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POTENTIAL OF PHYTOCHEMICAL PROPERTIES OF ZIZIPHUS MAURITANIA (MAGARYA) LEAF EXTRACTS FOR CORROSION INHIBITION

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Abstract: *Corrosion control is crucial from technical, economic, environmental, and aesthetic perspectives. To safeguard metals and alloys against corrosion, utilizing inhibitors derived from plant extracts is a highly favourable option. It offers environmental acceptability, easy availability, and renewability. The aim of this study is to examine the chemical properties of Ziziphus mauritiana and determine its suitability as a corrosion inhibitor. The leaf extracts of Ziziphus mauritiana were subjected to standard procedures for phytochemical screening. The findings revealed a diverse array of phytochemicals in the leaf extracts, including glycosides, anthraquinone, cardiac glucosides, flavonoids, alkaloids, and saponins. These compounds are known for their inhibitory effects and are commonly found in other plant extracts that have demonstrated efficiency in corrosion inhibition. This suggests that Ziziphus mauritiana may possess the ability to effectively mitigate metal corrosion. Therefore, the study recommends conducting experimental investigations using Ziziphus mauritiana extracts in relevant corrosive environments to more accurately assess its efficiency compared to other plant extracts.*

Keyword: *corrosion, leaf extract, Ziziphus mauritiana, corrosion inhibitor*

INTRODUCTION

Corrosion refers to the deterioration of metal due to exposure to corrosive environments, either through direct chemical reactions or electrochemical processes in contact with aqueous corrosive surroundings. This pervasive and expensive issue is challenging to completely eliminate. It poses significant concerns related to safety, preservation, and economics across multiple fields such as chemical, automotive, metallurgical, natural, and medical engineering. It particularly affects the design of diverse mechanical components, varying in size, function, and expected lifespan (Sharma, *et al*., 2011; Peter, *et al*., 2015). Corrosion can cause life-threatening damage to metal and alloy structures causing financial punishment in terms of renovation, replacement, product losses, safety and environmental pollution (Patni, *et al.*, 2013). The deterioration of metal can lead to increased loss of productivity due to the impaired functioning of corroded tools and the contamination of key industrial products, such as chemicals, with the by-products of aqueous corrosion. Product leakage further reduces efficiency (Farahati, *et al.*, 2020).

Globally, corrosion leads to an economic loss of approximately 2.5 trillion US dollars, accounting for nearly 3.4% of the total GDP. However, by effectively implementing existing technologies for corrosion prevention, it is possible to reduce the cost of corrosion by 15-35%, amounting to a significant range of 375-875 billion US dollars (Verma, *et al.*, 2018; Munis, *et al*., 2020). The significant costs of corrosion is also experienced by the oil and gas sector (Fayomi, *et al*., 2019) as well as the food and agro-processing industries of Nigeria (Jekayinfa, *et al.*, 2005). If the materials affected by corrosion are not treated, it can result in equipment failures for the industry (Salhah, *et al*., 2021).

Due to these harmful effects, corrosion is an unattractive observable fact that must be prevented. Prevention would be more realistic and practicable than complete eradication (Gabsi, *et al.*, 2023). The prevention of metals against corrosion has attracted much attention globally as a result of huge losses of natural resources and finances that are sustained annually all over the world due to corrosion (Ating, *et al.*, 2010). Corrosion inhibitors are substances that are added in small amounts on metal surfaces or are added to the corrosive medium, reducing the tendency to be affected by corrosion. The use of common corrosion inhibitors is sometimes limited, since these are based on dangerous substances for human health, such as chromium-based treatments (Jiang, *et al.*, 2017). Recent approaches take advantage of organic compounds that can be obtained from expired pharmaceutic drugs, mushroom extracts, and even plant extracts (Dohare, *et al.*, 2017; Gholamhosseinzadeh, *et al.*, 2019). There is a variety of green organic compounds that function as corrosion inhibitors that show excellent properties in protecting metal surfaces, for example, derivatives of chitosan (El-Haddad, *et al.*, 2019). hybridization of neem leaf, bitter leaf and moringa leaf (Aji, *et al.*, 2016), *leptadenia hastata* (Yadiya) leaves extracts (Maina, *et al.*, 2021; Maina, *et al*., 2022), *polyalthia longifolia* leaves extract (Zubairu, *et al.*, 2021) and many others. In consequence, these compounds replace the traditional toxic corrosion inhibitors. Promising advancements have been made in the development of exceptionally effective corrosion inhibitors utilizing these sustainable and environmentally friendly sources. Extracts from plants, in particular, are of significant interest as they provide an initial exploration into identifying natural compounds that aid in inhibiting the corrosion process.

Ziziphus mauritiana, commonly known as magarya, is a fruit-bearing tree that belongs to the *Rhamnaceae* family and is known for its nutritional and medicinal properties. The tree thrives in various regions of Nigeria and is well-adapted to the local climate. Generally, each plant each extract contains numerous phytochemicals of moderate to complex molecular. These electron-rich hydrophilic centres interact (adsorb) on the metallic surface where hydrophobic parts of the phytochemicals float in an electrolytic solution and avoid its contact with a metallic surface (Verma, *et al.*, 2018). This study seeks to investigate the presence of these phytochemicals in the leaf extracts of *Ziziphus mauritiana.*

2.0 MATERIALS AND METHODS

2.1. Materials and Equipment

Fresh leaves of Z*iziphus mauritiana* plant were collected from around University of Maiduguri campus. Commercial grade ethanol was purchased from a local store in Maiduguri metropolis. The equipment used include sieve, beakers, test tube, funnels, sensitive digital scale (with precision of 0.01g), grinder, measuring cylinder (100ml and 10ml), filtration equipment, and evaporator machine.

2.2 Methods

2.2.1 Preparation of the leaves sample

The freshly collected leaves of *Ziziphus mauritiana* were cleansed by washing them with water to remove any dust or debris. Subsequently, the leaves were chopped into smaller fragments and left to undergo a drying process for a duration of six days, resulting in a significant reduction of moisture content by 91%. Once dried, the leaves were finely ground into a powder to facilitate the extraction process.

2.2.2 Extraction

850g of the powdered leaves was weighed and placed into a thimble. The thimble was then inserted into the extraction chamber of a maceration extractor. A volume of 20000ml of ethanol was carefully measured using a measuring cylinder and poured into the extraction chamber, allowing the constituents to extract over a period of two days. After the two-day extraction period, the samples were filtered, and the resulting filtrates underwent distillation using appropriate distillation equipment to remove the ethanol from the samples.

2.3. Phytochemical Screening Method

Phytochemical screenings are preliminary tests conducted to detect the presence of both primary and secondary metabolites in an extract. Phytochemical analysis of the extracts was done at Pharmacognosy Laboratory, Faculty of Pharmacy, University of Maiduguri. The qualitative analyses described below have been used to detect the presence of alkaloids, glycosides, flavonoids, tannins, saponins, flavones, sterols, and cardiac glycosides following the standard procedures as used by Usman, *et al.* (2010), Yadav, *et al.* (2010) and Gul, *et al.* (2017).

2.4.1 Test for Tannins

10 ml of bromine water was added to the 0.5 g aqueous extract. Few drops of 1% ferric chloride solution was then added. Occurrence of a blue-black, green or blue-green precipitate will show the presence of tannins.

2.4.2 Test for Cardiac glycosides

0.5 g aqueous extract was dissolved in 2ml of chloroform tetraoxosulphate (iv) acid to form a lower layer. Appearance of a reddish- brown colour or yellow at the interface will be an indication for the presence of a steroidal ring (i.e., aglycone portion of cardiac glycoside) or methylated sterols

2.4.3 Test for Saponins

The extract, weighing one gram, was boiled with 5ml of distilled water. The resulting mixture was then filtered, and the filtrate was divided into two equal portions. In the first portion, approximately 3ml of distilled water was added, followed by shaking for approximately 5 minutes. The presence of persistent frothing upon warming is considered as evidence for the presence of saponin. In the second portion, 2.5ml of a mixture consisting of equal volumes of Fehling's solution A and B was added. The appearance of a brick-red precipitate indicates the presence of saponin.

2.4.4 Test for Flavonoids

The extract was boiled with distilled water and then filtered. To 2ml of the filtrate and few drops of 10% ferric chloride solution was then be added. A green-blue or violet colouration will be indicated the presence of flavonoid.

2.4.5 Test for alkaloids

Mayer’s test: Crude extract was mixed with Mayer’s reagent (potassium mercuric iodide solution). The cream colour precipitate was formed, indicating the presence of alkaloids.

Dragondroff’s test: Crude extract was mixed with Dragondroff’s reagent (potassium bismuth iodide solution). The reddish-brown precipitate suggests the presence of alkaloids.

2.4.6 Test for Anthraquinones

10 ml of benzene was added to 6 g of the Ephedra powder sample in a conical flask and soaked for 10 minutes and then filtered. Further, 10 ml of 10% ammonia solution was added to the filtrate and shaken vigorously for 30 seconds. The presence of pink, violet or red colour indicates the presence of anthraquinones in the ammonia phas

3.0 RESULTS AND DISCUSSION

Figure 1 presents the experimental procedure and the extraction of the leaf extracts.

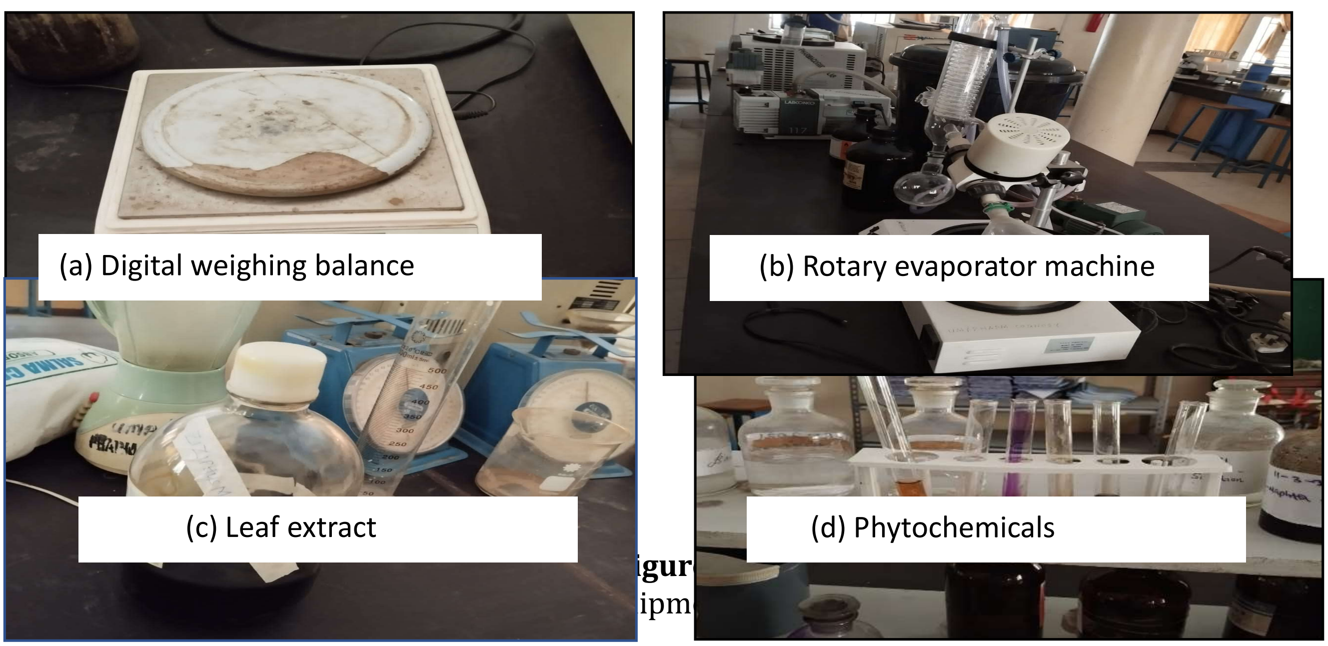

Table 1 presents the results of the phytochemical analysis of the leaf extracts of *Ziziphus mauritiana*. The results of the experiment revealed the presence of several compounds, including glycosides, anthraquinone, cardiac glucosides, flavonoids, alkaloids, and saponins. However, the absence of tannin was observed. These findings have significant positive implications for the inhibition potential of *Ziziphus mauritiana* leaves as a corrosion inhibitor.

Table 1: phytochemical analysis of leaf extracts of *Ziziphus mauritiana*

S/N	Phytoconstituents	Test	Results
1	Anthraguinone	Borntraser test	+
2	Cardiac glucosides	Keller killiani test	+
		Salkowski test	+
		Legal's test	+
3	Flavonoids	Shinoda's test	+
		Sodium hydroxide test	+
4	Tannins	Braymer's test	-
5	Alkaloids	Wagner's test	+
		Meyer's test	+
		Dragendoff's test	+
6	Saponins	frothing test	+
		Steroid test	+

Glycosides are a class of compounds known for their various biological activities and potential inhibitory effects. They have been reported to possess antioxidant properties, which can help in mitigating the oxidative processes that contribute to metal corrosion. Anthraquinones, another identified compound, have demonstrated promising antimicrobial and antioxidant properties, which may aid in inhibiting the corrosive processes. Cardiac glucosides, commonly found in plant species, possess diverse biological activities, including potential anticorrosion properties. These compounds have been associated with inhibitory effects on metal corrosion due to their ability to scavenge free radicals and reduce oxidative stress (Dohare, *et al.*, 2017).

Flavonoids, well-known plant compounds, exhibit a wide range of biological activities, including antioxidant and metal chelating properties. These characteristics make them valuable in inhibiting metal corrosion by preventing the initiation and propagation of corrosive reactions. Alkaloids, a diverse group of compounds, have shown potential as corrosion inhibitors due to their ability to form protective films on metal surfaces, thereby reducing the likelihood of corrosion (Uwah, *et al.*, 2013; Gholamhosseinzadeh, *et al.,* 2019).

Saponins, present in *Ziziphus mauritiana* leaves, possess surface-active properties and can form protective coatings on metal surfaces. This film formation impedes the access of corrosive agents to the metal, thus hindering the corrosion process (Uwah, *et al.*, 2013).

The absence of tannins, on the other hand, may not directly contribute to the inhibitory potential of *Ziziphus mauritiana* leaves in terms of metal corrosion. Tannins are known to possess antioxidant properties and can form complexes with metal ions, potentially inhibiting corrosion. However, the absence of tannins in *Ziziphus mauritiana* leaves does not necessarily diminish its overall inhibitory potential, as other identified compounds may compensate for this absence (Dohare, *et al.*, 2017).

Table 2 presents similar studies on the phytochemical analysis of extracts of some plants.

Table 2: Comparative Analysis of Phytochemical Contents of different Plant Extracts

Plant	Plant part	Phytochemical present	Steel used; corrosive media	Inhibition efficiency (%)	Reference
Coconut	Coir dust	Saponins Flavonoids Tannins Phlobatannins Polyphenols	Mild steel 0.5M H_2SO_4	85	(Umoren, *et al.*, 2014)
Nauclea Latifolia	Leaves	Anthraquinones Flavonoids Tannins Alkaloids	Mild steel 1.0M H_2SO_4	91	(Uwah, *et al.*, 2013)
Sida acuta	Leaves	Saponins Flavonoids Tannins Alkaloids Anthraquinones	Mild steel 0.5 M H_2SO_4	85	(Umoren, *et al.*, 2016)
Hemidesmus indicus	Leaves	Alkaloids Flavonoids Tannins Carbohydrate Glycosides Proteins	Mild steel H_2SO_4	96	(Patel & Snita, 2014)
Calotropis gigantiea	Stem	Alkaloids Glycosides Tannins Saponins	Carbon steel 0.5M H_2SO_4	90	(Gobara, *et al.*, 2015)
Acacia senegalensis	Leaves	Alkaloids Flavonoids Tannins Saponins Carbohydrate Proteins	Aluminium alloy 0.5M H_2SO_4	92	(Suleiman, *et al.*, 2018)
Fenugreek	Seed	Flavonoids Alkaloids terpenoids Phenolic Proteins	Copper, nickel 0.5M H_2SO_4	85 for Cu, 83 for NI	(Srivastava, *et al.*, 2010)
Gongronema Latifolium	Leaves	Tannins Saponins Alkaloids Carotenoids	Mild steel 5.0 M H_2SO_4	94	(Eddy & Ebenso, 2010)

		Steroids Anthrocyaninin			
Ziziphus mauritiana	Leaves	Glycosides Anthraguinone, Cardiac glucosides Flavonoid Alkaloid Saponin	-	-	Present study

From Table 2 several plant extracts, including the leaf extracts of *Sida acuta*, *Hemidesmus indicus*, and *Gongronema Latifolium*, have been found to contain similar phytochemicals as *Ziziphus mauritiana*. The inhibition efficiency of these extracts has been previously reported to be 85%, 94%, and 96%, respectively in H_2SO_4 media. Based on this information, it is reasonable to expect that *Ziziphus mauritiana*, which also possesses similar phytochemicals, may exhibit comparable or potentially higher inhibition efficiency against corrosion.
However, it is important to note that the inhibition efficiency of *Ziziphus mauritiana* as a corrosion inhibitor would require experimental validation. Conducting specific corrosion inhibition studies using *Ziziphus mauritiana* extracts in relevant corrosive environments would provide empirical evidence to support and quantify its inhibition potential.

4.0 CONCLUSION AND RECOMMENDATIONS

This study investigates the phytochemical properties of leaf extracts of *Ziziphus mauritiana.* From the results, the following conclusions are drawn:

i. Extract from the leaves of *Ziziphus mauritiana* was successfully produced.
ii. The leaf extracts of *Ziziphus mauritiana* contains a diverse range of phytochemicals, including glycosides, anthraquinone, cardiac glucosides, flavonoids, alkaloids, and saponins. These compounds are known for their potential inhibitory effects and are commonly found in other plant extracts with reported inhibition efficiencies against corrosion.
iii. The presence of these phytochemicals in the leaf extracts of *Ziziphus mauritiana* suggests its potential as a corrosion inhibitor. The identified compounds possess properties such as antioxidant activity, film formation, metal chelation, and surface protection, which are associated with inhibiting the corrosion process. This indicates that *Ziziphus mauritiana* may have the ability to mitigate metal corrosion effectively.

While the presence of phytochemicals in leaf extracts *Ziziphus mauritiana* supports its potential as a corrosion inhibitor, it is important to conduct specific corrosion inhibition studies to empirically validate its efficacy. Therefore, the study recommends that experimental investigations involving *Ziziphus mauritiana* extracts in relevant corrosive environments should be carried out to enable more accurate assessment of its efficiency compared to other plant extracts.

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