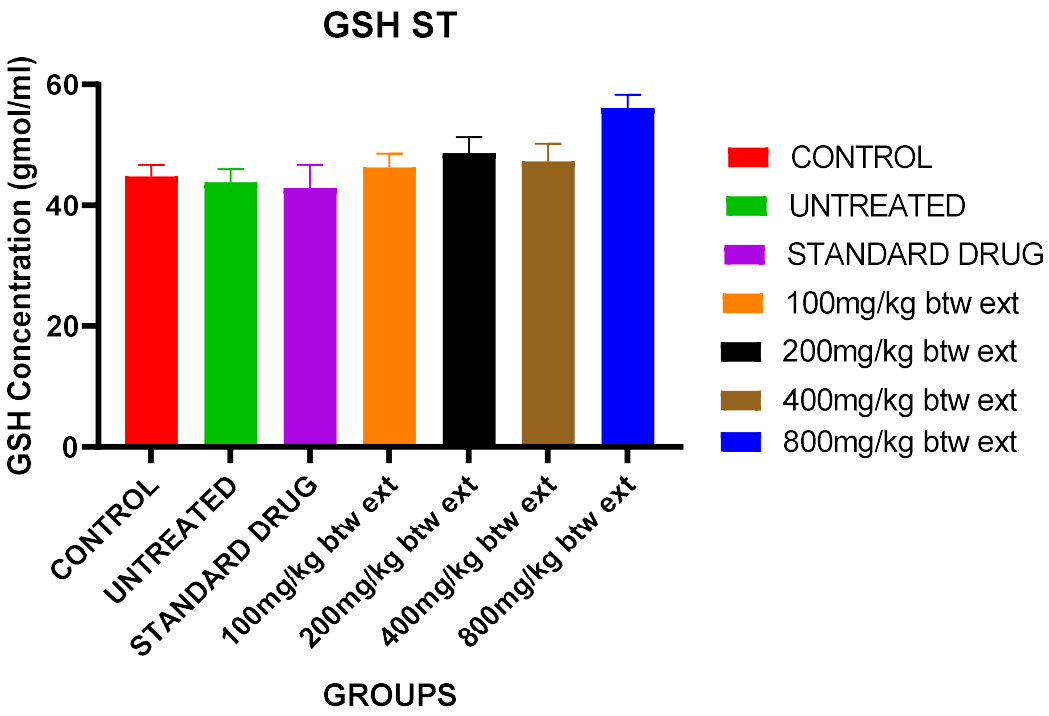
S/N	Title	Control	Untreated	Standard Drug	100mg/kg	200mg/kg	400mg/kg	800mg/kg
1.	SOD ST	6.149	6.010	6.529	5.676	5.764	6.342	4.187
2.	SOD L	7.596	7.469	5.789	6.841	6.844	6.928	6.399
3.	GST ST	0.145	1.101	1.429	1.318	1.764	0.953	1.129
4.	GST L	3.111	1.044	4.491	2.750	1.271	1.256	2.545
5.	CATALASE ST	21.954	25.573	28.745	23.065	23.852	27.050	17.314
6.	CATALASE L	16.864	35.526	26.274	29.912	30.348	33.026	27.756
7.	ALT ST	1.882	2.648	4.184	4.414	3.139	3.620	4.234
8.	ALT L	1.799	2.827	4.763	6.985	4.008	3.345	3.508
9.	AST ST	10.738	16.392	15.109	17.544	15.055	10.6000	14.954
10.	AST L	7.938	8.740	9.827	8.036	12.731	11.236	10.199
11.	PROTEIN ST	36.732	38.194	34.905	40.387	40.205	35.636	52.632
12.	PROTEIN L	45.321	29.788	36.367	33.443	34.539	32.346	36.732
13.	ALP L	13.992	18.701	19.062	22.743	18.862	18.736	19.329
14.	ALP ST	29.807	15.891	25.233	20.000	17.027	21.325	37.854
15.	N.O ST	49.218	46.615	87.500	53.385	46.615	41.928	44.010

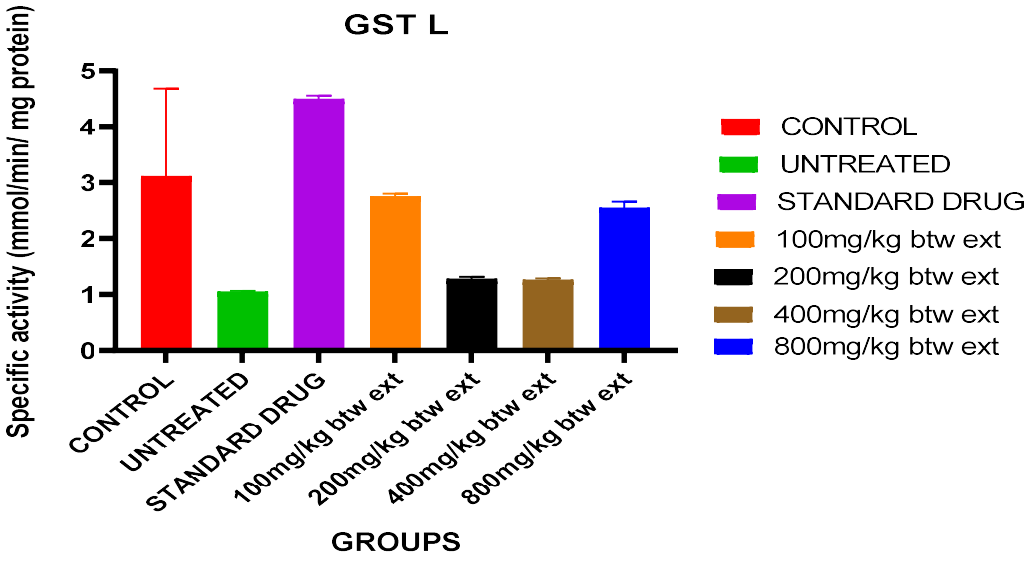
16.	N.O L	45.833	30.208	30.989	57.813	29.688	27.865	29.427
17.	MPO ST	2.040	1.931	2.144	2.772	9.036	1.701	7.717
18.	PEPSIN ST	1.494	4.305	1.932	1.214	0.872	1.855	1.787
19.	MDA ST	9.799	5.673	6.514	7.828	11.899	12.000	15.168
20.	MDA L	5.601	3.966	6.042	3.966	3.598	6.082	4.079
21.	GSH ST	44.761	43.750	42.831	46.232	48.621	47.243	56.066
22.	GSH L	86.949	45.954	62.776	61.029	67.463	52.941	87.776
23.	GGT ST	9.031	8.646	9.361	8.564	8.1840	9.459	7.105
24.	GGT L	7.683	11.564	9.140	10.788	12.527	10.891	9.906
25.	GPX ST	2.744	2.669	2.776	2.879	2.958	2.999	2.065
26.	GPX L	3.216	3.293	2.679	3.098	2.698	2.738	3.057
27.	G.R. ST	100.0127	91.877	95.276	95.276	105.668	93.681	75.528
28.	G.R. L	106.241	89.739	84.565	88.753	71.709	77.282	82.127

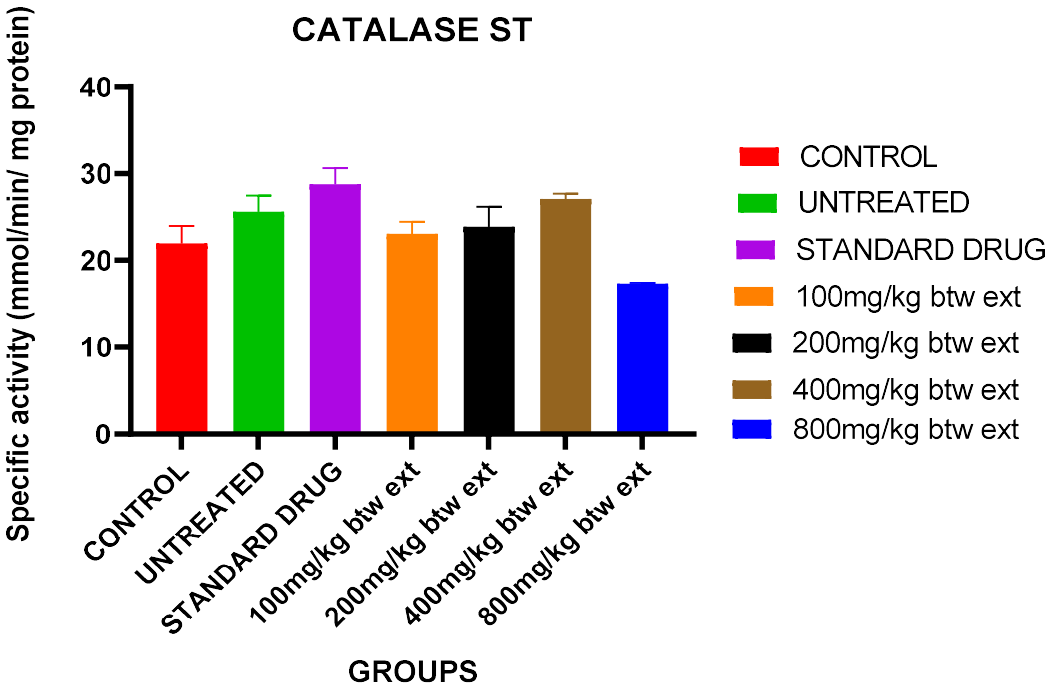
KEY: Control is Group 1, Untreated is Group 2, Standard Drug is Group 3, 100mg/kg is Group 4, 200mg/kg is Group 5, 400mg/kg is Group 6, 800mg/kg is Group 7.

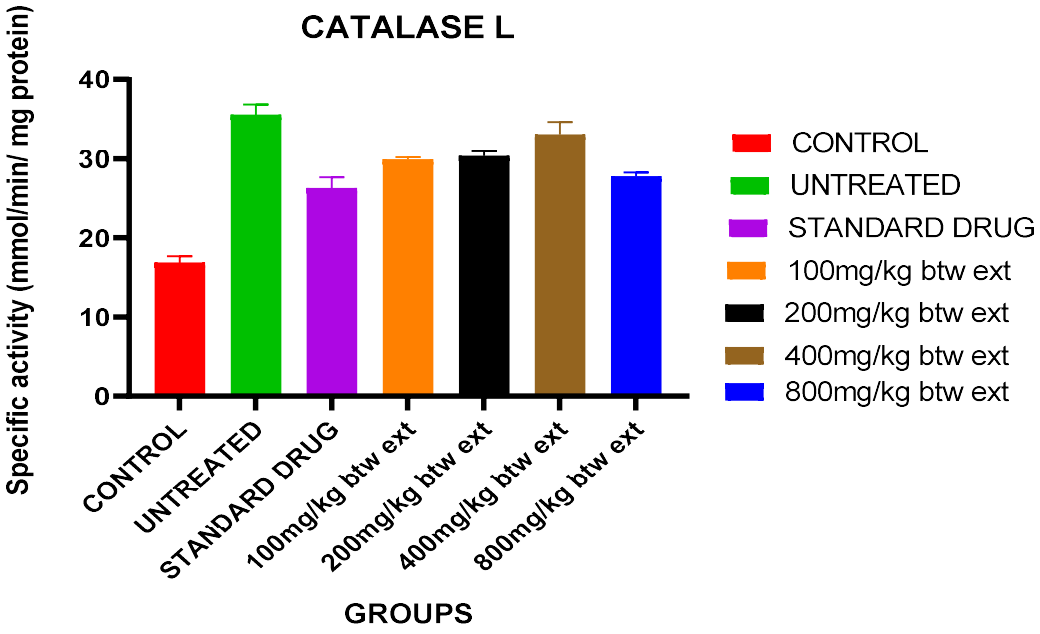

SOD ST
Specific activity (mmol/min/ mg protein)
8
6
4
2
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

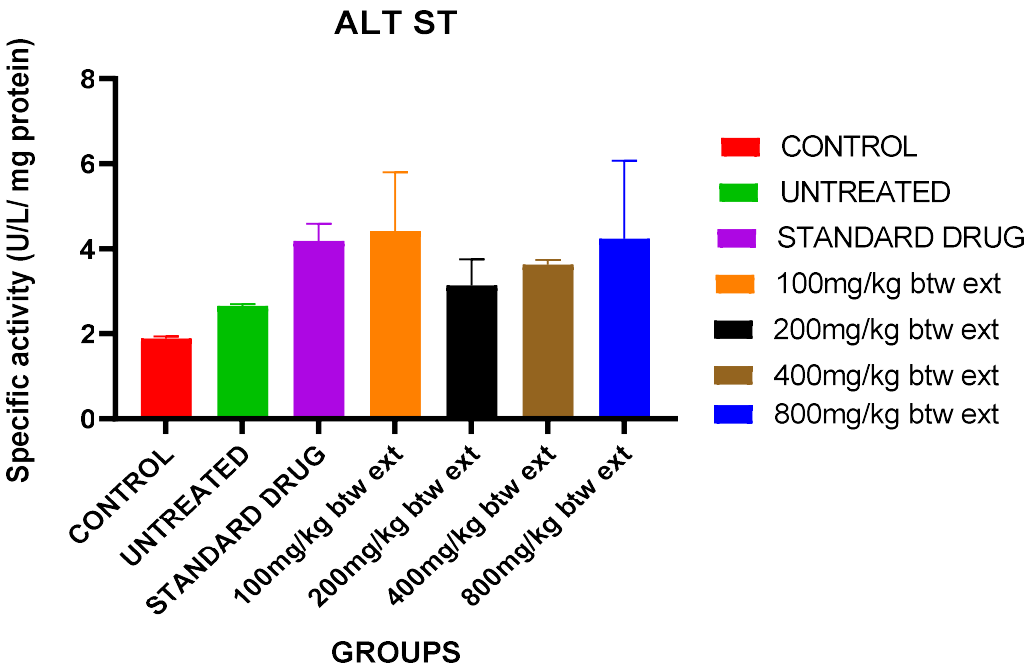

SOD L
Specific activity (mmol/min/ mg protein)
8
6
4
2
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

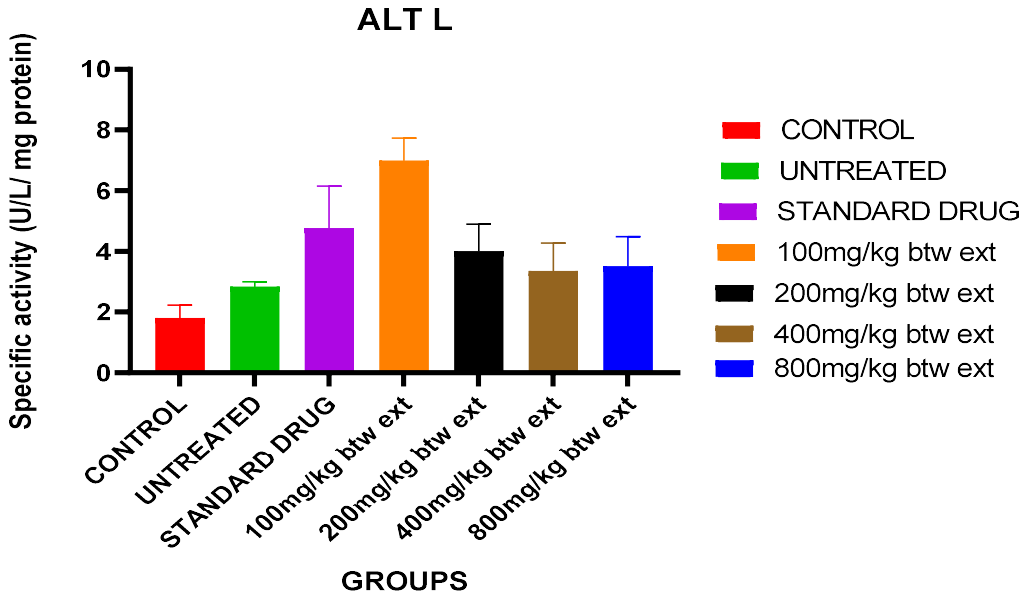

GSH ST
GSH Concentration (gmol/ml)
60
40
20
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

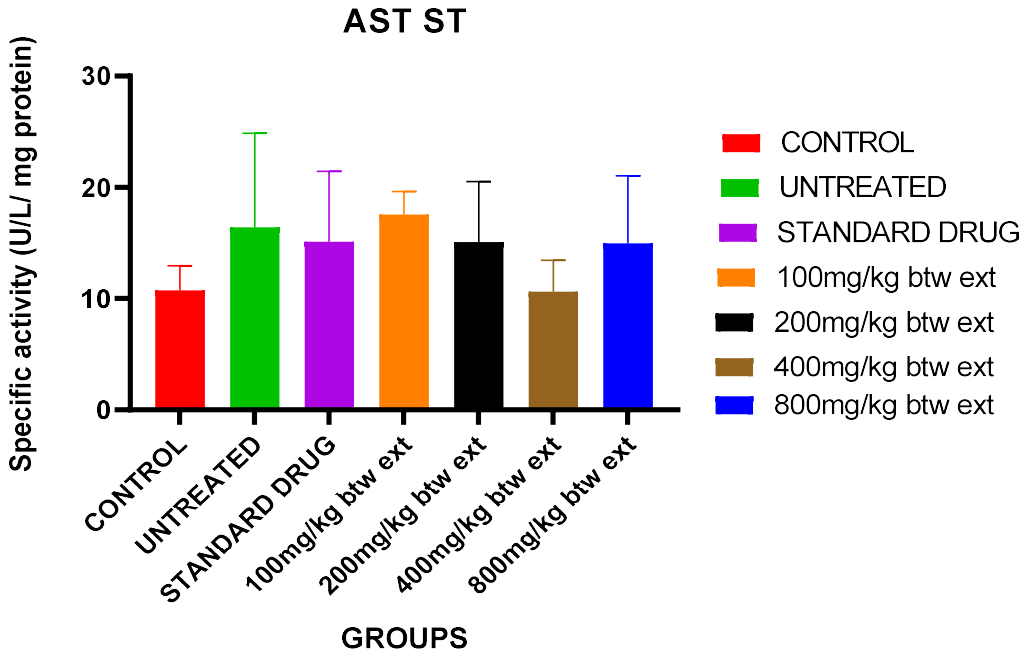

GST L
Specific activity (mmol/min/ mg protein)
5
4
3
2
1
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

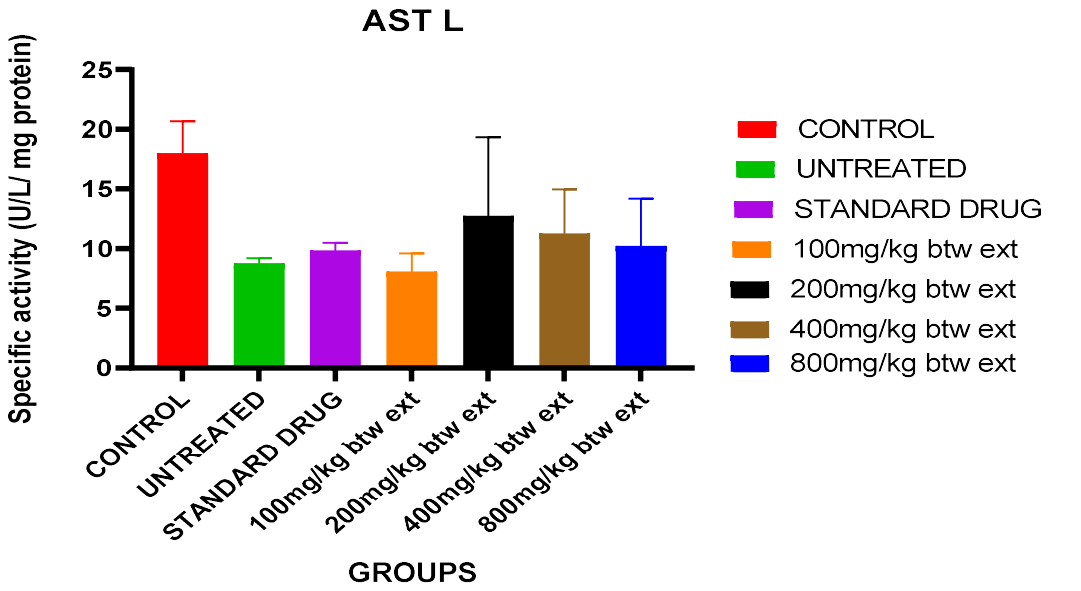

CATALASE ST
Specific activity (mmol/min/ mg protein)
40
30
20
10
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

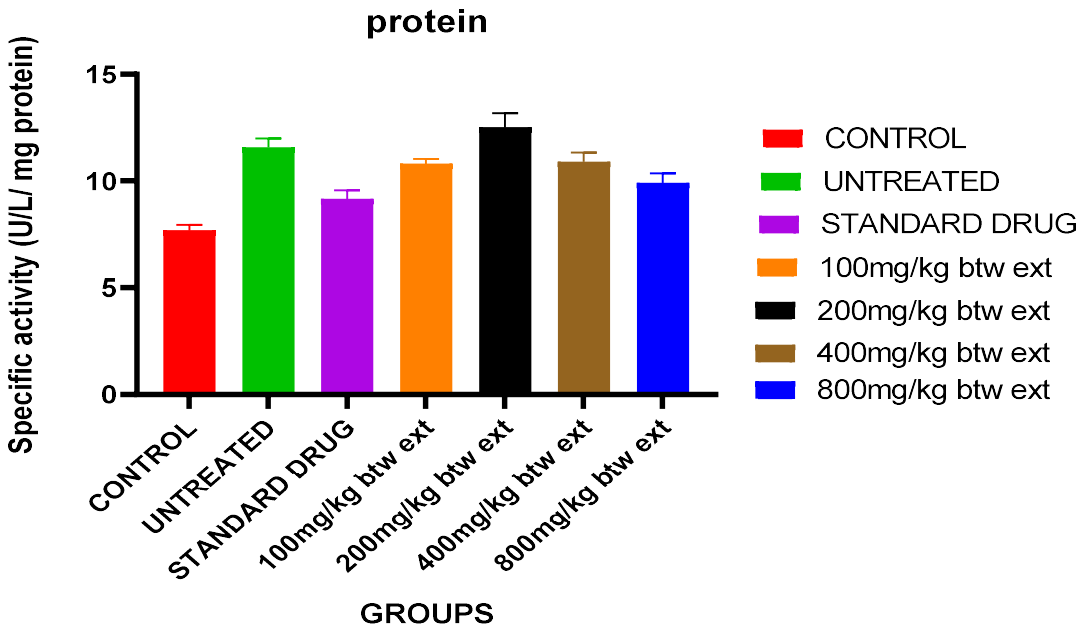

CATALASE L
Specific activity (mmol/min/ mg protein)
40
30
20
10
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

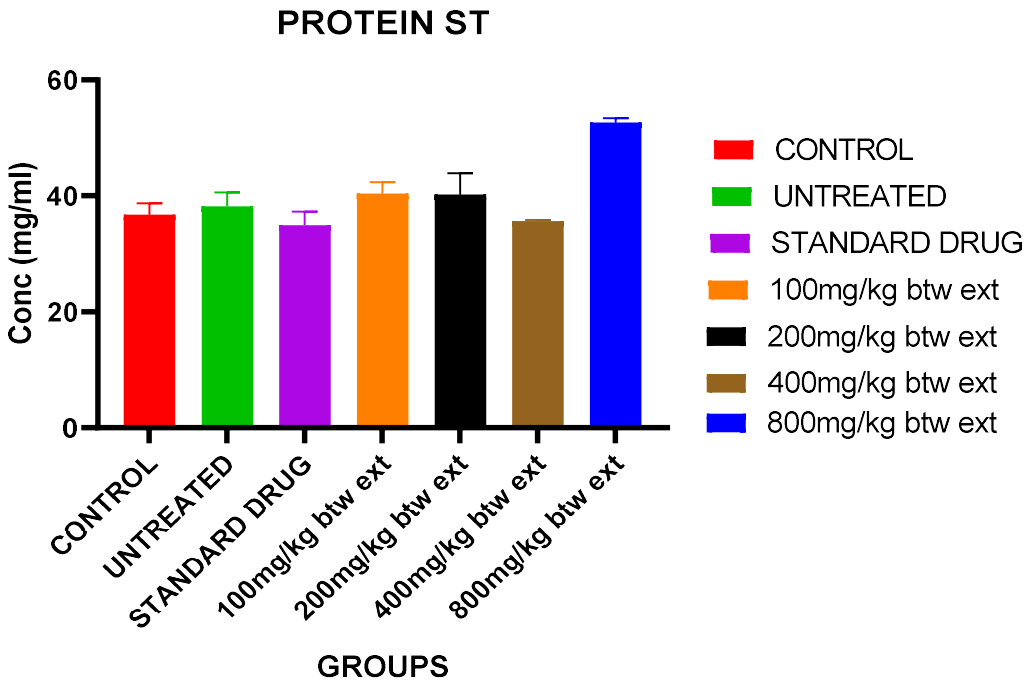

ALT ST
Specific activity (U/L/ mg protein)
8
6
4
2
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

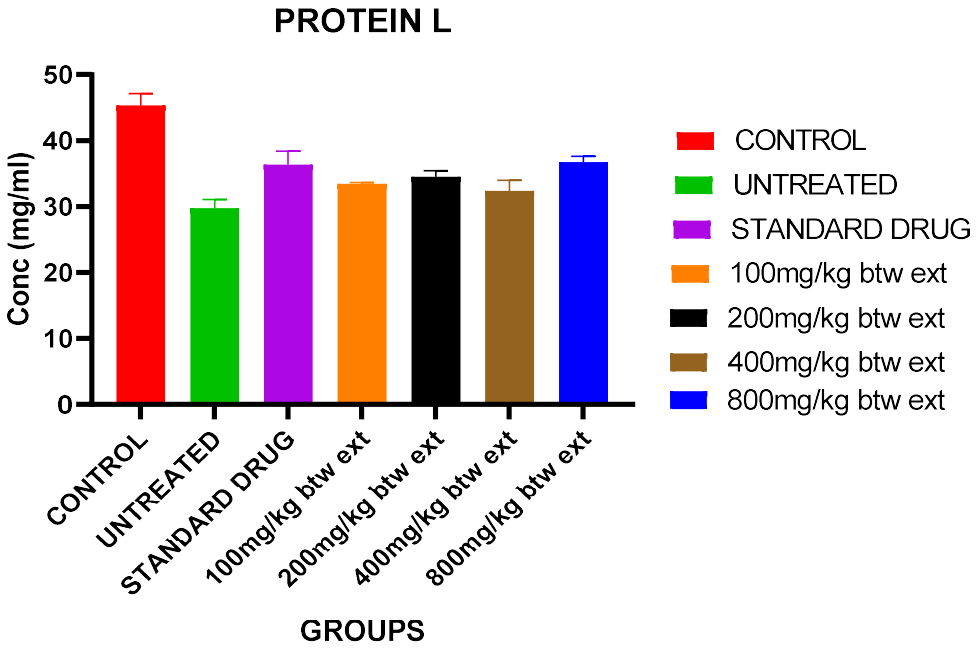

ALT L
Specific activity (U/L/ mg protein)
10
8
6
4
2
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

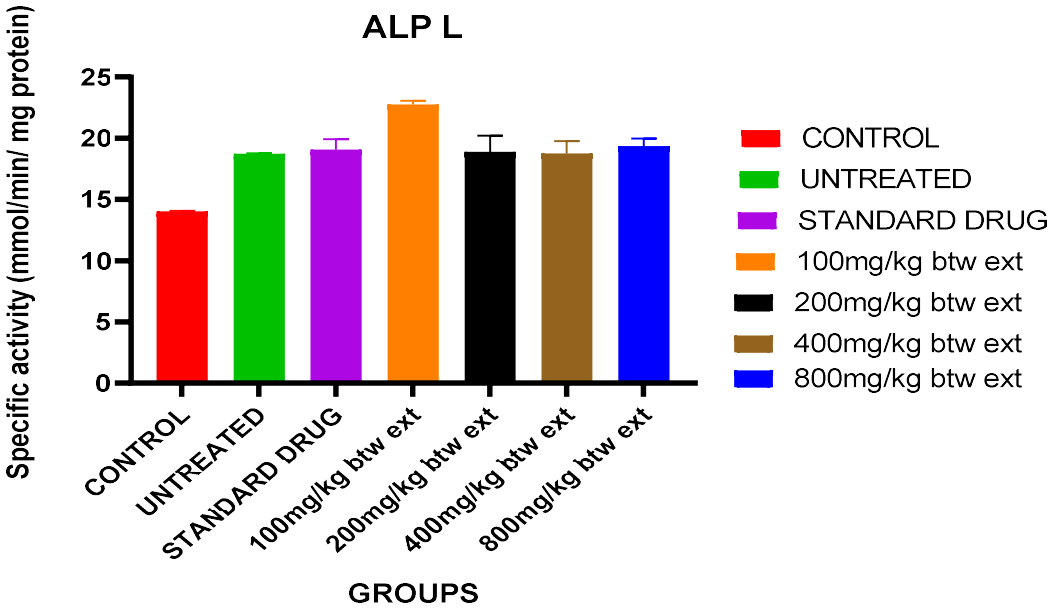

AST ST
Specific activity (U/L/ mg protein)
30
20
10
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

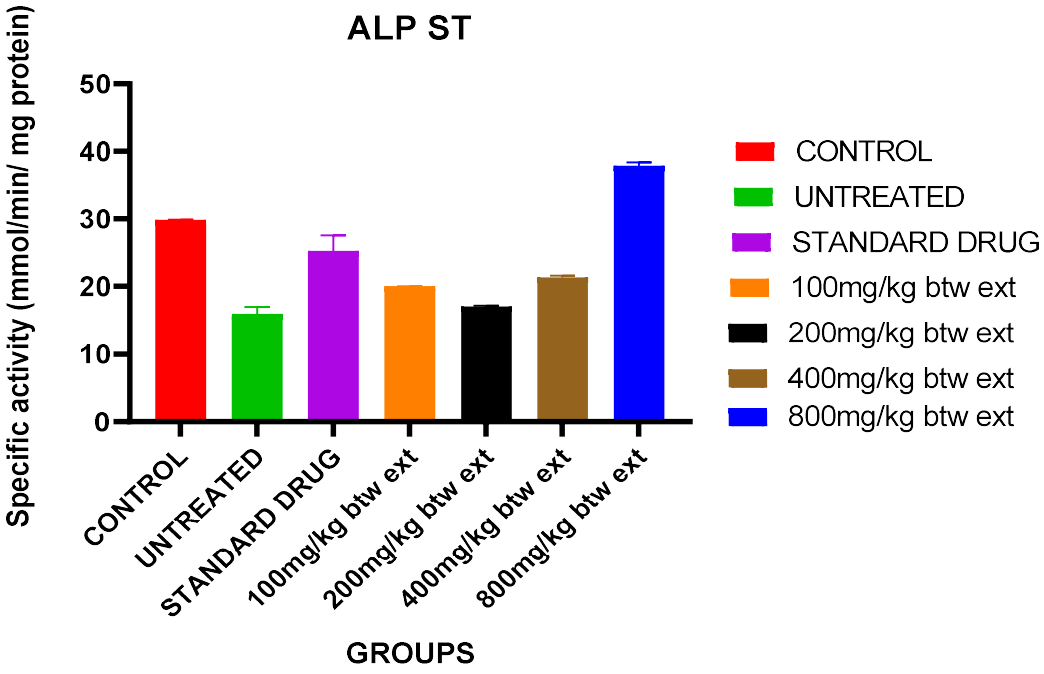

AST L
Specific activity (U/L/ mg protein)
25
20
15
10
5
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

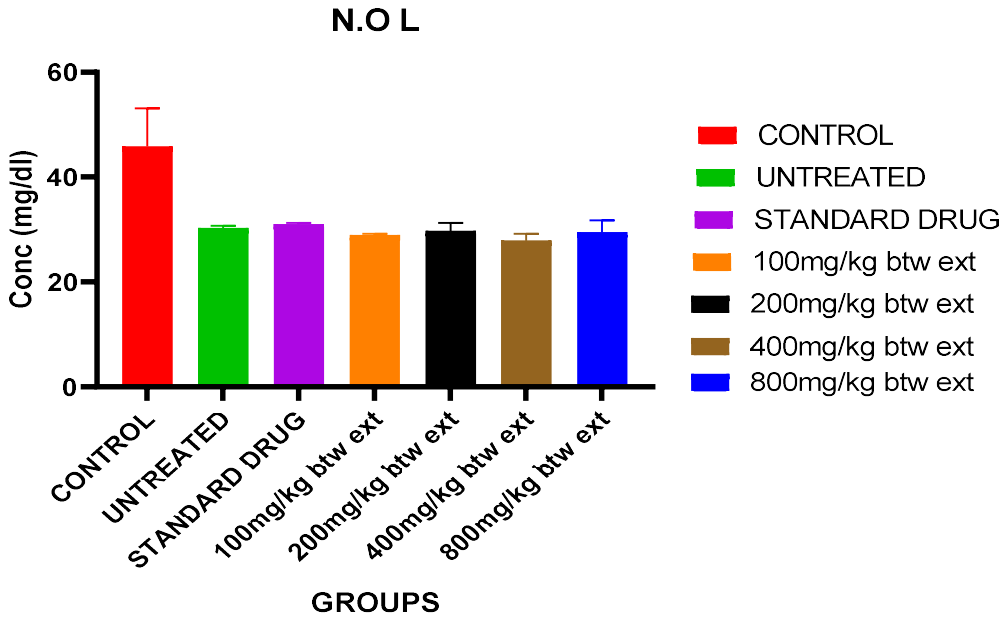

protein
Specific activity (U/L/ mg protein)
15
10
5
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

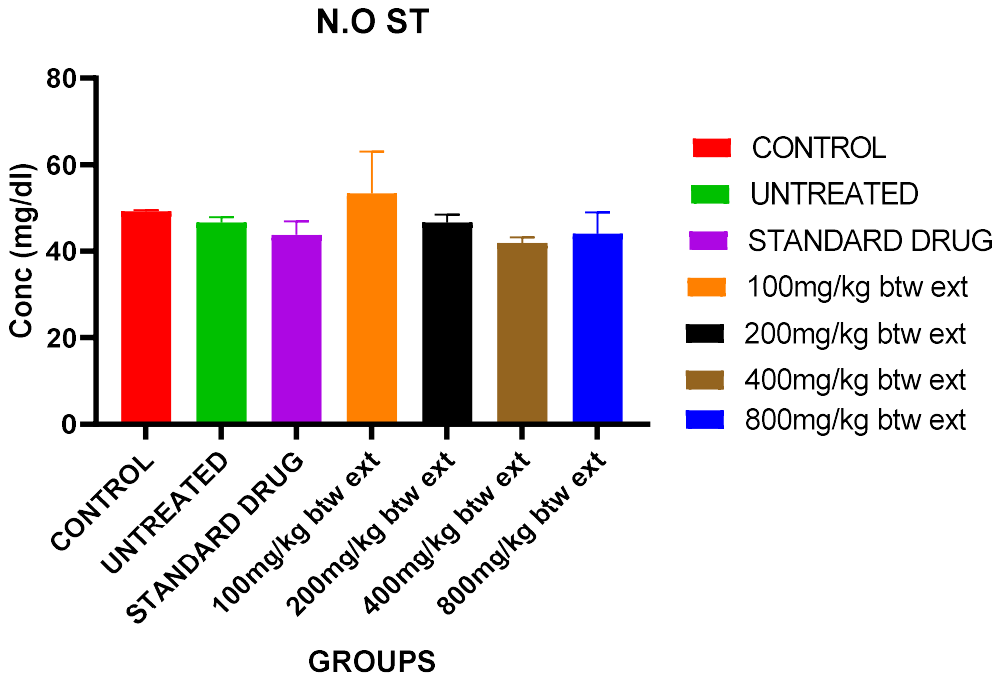

PROTEIN ST
60
40
20
0
Conc (mg/ml)
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

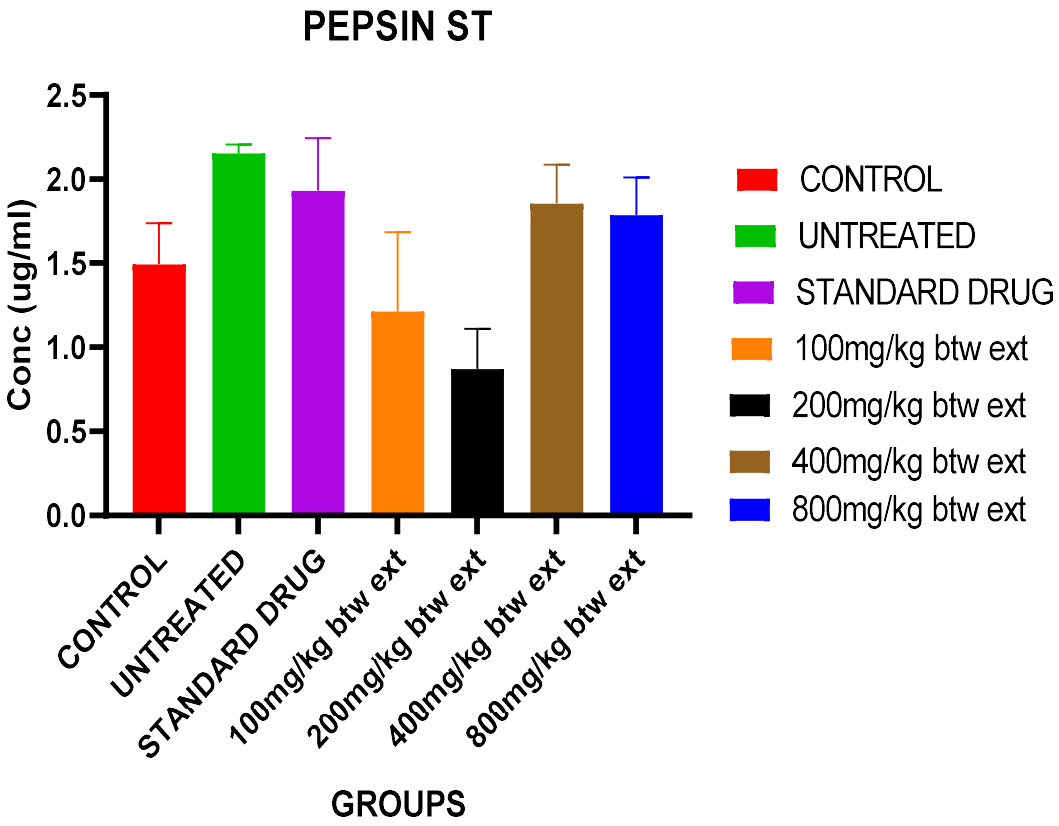

PROTEIN L
50
40
30
20
10
0
Conc (mg/ml)
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

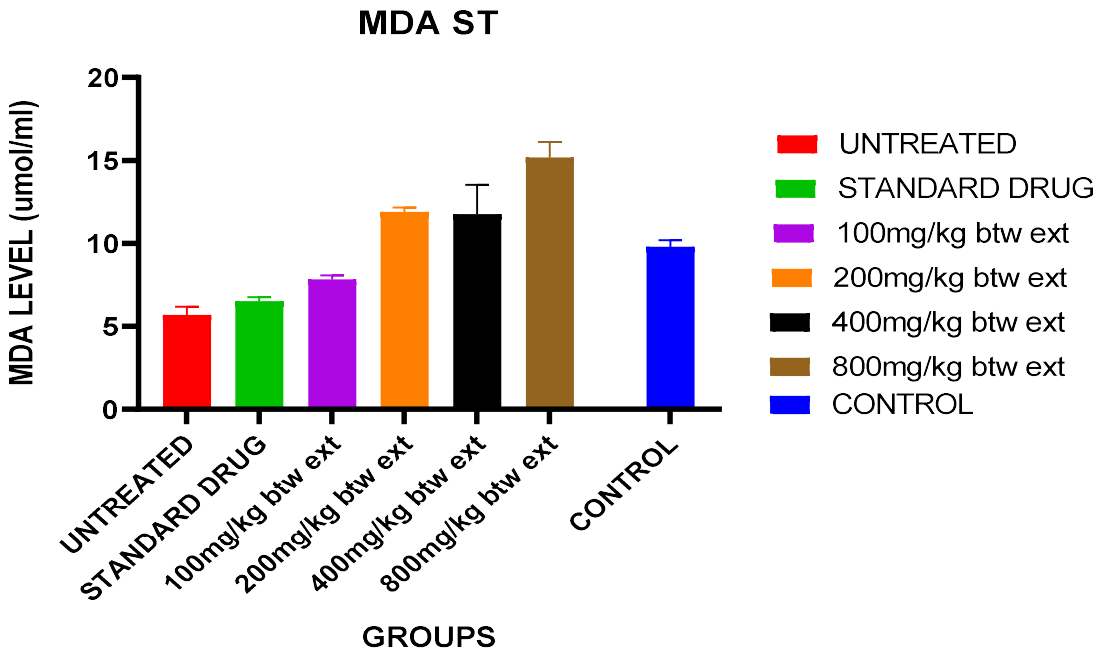

ALP L
Specific activity (mmol/min/ mg protein)
25
20
15
10
5
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

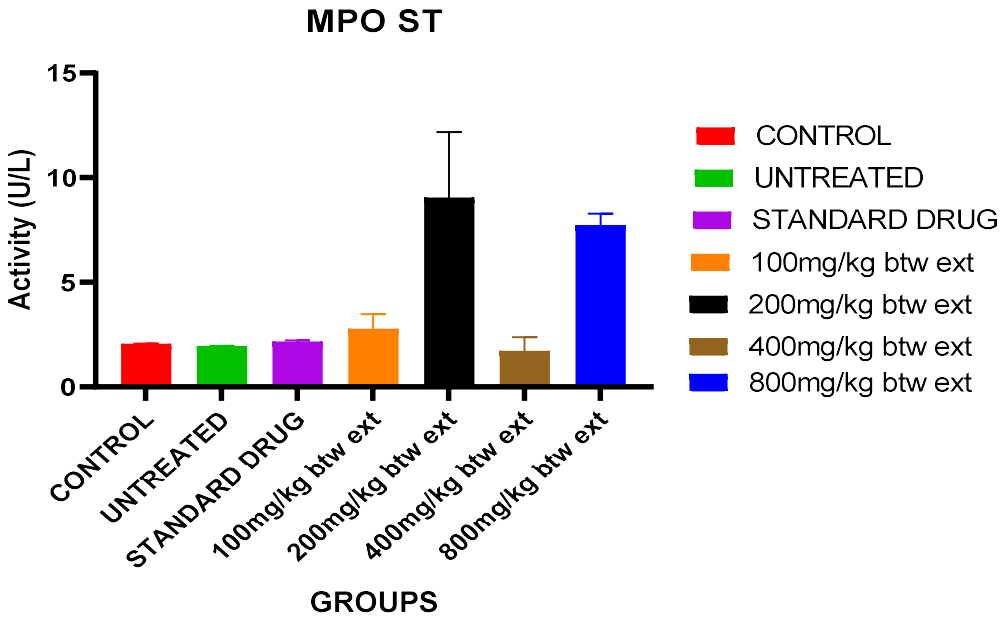

ALP ST
Specific activity (mmol/min/ mg protein)
50
40
30
20
10
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

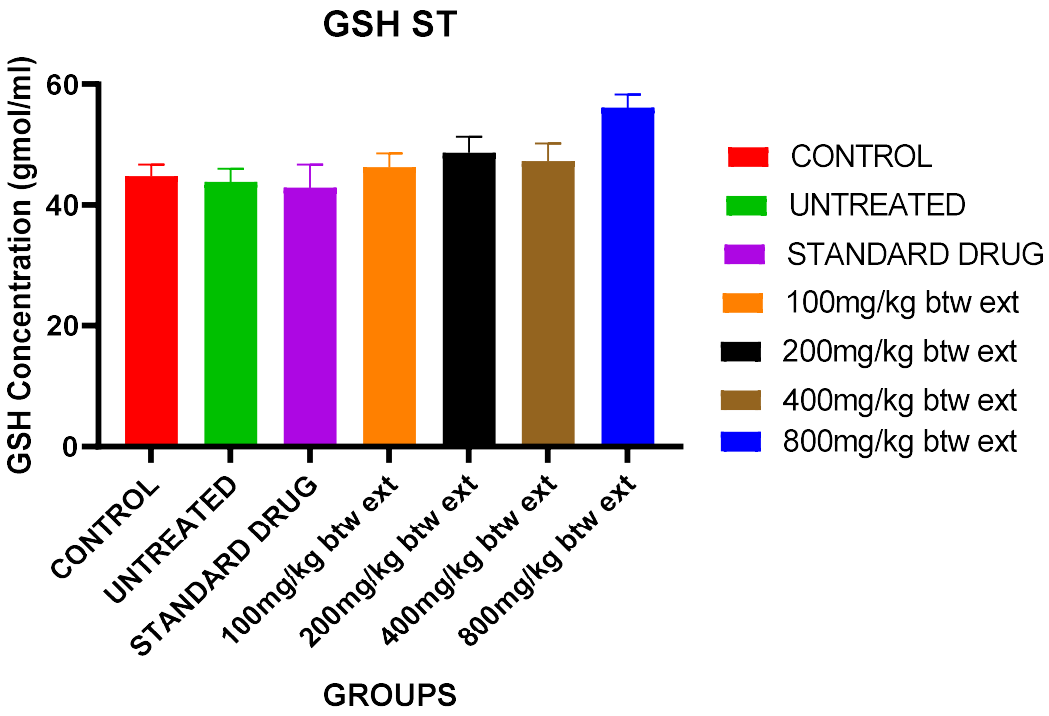

N.O L
60
40
20
0
Conc (mg/dl)
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

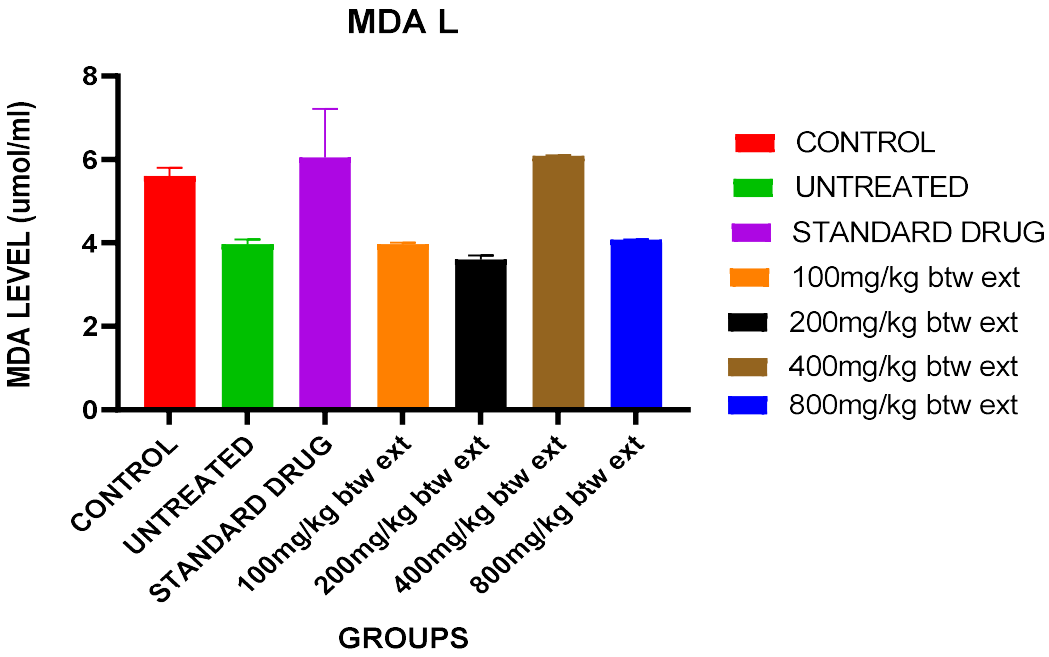

N.O ST
80
60
40
20
0
Conc (mg/dl)
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

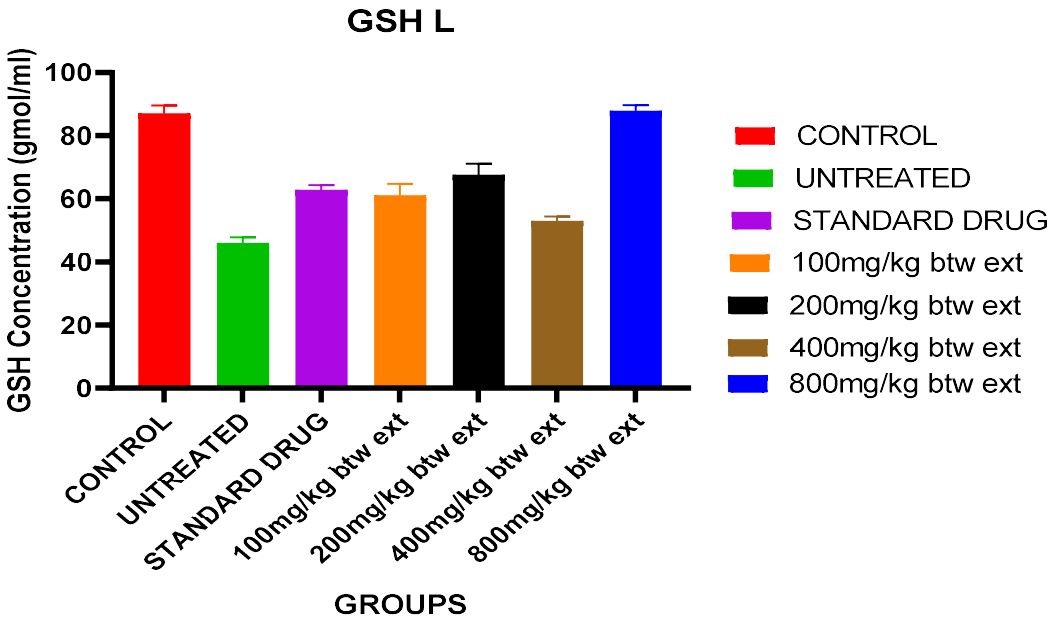

PEPSIN ST
Conc (ug/ml)
2.5
2.0
1.5
1.0
0.5
0.0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

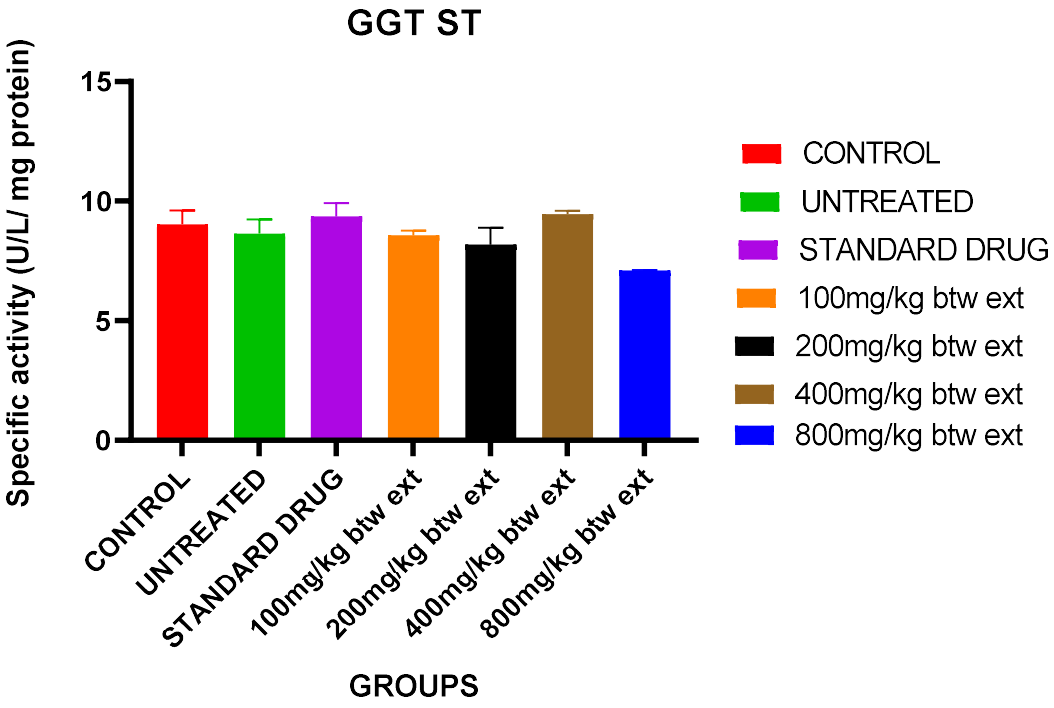

MDA ST
MDA LEVEL (umol/ml)
20
15
10
5
0
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
CONTROL
GROUPS

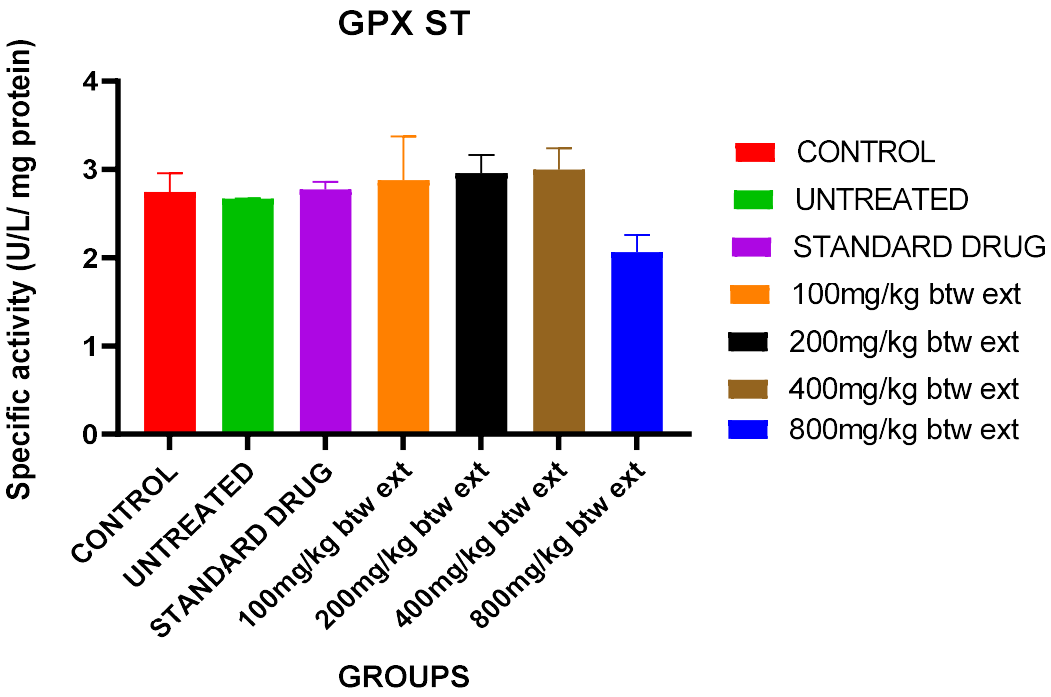

MPO ST
Activity (U/L)
15
10
5
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

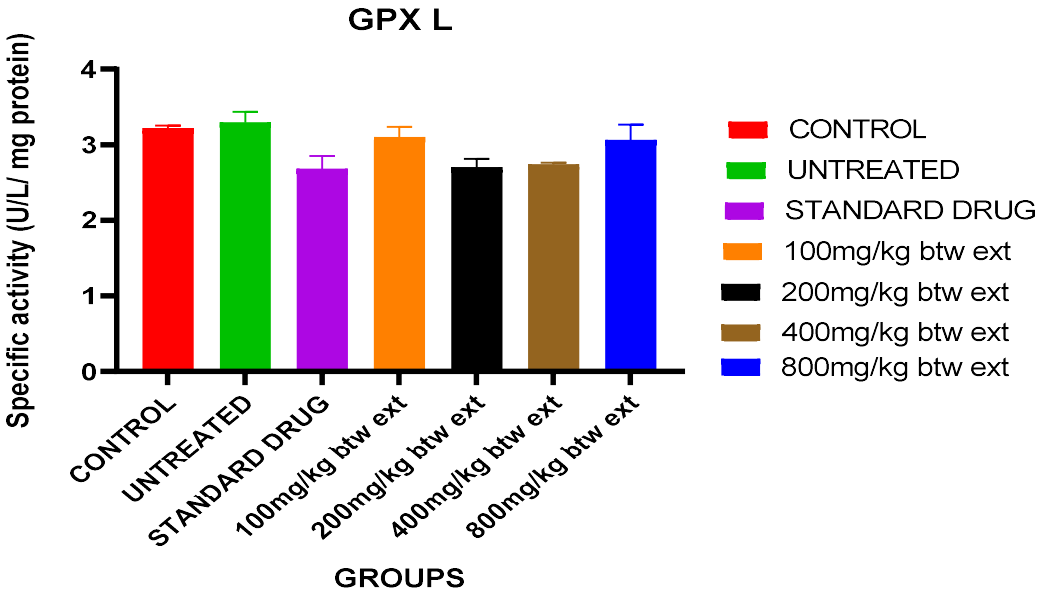

GSH ST
GSH Concentration (gmol/ml)
60
40
20
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS

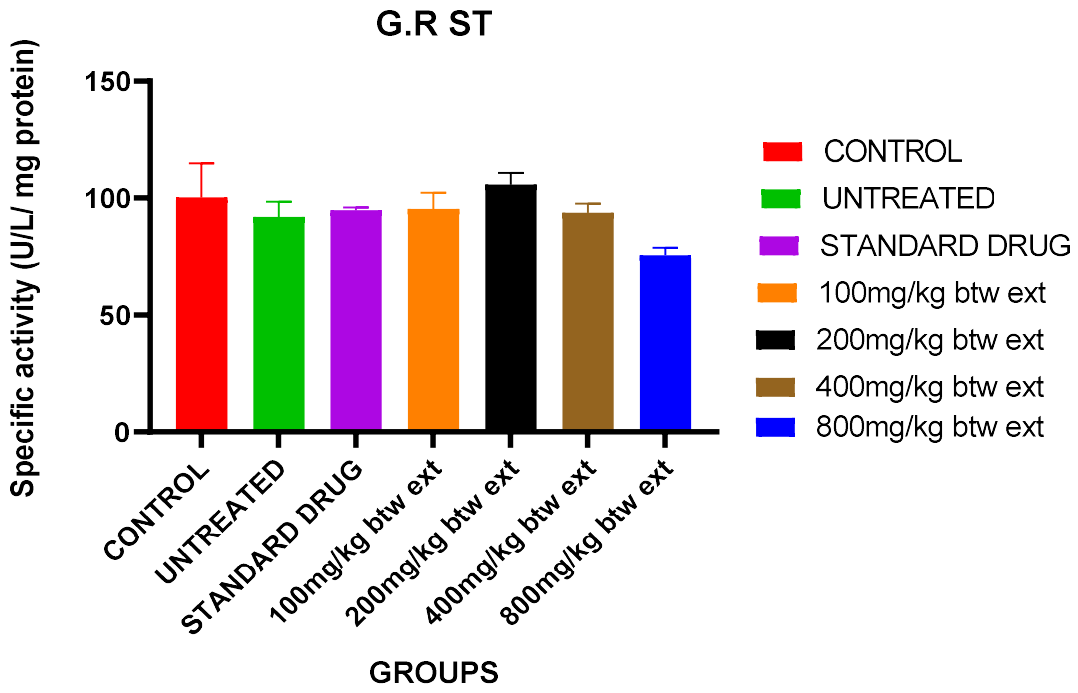

MDA L
MDA LEVEL (umol/ml)
8
6
4
2
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS


GSH L
GSH Concentration (gmol/ml)
100
80
60
40
20
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS


GGT ST
Specific activity (U/L/ mg protein)
15
10
5
0
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS


GPX ST
Specific activity (U/L/ mg protein)
0
1
2
3
4
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS


GPX L
Specific activity (U/L/ mg protein)
0
1
2
3
4
CONTROL
UNTREATED
STANDARD DRUG
100mg/kg btw ext
200mg/kg btw ext
400mg/kg btw ext
800mg/kg btw ext
GROUPS



4.6. Ulcerated Area Measurement

The ulcerated areas, characterized by measurements of length and breadth at affected sites, are summarized in Table 6. Group 4 recorded the largest ulcerated areas, with ulcer lengths ranging from 1.3 cm to 3.0 cm and breadths ranging from 0.6 cm to 1.2 cm. Group 3 also exhibited relatively large ulcerations, particularly in breadth. In contrast, Groups 2, 6, and 7 displayed smaller ulcerated areas, indicating lesser degrees of mucosal damage. No ulcer data were recorded for Group 1.

Table 4.6: Measurement of Ulcerated Areas (Length and Breadth) in Different Groups

Group	Sample	Length (L)	Breadth (B)
Group 1	1a		
Group 2	2a	0.96	0.60
Group 3	3a	2.05	1.5
Group 4	4a	1.85	0.90
Group 5	5a	1.5	0.73
Group 6	6a	1.23	0.50
Group 7	7a	1.27	0.50

4.7. Stomach Area Measurement

The stomach areas (SA), measured as length and breadth, are presented in Table 7. Generally, all groups exhibited similar stomach dimensions, with lengths ranging from 3.3 cm to 4.5 cm and breadths ranging from 2.1 cm to 3.9 cm. Group 2 recorded the highest values for both length (4.5 cm) and breadth (3.9 cm), while Group 6 showed the lowest breadth value (2.1 cm). No stomach area data were recorded for Group 1.

Table 4.7: Stomach Area (Length and Breadth) Measurements of Different Groups

Group	Sample	Length (L)	Breadth (B)
Group 1	1a		
Group 2	2a	4.23	3.60
Group 3	3a	3.75	3.00
Group 4	4a	3.80	2.90
Group 5	5a	3.70	2.73
Group 6	6a	3.80	2.53
Group 7	7a	3.83	2.86

4.8 Hematological Composition of Rats blood samples

Table 4.8 presents the hematological parameters of the experimental groups. White blood cell (WBC) counts ranged widely across the groups, with the highest value (10.3×10^9/L) recorded in Group 4 and the lowest (1.98×10^9/L) observed in Group 6. Generally, Groups 6 and 7, which received higher doses of the extract (400 mg/kg and 800 mg/kg respectively), exhibited marked reductions in WBC counts compared to the control group, suggesting potential immunosuppressive effects at higher doses.

Neutrophil (NEU) and lymphocyte (LYMPH) percentages remained relatively balanced across groups, though Groups 5 and 6 showed slight elevations in neutrophil

percentages and reductions in lymphocytes. These shifts could imply a mild stress or inflammatory response, particularly at higher extract concentrations.

Red blood cell (RBC) counts showed notable stability across the groups, ranging from 5.00 × 10^{12}/L to 6.00 × 10^{12}/L. Groups 1 is the lowest, and Group 4 exhibited relatively higher RBC values, indicating enhanced erythropoietic activity in these groups. Similarly, haemoglobin (Hb) concentrations and packed cell volume (PCV) followed this trend, with Groups 2 and Group 4 showing higher values (Hb: 12.46 g/dL and 12.10 g/dL; PCV: 37.66 % and 36.67 % respectively). These findings suggest that moderate extract doses might support erythropoiesis and improve oxygen-carrying capacity.

The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) remained within normal ranges across all groups. However, slightly lower MCV values were observed in Groups 6 and Group 1, possibly indicating the early onset of microcytic changes at very high extract doses.

Table 4.8 Hematological Composition of Rats blood samples

S/N	SAMPLE I.D	WBC ×10^9/L	NEU (%)	LYMPH (%)	EOS (%)	MON (%)	BASO (%)	RBC ×10^{12}/L	HB (g/dl)	PCV (%)	MCV (fl)	MCH (Pg)	MCHC (g/dl)
1	Group 1	8.20	27.30	72.30	NIL	NIL	NIL	5.00	10.33	31.00	64.00	21.10	33.00
2	Group 2	6.73	28.00	70.66	NIL	NIL	NIL	5.96	12.45	37.66	64.33	20.90	33.06

3	Group 3	8.00	25.51	74.50	NIL	NIL	NIL	5.55	11.35	34.50	62.15	20.25	32.85
4	Group 4	10.33	32.66	70.67	NIL	NIL	NIL	6.00	12.10	36.67	61.17	20.13	33.00
5	Group 5	6.03	33.33	66.66	NIL	NIL	NIL	5.57	11.33	34.00	61.00	20.33	33.30
6	Group 6	1.98	37	62.33	NIL	NIL	NIL	5.76	11.43	34.33	59.56	19.83	33.30
7	Group 7	3.60	30	70	NIL	NIL	NIL	5.65	11.20	32.50	57.55	19.85	34.50

Keys: WBC: White Blood Cell, BASO: Basophil, PCV: Packed Cell Volume, NEU: Neutrophil, Eosin: Eosinophil, MCV: Mean Cell Volume, Lymph: Lymphocyte, RBC: Red Blood Cell, MCH: Mean Cell Haemoglgbin, MONO: Monocyte, MCHC: Mean Cell Haemoglgbin Concentration, Hgb: Haemologbin.

CHAPTER FIVE

5.0 DISCUSSION

The present study investigated the physiological, nutritional, hematological, and phytochemical impacts of *Sida acuta* extracts, with results demonstrating both consistency and reinforcement of earlier findings reported in similar research.

5.1 Body Weight Gain in Experimental Animals

The analysis of body weight gain in experimental animals over a 14-day period revealed that most groups showed appreciable increases, especially Groups 1, 4, and 6, suggesting positive anabolic or nutritive properties of *Sida acuta* at moderate doses. Notably, Group 3 experienced a slight weight loss, and Group 7 exhibited stable weight with minimal reduction. These findings echo the results of Ibeagi et al. (2023), who demonstrated that low to moderate doses of *Sida acuta* enhanced growth performance in Wistar rats. Similarly, Idakwoji et al. (2022) reported comparable weight fluctuations depending on dosage and duration of administration, affirming that *Sida acuta* possesses nutritive properties that can promote weight gain, but potentially leads to metabolic stress or suppressed appetite at high concentrations.

The proximate composition revealed high levels of crude protein (13.56%–13.78%) and dietary fiber (27.52%–29.22%), moderate carbohydrate levels (30.68%–

31.64%), and relatively low fat content (7.07%–7.21%). These values are consistent with findings by Nwankpa et al. (2015), who highlighted the nutritional potential of *Sida acuta* in animal feed formulations. The protein content positions the plant as a viable source of dietary nitrogen, while the high fiber content suggests benefits in gastrointestinal health and possible roles in satiety and lipid metabolism.

5.2 Phytochemical

The phytochemical screening revealed the presence of important bioactive compounds such as saponins, tannins, flavonoids, phenols, and glycosides. These compounds are known for a range of therapeutic activities, including antioxidant, anti-inflammatory, and antimicrobial effects. The findings support those of Owoeye and Salami (2024), who demonstrated the antioxidant potential of *Sida acuta* in reducing oxidative stress in rats. These phytochemicals provide pharmacological value that supports the ethnomedicinal use of the plant in traditional medicine.

Saponins was found to be present in the Sample respectively. Saponins are secondary metabolites that have been reported to be useful in soaps, medicinal, fire extinguisher, speciously as dietary supplements, for synthesis of steroids, and in carbonated beverages (Akangbe *et al*., 2019). Present of saponins in the sample and implies that the extracts can be useful in soap industry as well as antimicrobial agents.

They are used by plants for their growths, aroma of oils and defense against microorganisms.

Tannins was found to be present in the Sample. Tannins are a class of astringent, polyphenol biomolecules that binds to and precipitate proteins and various other organic compounds including amino acids and alkaloids (Akange *et al*., 2019). The presence of tannins reveals that the extracts exhibit medicinal properties and can be useful for pharmacological purposes.

Flavonoid was found to be presence in the sample respectively. Flavonoids are powerful antioxidants with anti-inflammatory and immune system benefits (kimar *et al*., 2018). Presence of flavonoids in all samples is an indication that the extracts have medicinal benefits. They are used by plants for their growths, aroma of oils and defense against microorganisms.

Alkaloid was found to be present in Sample. Certain alkaloids act as cardiac or respiratory stimulants, treat arrhythmias, or irregular rhythms of the heartbeat. Many alkaloids affect respiration, but in a complicated manner such that severe respiratory depression may follow stimulation (ching *et al*., 2001).

Phenol was found to be present in the sample. Phenolic compounds are secondary metabolites that are involved in adaptation processes in plants during stress conditions such as wounding, infection or exposure to UV radiation (Gupta *et al*., 2017).

5.3 Proximate Analysis

The proximate analysis revealed that sample of *Sida acuta* is rich in macronutrients, *Sida acuta* particularly crude protein, making them suitable for nutritional applications. exhibited slightly higher protein contents, suggesting better suitability for energy and protein supplementation. The moderate crude lipid content indicates a low-fat profile, which may be beneficial for individuals on low-fat diets. High crude fiber content, especially in *Sida acuta*, highlights the potential of *Sida acuta* in promoting digestive health, although excessive fiber might reduce nutrient bioavailability. Low moisture content in both samples implies good shelf stability and reduced susceptibility to microbial spoilage.

Sample *Sida acuta* and was found to have highest moisture content. The moisture content is the amount of water in the *Sida Acuta* and is usually expressed as a percentage. The low moisture content will increase the shelf life by preventing oxidation (Sanderson, 2007). (Ibeagi *et al*. 2023) reported a protein content of 13.4% in *Sida acuta* leaf extract, which closely aligns with the present findings. Similarly, the work of Ogbaji et al. (2018) reported a range of 12.5%–14.2%, indicating that environmental factors and soil conditions may slightly affect protein accumulation but generally confirm the plant's nutritional reliability.

Sample *Sida acuta* contained 13.56% crude protein. These values demonstrate that *Sida acuta* is a good source of plant-based protein. Protein plays an essential role in body repair, enzyme synthesis, and muscle development, which makes *Sida acuta* a promising supplement in both animal feed and human diets. (Ibeagi *et al*. 2023) reported a protein content of 13.4% in *Sida acuta* leaf extract, which closely aligns with the present findings. Similarly, the work of Ogbaji et al. (2018) reported a range of 12.5%–14.2%, indicating that environmental factors and soil conditions may slightly affect protein accumulation but generally confirm the plant's nutritional reliability.

The lipid contents of *Sida acuta* was 7.14%, respectively. Though relatively low, these values suggest a modest energy contribution and the presence of essential fatty acids, which are crucial for maintaining cellular integrity and hormone production. According to (Oko *et al*. 2016), the lipid content of *Sida acuta* was estimated at 6.85%, slightly lower but within range. Their findings also emphasized the plant's potential as a low-fat energy source, reinforcing its desirability in diets meant to manage obesity or cardiovascular risk.

Ash content represents the total mineral matter in the plant. *Sida acuta* recorded 11.39%, respectively. These values indicate high inorganic matter, pointing to rich mineral content such as calcium, potassium, and magnesium. (Ajayi *et al*., 2017) found ash content in *Sida acuta* to be around 10.8%, which corroborates the mineral-rich nature

of the plant. This makes the plant highly beneficial in addressing micronutrient deficiencies.

Fibre content was significant lower at 27.52%. High fibre promotes digestive health and helps regulate blood sugar and cholesterol levels. In alignment with the findings of (Chukwuma *et al*., 2020), who reported a fibre content of approximately 28.9%, this study reinforces *Sida acuta's* use in promoting gastrointestinal health and satiety in both humans and animals.

5.4 Hematological Findings

Hematological analysis revealed variations across the different experimental groups. White blood cell (WBC) counts were highest in Group 4 (10.33×10^9/L) and lowest in Group 6 (1.98×10^9/L), suggesting that higher doses of the extract may exert immunosuppressive effects. This observation agrees with earlier findings by Adeoye and Omotayo (2020), who reported a decline in WBC levels following administration of high doses of plant extracts, indicating potential immune modulation or toxicity.

On the other hand, red blood cell (RBC) counts, hemoglobin (Hb) levels, and packed cell volume (PCV) were relatively stable, with moderate doses contributing to improved erythropoiesis. Groups 2 and 4 demonstrated the highest Hb and PCV values, implyin g a stimulatory effect on red cell production. These results reinforce the findings

of Owoeye and Salami (2024), who found that *Sida acuta* supports hematopoiesis and may help manage conditions like anemia at appropriate doses.

Importantly, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) remained within normal physiological ranges. However, slightly reduced MCV values in Groups 6 and 1 may suggest early signs of microcytic anemia at high extract doses, underscoring the importance of dosage regulation.

5.5 Mineral Contents

Mineral analysis indicated that *Sida acuta* contains appreciable levels of iron (2.023 mg/100g), copper (1.0948 mg/100g), potassium (5.833 mg/100g), magnesium (5.376 mg/100g), and calcium (4.031 mg/100g). These minerals are essential for physiological functions such as hemoglobin formation, electrolyte balance, muscle contraction, and nervous system regulation. The high potassium-to-sodium ratio is particularly noteworthy as it suggests cardiovascular benefits, including potential blood pressure-lowering effects. These findings are corroborated by Ajayi et al. (2017), who emphasized the rich mineral profile of *Sida acuta* in nutritional and medicinal contexts.

5.6 Ulcerated Area

Measurement of ulcerated regions revealed a clear distinction between groups in terms of mucosal damage. Group 4 exhibited the largest ulcerated areas, with lengths ranging from

1.3 cm to 3.0 cm and breadths from 0.6 cm to 1.2 cm, indicating substantial mucosal injury. Group 3 also presented considerable ulceration, particularly in breadth (up to 1.5 cm), suggesting similar susceptibility or lower protection against ulcerogenic agents. Conversely, Groups 2, 6, and 7 showed significantly smaller ulcerated areas, implying better protective or healing effects, possibly due to the administration of Sida acuta extract or other therapeutic agents. Group 1, presumed to be the control, recorded no ulceration, reinforcing the idea that the experimental ulcer induction was treatment-specific.

5.7 Stomach Area

Stomach length and breadth remained relatively stable across groups, indicating that ulceration or treatment with Sida acuta did not significantly alter overall stomach dimensions. Group 2 recorded the highest stomach size (4.23 cm by 3.60 cm), while Group 6 had the smallest breadth (2.53 cm). These differences, though mild, may reflect slight variations in tissue response to treatment or inflammation. Importantly, no gastric atrophy or gross morphological distortion was observed.

5.8 Total Tannin Content

Phytochemical analysis using UV spectrophotometry confirmed the presence of tannins in Sida acuta extract, with high absorbance values recorded in both liver and tail extracts (0.9116–1.3847 nm). The consistency in absorbance across replicates validates the

presence of substantial tannin content. Tannins are known for their astringent, antioxidant, and anti-ulcerogenic properties, which may account for the reduced ulceration observed in certain treatment groups (e.g., Groups 2, 6, and 7). These findings reinforce previous reports on the protective role of tannins against gastrointestinal damage and support the therapeutic potential of Sida acuta.

CONCLUSION

The present study comprehensively evaluated the physiological, nutritional, hematological, and phytochemical impacts of *Sida acuta* extracts on experimental animals, yielding results that strongly align with findings from earlier studies, thus reinforcing the plant's therapeutic and nutritional potential.

The weight gain analysis demonstrated that *Sida acuta* supports body mass increase, particularly at moderate dosages, echoing the conclusions that Groups 1, 4, and 6 showing significant weight gain. The proximate analysis confirmed that *Sida acuta* is a rich source of crude protein. The phytochemical screening further validated the presence of potent bioactive compounds saponins, tannins, flavonoids, phenols, and glycosides known for their antioxidant, antimicrobial, anti-inflammatory, and cardioprotective properties. From a hematological standpoint, the extract positively influenced red blood cell production, hemoglobin concentration, and packed cell volume, particularly at moderate doses (Groups 2 and 4). These effects suggest *Sida acuta's* role in supporting erythropoiesis and managing conditions like anemia. The mineral composition of *Sida acuta* (Fe, Cu, Zn, K, Mg, Ca) further adds to its nutritional value, supporting metabolic functions, hematopoiesis, and cardiovascular health.

RECOMMENDATION FUTURE RESEARCHERS

In view of the comprehensive findings from this study on the physiological, nutritional, hematological, and phytochemical impacts of *Sida acuta*, the following recommendations are made to guide future research efforts:

Conduct Clinical Trials and Human Studies

Future researchers are encouraged to extend this investigation beyond animal models to human clinical trials. This would validate the safety, efficacy, and dosage thresholds of *Sida acuta* in treating conditions such as anemia and nutritional deficiencies in humans.

Isolate and Characterize Active Componds

While the study confirmed the presence of several bioactive compounds, further research should focus on isolating, purifying, and characterizing these phytochemicals. This could lead to the development of novel drugs or therapeutic agents from *Sida acuta*.

Evaluate Long-Term Toxicity and Safety Profile

Long-term administration and chronic toxicity studies are needed to assess the potential side effects or cumulative impacts of *Sida acuta* extract, particularly at higher doses. This will help define its safety margin and therapeutic window.

Investigate Synergistic Effects with Other Herbs or Drugs

It would be beneficial to explore potential synergistic or antagonistic interactions between *Sida acuta* and other medicinal plants or conventional pharmaceuticals. This could broaden its application in integrated medicine.

Broaden the Scope of Nutritional and Functional Assessments

Researchers are advised to assess additional nutritional indices and organ-specific effects (e.g., liver and kidney function tests), to better understand the systemic effects of *Sida acuta* and its suitability as a functional food or supplement.

Utilize Omics-Based Approaches

Integrating genomics, proteomics, and metabolomics into future studies may help uncover more comprehensive insights into the biological pathways influenced by *Sida acuta*, and identify potential biomarkers of efficacy or toxicity.

By pursuing these directions, future research can further elucidate the therapeutic potential of *Sida acuta*, support its safe application in traditional and modern medicine, and contribute to the development of novel plant-based interventions.

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APPENDIX

English Name is common wireweed. It's also sometimes referred to as broom weed.

Rank	Scientific Name and Common Name
Kingdom	Plantae – Plants
Subkingdom	Tracheobionta - Vascular plants
Superdivision	Spermatophyta - Seed plants
Division	Magnoliophyta - Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Dilleniidae
Order	Malvales
Family	Malvaceae Juss. - Mallow family
Genus	Sida L. – fanpetals
Species	Sida acuta Burm. f. - common wireweed

English Name is Wistar Albino Rat

Rank	Scientific Name and Common Name
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Rodentia
Family	Muridae
Genus	Rattus
Species	Rattus norvegicus

MATERIAL USED

Weighing balance was employed for accurate measurement of solid substances.

Blender facilitated sample homogenization.

Standard measuring cylinders (100 ml and 200 ml).

Beakers, and **conical flasks** were used for measuring and preparing solutions.

Test tubes, along with **racks** and **holders**, supported sample handling and reaction observations.

C**entrifuge** was used to separate components based on density.

Oven assisted in drying and sample preparation.

Filter paper was used for filtration.

Glass slides aided in microscopic analysis.

Spatula was used for transferring powders.

Spectrophotometer measured absorbance during phytochemical analysis.

Reagent bottles, **Petri dishes**, **cotton wool**, **foil**, and **pH paper** supported storage, culture, and pH monitoring.

Hand gloves ensured safety during handling of samples and reagents.

Sample bottles including **EDTA and universal bottles** were used for blood and liquid sample collection.

Micropipettes, **syringes**, and **needles** allowed for precise liquid handling.

37°C water bath maintained required incubation temperatures.

General **laboratory glassware**, **dissecting sets**, **thermometers**, and **measuring cylinders** supported a variety of analytical tasks.

Animal cages and **grower's mash** were essential for the housing and feeding of experimental animals.