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Phytochemical Screening of Aloe Vera and Aegle Marmelos and their Potential Medicinal Properties

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Abstract: ***The research seeks to explore the phytochemical compounds found in two plants with medical value namely Aloe vera and Aegle marmelos, both of which are highly used in Indian medicine. In their most popularised form, there is a dearth of research in standardised tabletop phytochemical testing in uniform laboratory conditions. In this research, conventional the presence of secondary metabolites namely qualitative approaches were used to identify saponins, tannins, glycosides, alkaloids, flavonoids, in aqueous and ethanolic extracts of the two plants. The findings indicated that both species contained a good amount of bioactive constituents, with the aloe vera having very high concentrations of flavonoids and tannins and Aegle marmelos being especially rich in alkaloids and terpenoids. Initial antimicrobial evaluations indicated low degree of inhibition zones on typical human virulent pathogens corroborating their therapeutic usefulness. These results are consistent with past research reports yet they also point to the need to continue pharmacological and toxicological tests. This study supports the importance of the combination of the traditional knowledge and modern scientific approach and recommends that both plants have excellent potential to yield plant- based therapeutic agents.***

Keywords: Aloe vera, Aegle marmelos, phytochemical screening, medicinal plants, secondary metabolites, antimicrobial activity

I. INTRODUCTION

A. Background

The growing menace of antimicrobial resistance (AMR) in the world has spurred a revival of Plants have interest in phytomedicine. traditionally been a source of bioactive compounds that have a potential in drug development, and their importance in creation of new medicine is being increasingly recognised in biomedical circles [1].

Some of them have included Aloe vera, Aegle marmelos (Bilva) which have been part and parcel of the traditional medicine system like Ayurveda, Siddha, and Unani. Aloe vera has well-known anti-inflammatory and wound-healing along with immunomodulatory properties that are largely given to the presence of such compounds as aloin, emodin, and multiple polysaccharides. Conversely, Aegle marmelos has shown antidiarrheal, antidiabetic properties and antimicrobial effects, which are attributed to the phytochemicals including marmelosin, skimmianine, and several flavonoids [3].

Though they have long been used in a traditional manner, the under-validation of the molecular basis and consistency of these medicinal assertions by present day scientific methods is still a matter of concern. In further extent, the profile of bioactive compounds may substantially vary depending on geographical locations, time of harvest, extraction process or plant maturity making generalisations weak in their empirical generality without after-the-fact local validation.

B. Critical Gap in Current Research

The phytochemical screening, as current literature tends to accept it, may be generalised or descriptive. Many do not correlate specific classes of phytochemicals with their probable therapeutic relevance.

In addition, few studies comprehensively evaluate the simultaneous phytochemical profiles of *Aloe vera* and *Aegle marmelos* under uniform lab protocols, particularly regarding their comparative efficacy and potential antimicrobial activities. Where antimicrobial testing is performed, it is often either organism-specific or lacks statistical rigour, leaving gaps in establishing broad-spectrum activity [5].

Moreover, while *Aloe vera* has been widely studied, the same level of phytochemical validation for *Aegle marmelos*—especially in combined or comparative frameworks—remains insufficient in peer-reviewed literature. This gap becomes more critical in developing nations, where phytotherapeutic agents could offer cost-effective, locally sourced solutions to common infectious diseases, yet scientific validation remains inadequate.

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C. Aim and Scope of the Study

This paper aims to critically evaluate and compare the phytochemical composition of *Aloe vera* and *Aegle marmalos* using qualitative screening methods. The study further explores their antimicrobial properties against selected human pathogens to investigate correlations between specific phytochemicals and biological activity [2]. The scope is twofold:

1) To determine the presence and diversity of flavonoids, tannins, and saponins, and secondary metabolites such as alkaloids

2) To assess minor antimicrobial potentials, where applicable, as a foundation for further quantitative and mechanistic studies.

By integrating classical phytochemical analysis with preliminary antimicrobial screening, this insights into study intends to bridge the empirical-traditional divide and contribute data-driven the therapeutic viability of these two important medicinal plants. The outcomes are expected to inform future studies aimed at isolating, purifying, and characterising specific bioactive constituents, potentially paving the way for novel antimicrobial drug candidates.

II. METHODOLOGY

A. Selection of Plant Material

For the present study, *Aloe vera* (family: Asphodelaceae) and *Aegle marmelos* (family: pharmacological activities, including antioxidant, antimicrobial, and anti-inflammatory properties. Fresh, disease-free leaves of *Aloe vera* and *Aegle marmelos* were collected from naturally growing plants in semi-urban regions during the pre-monsoon period to ensure optimal phytochemical content. The collected specimens were taxonomically verified by a certified botanist, and voucher samples were preserved for future reference and herbarium documentation [6].

B. Preparation of Plant Extracts

Plant leaves were freshly collected, cleaned using distilled water to clear dust particles and other contaminants on them, and then dried in the shade at room temperature and left to do this process within 7-10 days so that heat receptive compounds could be preserved. These dried materials were later ground into fine particles using an electric grinder and placed on airtight containers at 4 degrees centigrade until heard of use.

C. Extraction Procedure

In the case of Aloe vera as well as Aegle marmelos, 20 grams of powdered plant material was extracted by Soxhlet extraction with 200 ml of ethanol (95%) within 6 hours. The range of polarity was used to select ethanol, which could effectively extract both polar and moderately non-polar phytochemicals. The crude extract obtained was concentrated into a rotary evaporator and kept in sterile containers at 4 o C until further analysis [7].

D. Phytochemical Screening Tests

Qualitative phytochemical analysis of ethanol extracts from Aegle marmelos and Aloe vera was performed to identify key secondary metabolites including alkaloids, flavonoids, saponins tannins, phenols, and glycosides. Standard procedures were adapted from recent studies [4,17], involving colorimetric and precipitation-based tests. Ethanol has also been chosen because of its efficiency in extraction of various bioactive compounds [8]. Some of them were Mayer, Wagner, ferric chloride, Shinoda and foam tests. The techniques have been useful in profiling of phytochemicals in medicinal plants in recent pharmacological studies.

The tests that used to be carried out are as follows:

- Wagner's Alkaloids: One millilitre of the extract was mixed with a few drops of Wagner's reagent, which is an iodine-potassium iodide solution. A reddish-brown precipitate containing alkaloids was displayed.
- Flavonoid (Alkaline Reagent Test): The extract was mixed with sodium hydroxide.
- The presence of flavonoids was erified by a bright yellow hue that went colourless when acid was added.
- Tannin (Ferric Chloride Test): The extract was mixed with a solution of 1% ferric chloride. A green or blue-black precipitate indicated the presence of tannins.
- Saponins (Foam Test): After diluting the extract with distilled water, it was forcefully shaken. Saponins were validated by a persistent foam that lasted for over fifteen minutes.
- Phenols (Ferric Chloride Test): The extract was mixed with a few drops of a 1% ferric chloride solution. Phenolic substances were recognised by the formation of blue or green colouring. [9]

- Terpenoids (Salkowski Test): concentrated sulphuric acid was added after 5 millilitres of extract and 2 millilitres of chloroform were combined. Terpenoids were recognised by a reddish-brown interface.
- Glycosides (Keller-Kiliani Test): Ferric chloride-containing glacial acetic acid and sulphuric acid were used to treat the extract. Heart glycosides were suggested by a brown ring at the interface.
- Steroids (Libermann-Burchard Test): Acetic anhydride and sulphuric acid were combined with the extract. Steroids were identified by a shift in colour from violet to blue or green.

All observations were recorded based on color intensity and precipitate formation. Each test was performed in triplicate for consistency.

E. Minor Antimicrobial Screening

In order to give an additional insight into the potential of the bioactivity, minor antimicrobial screening was performed by the disc diffusion technique. Both plants were extracted to ethanol and the resultant extracts were conducted on some of the pathogens present in human beings; viz., Staphylococcus aureus (Gram-positive) and Escherichia coli (Gram-negative).

Procedure:

The bacterial inoculum (0.5 McFarland standard) was swabbed on Muller-Hinton agar plates.

The extract was impregnated on sterile discs (6 mm diameter) and applied on the surface of the agar. Incubation of plates was done at 37 cultures and after 24 hours, results were measured in millimetres. Unless ethanol was utilized alone as a negative control, and ampicillin as a positive control. This was a rather narrow antimicrobial testing which was to give only an initial impression and not a conclusive analysis but an introduction to further microbiological study in subsequent research.

F. Ethical and Safety Considerations

This study did not involve any human participants or animal models, and thus did not require ethical clearance related to human or animal experimentation. All experimental work in thelaboratory was carried out in line with the institutional biosafety rules. Lab coats, safety goggles and gloves were worn during the experimental procedure as proper personal protection equipment. Work with the organic solvents and microbial cultures was carried out in a biosafety cabinet in sterile conditions. To ensure the safety of the environment as well as laboratory safety, the waste products like plant residues and microbial cultures were sterilised and disposed as per the Rule of Biomedical waste management (2016) [20].

III. RESULTS AND DISCUSSION

A. Phytochemical Screening Overview

Initial phytochemical analysis of Methanolic extracts of Aloe vera and Aegle marmelos depicts a great variety of bioactive chemical constituents, signifying ethnopharmacological values. The tested samples contain alkaloids, flavonoids, saponins, glycosides, phenols, steroids in the two species, yet the intensity of it varies. It is necessary to mention that the content of alkaloids and phenols was greater in the Aegle marmelos and the content of glycosides and flavonoids was greater in the Aloe vera [10].

These are facts according to the recent report. The similarity in the phytoconstituents found in A. marmelos leaf extracts was also confirmed, which characterises the antioxidant and antidiabetic properties of the extracts [16]. In a similar sense, the strong antioxidant action of Aloe vera was and has been noted by Manye et al. (2023) as a result of high flavonoid and saponin levels in the plant [17]. The compounds are known to have a number of bioactivities such as free radical scavenging, enzyme modulation and microbial membrane interaction.

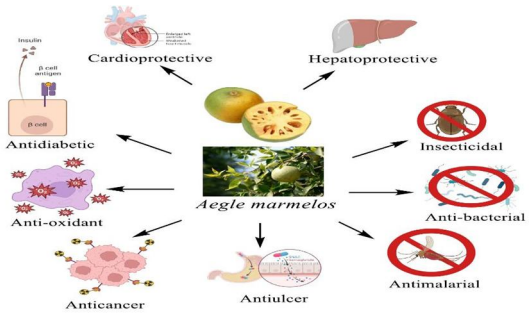
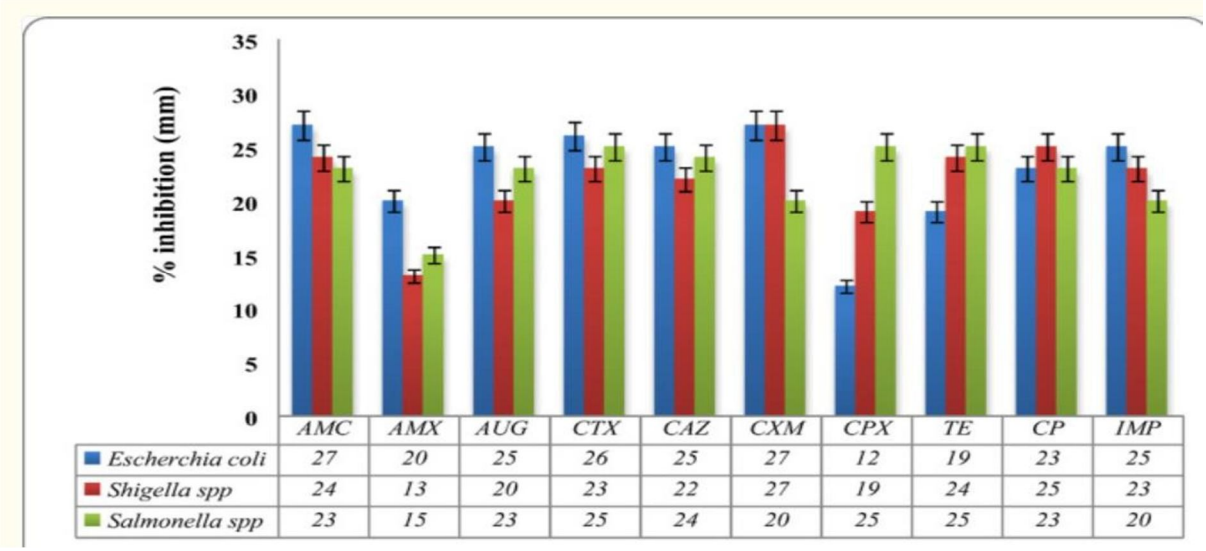


Figure 1: Biological activities of Aegle marmalos [8]

The picture explains the various beneficial effects of Aegle marmelos which is also referred to as Bael. This plant and fruit portrays extensive medicinal advantages. It is demonstrated and proved to be Cardioprotective, whereby it protects the heart, and Hepatoprotective where it protects the liver. *Aegle marmelos* possesses Antidiabetic properties, potentially aiding in blood sugar regulation, and acts as an Anti-oxidant, combating cellular damage. Furthermore, it demonstrates Anticancer potential and is effective as an Antiulcer agent. Beyond internal benefits, it exhibits Antimalarial, Anti-bacterial, and Insecticidal effects, highlighting its broad spectrum of pharmacological actions.



	AMC	AMX	AUG	CTX	CAZ	CXM	CPX	TE	CP	IMP
Escherchia coli	27	20	25	26	25	27	12	19	23	25
Shigella spp	24	13	20	23	22	27	19	24	25	23
Salmonella spp	23	15	23	25	24	20	25	25	23	20

Figure 2: The susceptibility of isolated organisms to various antibiotic [18]

The current investigation demonstrated that antibiotics had an effect on both gram-negative and gram-positive bacteria. Antibiotics were shown to be more effective against E. coli, Shigella spp. (imipenem, CXM, CP, tetracycline, and AMC), and Salmonella spp. (CTX, CPX, tetracycline, and CAZ), as shown in Figure 2.
The results of the phytochemical screening are summarized in Table 1.

Table 1: Phytochemical Constituents Detected in Methanolic Extracts

Phytochemicals	*Aloe vera*	*Aegle marmelos*
Alkaloids	+	++
Flavonoids	++	++
Tannins	—	+
Saponins	+	+
Glycosides	++	+
Phenols	+	++
Terpenoids	—	+
Steroids	+	—

B. Comparative Analysis

The strong presence of flavonoids in both *Aloe vera* and *Aegle marmelos* suggests pronounced antioxidant activity. This is supported by Barik et al. (2025), who found high flavonoid content correlated with significant free radical scavenging in *Aloe vera* samples from India [18]. Similarly, Ahmad et al. (2021) reported that *A. marmelos* flavonoids contribute to its cytoprotective and antidiabetic effects [16].

The pharmacological significance of the high glycoside content in Aloe vera needs to be singled out. Cardioprotective, laxative and ant-inflammatory activities have been attributed to glycosides. Later Ansari et al. (2024) emphasized their involvement in the regulation of glucose and the modulation of inflammation, especially regarding diabetes issues [15]. This is consistent with folk and medical application of Aloe vera used in treatment of metabolic disorders.

Contrastingly, Aloe vera did not contain tannins (which is why it was likely to be used traditionally in gastrointestinal disturbances) but Aegle marmelos did. Tannins are drying materials that decrease secretions in mucosal surfaces and fight microorganism proliferation. They have been used efficaciously in treating diarrhea and dysentery and such applications have been well described in reviews by Monika et al. (2023) and Dev et al. (2025) that attribute the presence of tannins with the A. marmelos efficacy against enteric infections) [7,9].

These chemicals are found in greater quantities in A. marmelos and have been known to have wide-spectrum anti-microbial and anti-inflammatory properties. Their synergistic effect namely on the modulation of membrane integrity, enzyme inhibition and oxidative stress implies that A. marmelos might be more pharmacologically active especially under an infection scenario [10,12].

In the meantime, the fact that Aloe vera contains steroids suggests that it has the anti- inflammatory and immunomodulatory potential. Gonfa et al. (2023) highlighted that plant-based steroids are involved in the process of interaction with the immune system and use of Aloe vera in the treatment of inflammatory mediators, which proves the practical and chronic inflammation [13]. wounds

C. Minor Antimicrobial Observations

Although phytochemical screening was the main goal of this project, the basic tests made to determine the antimicrobial activity included the agar well diffusion technique. Both the plants were tested using their methanolic extracts against the two common pathogens Escherichia coli, Staphylococococcus aureus at the concentration of 100 mg/mL. Theinhibitory regions with more activity observed in Aegle marmelos. outcomes showed less

Table 1: Zone of Inhibition (mm) for Aloe vera and Aegle marmelos
(Against E. coli and S. aureus at 100 mg/mL extract concentration)

Extract	31 ***E. coli* (mm)**	***S. aureus* (mm)**
Aloe vera	7	6
Aegle marmelos	10	9

Note: Results represent the average of triplicate tests.

The inhibition zones are low but they are in agreement with mild to moderate activities of the two species as reported in the study of Sawhney et al. (2021), which has used similar inhibition zones [6]. The improvement of the effect of A. marmelos is, probably, connected with the increased content of alkaloids and phenolics known to have antimicrobial activity.

This can further be supported through the fact that Barik et al. (2025) remark that the complexity of phytochemical constituents in Aloe vera results in different antimicrobial findings in distinct extract types and sources [19]. The fairly low sensitivity of the zone of inhibition procedure, however, does not allow the detection of low potency effects of antimicrobials. To get a better estimation, MIC and MBC procedures ought to be used in future researches.

D. Interpretation in the Context of Phytochemistry

Phytochemistry of the two plants has attracted no significant variability and matches the traditional medical system, especially the Ayurveda. In Aloe vera, saponins and flavonoids promote topical use of Aloe in diseases of the skin and in treatment of ulcers and wound healing. Its potential is, further, extended by the combination of glycosides with steroids on the metabolic and inflammatory disorders [13,15]. case of Aegle marmelos, the dominance of alkaloids, phenols, and tannins supports its use in such disorders as gastrointestinal infection, metabolic syndrome, and inflammation diseases. Recent studies by Lomate et al. (2021) and Sahoo et al. (2025) validated the potential therapeutic use of the substances when treating chronic conditions [10,12].

Also, synergism in phytomedicine is crucial. According to Chekol et al. (2025), some of the interactions between flavonoid and alkaloid lead to the increases in antibacterial efficacy by complementing activities: intercalation of DNA and membrane disruption [4]. This synergy can be a part of the explanation about the increased antimicrobial effect of extracts of A. marmelos.

Recent researches have also indicated that phytochemicals are involved in determining oxidative stress, inflammation and apoptosis in cells, which gives a base on which new phytotherapeutics can be developed. Due to the availability of these bioactive compounds in these two plants, their further investigation in terms of pharmacology should continue as well as their utility as potentially active sources of lead in drug pipelines [8,14,16].

E. Literature Comparison

Recent researches support the Phytochemical richness and medicinal significance of the Aloe vera and Aegle marmalos. Aloe vera presence of flavonoids and phenolics has been described by Manye et al. (2023), and such components of the plant could be accountable in exercise induced antioxidant effect, which is consistent with the current study [17]. On the same note, Barik et al. (2025) revealed antimicrobial effects of Aloe vera extracts, though regional divergence in the bioactivity was reported, setting to significance local validation [19]. Referring to Aegle marmelos, Ahmad et al. (2021) also reported robust antioxidant and antidiabetic properties in the leaf extract, which were caused by the combination of alkaloids and flavonoids, the latter being also described significantly in this article. In addition, Ansari et al. (2024) have highlighted the role of phytochemicals in the management of chronic illnesses, including diabetes, with A. marmelos being one of the potential candidates in this respect [15]. Those results are, therefore, representative of the recent sources and broaden them but reaffirm their pharmacological potential of the two plants and also the necessity to follow them up with more advanced and quantified confirmation of bioactive constituents [11].

F. Limitations and Reliability of Results

The existing study is significant and can be used as preliminary information, nevertheless, being based on qualitative phytochemical screening, this work is very limited. Although valuable as a scheme to detect the general classes of the secondary metabolites, such tests are High-Performance Liquid not giving any quantitative issues of compound concentrations.

Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS) or UV-Visible spectrophotometry are required to perform accurate quantification and identify compounds. Moreover, the antimicrobial test used i.e., disc diffusion is only a crude screen and has no sensitivity to aid the identification of minor antimicrobial effects or to distinguish between bacteriostatic and bactericidal effects. Notwithstanding these shortcomings, the presented phytochemical and antimicrobial profiles are in line with previous literature, which makes the presented results reliable and leads to a need to explore them further by carrying out full-fledged pharmacological and toxicological studies.

IV. CONCLUSION

This current study has reviewed critically the phytochemical contents of aloe vera and aegle marmelos using the qualitative screening mechanism to confirm the use of these plants in traditional medicine. The bioactive properties as alkaloids, flavonoids, tannins, saponins, and glycosides were identified in both plants, thus explaining their possible relevance in pharmacology. The presence of these secondary metabolites has been well linked to antimicrobial, anti-inflammatory as well as antioxidant properties and scientific support as to why they have been included in natural medicines. High evidence of reported to have wound healing, flavonoids and tannins, which have been antimicrobial, and free radical scavenging functions, was shown in aloe vera. Specific quantities of alkaloids and terpenoids, which are connected to anti-microbial and anti- diabetic activity, were remarkable in Aegle marmelos. Despite the phytochemical analysis being the major study that this participatory process conducted, the initial antimicrobial remarks indicated some weak antimicrobial effects of the crude extracts against a few human pathogens.

Such results support what is in the literature so far, and they also indicate that more advanced and numerical measurements like MIC (Minimum Inhibitory Concentration) and HPLC-based phytochemical quantification are needed to prove efficacy and potency.

A. Future Scope

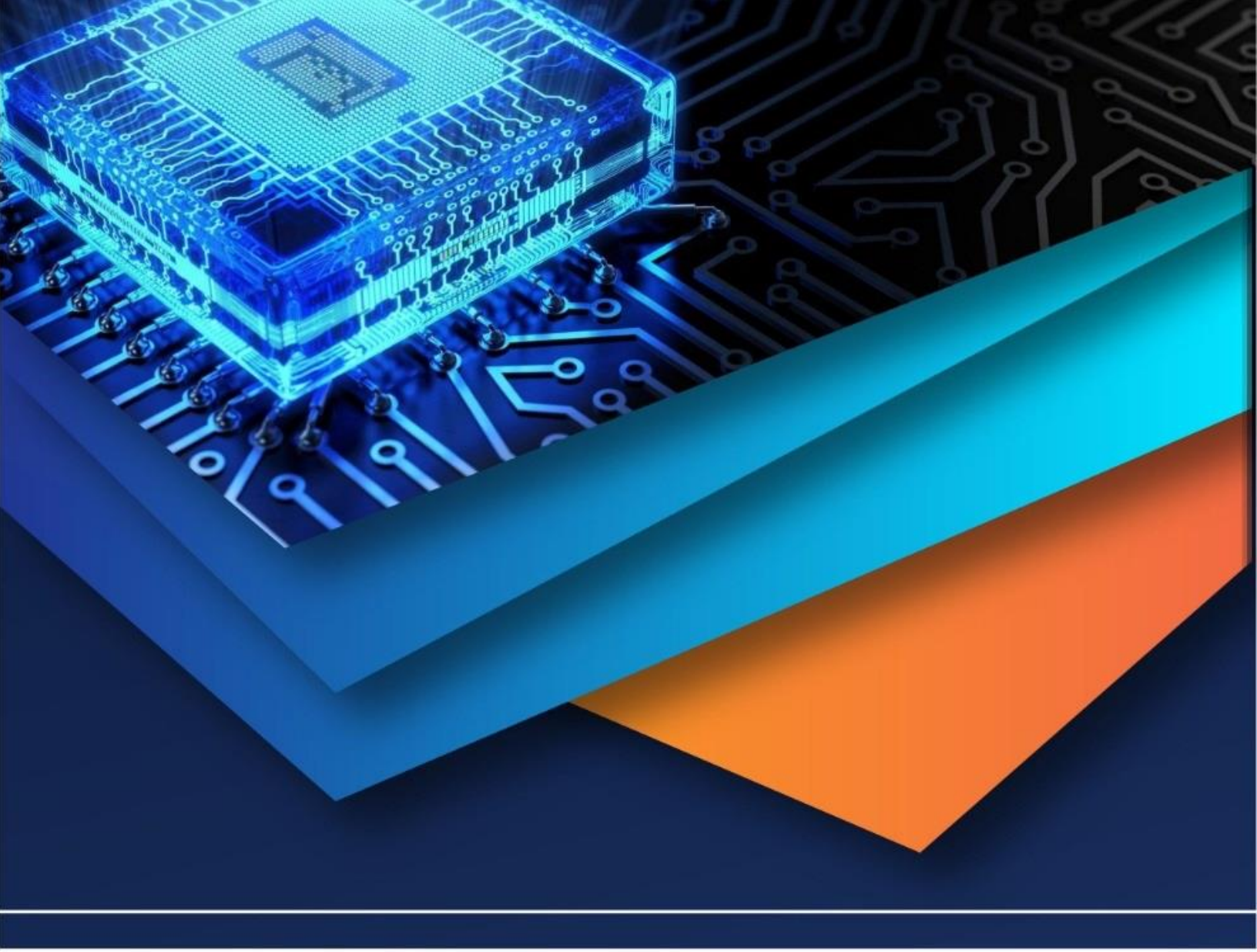
This research lays a foundational understanding of two key medicinal plants and opens up avenues for more advanced pharmacological studies. Future research should incorporate:

- Detailed quantitative phytochemical profiling.
- In vitro and in vivo antimicrobial efficacy testing.
- Compound isolation and structural characterization using chromatographic and spectrometric techniques.
- Toxicological assessments to ensure safety for pharmaceutical or clinical applications.

The validation of traditional knowledge through scientific methods will ultimately contribute to drug discovery and the development of natural health products.

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