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Antimicrobial Effects of *Aloe vera*, *Psidium guajava* and *Hibiscus sabdariffa* Extracts on Selected Pathogens

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Plant materials are repositories of bioactive compound of medicinal values. Traditional medicines relies on the therapeutic potential of herbal plants. This study aimed to assess the antimicrobial effects of *Aloe vera*, *Psidium guajava* and *Hibiscus sabdariffa* extracts on *Salmonella typhi*, *Staphylococcus aureus* and *Escherichia coli* and *Candida albicans*. Plant extracts were obtained by soxhlet extraction, using ethanol as solvent. Extracts were qualitatively screened for the presence of alkaloid, saponins, flavonoid and tannins. Saponins and flavonoids were detected in all plant extracts; alkaloid in *P. guajava* and *H. sabdariffa* extracts, and tannins in *A. vera* and *P. guajava* extracts. The concentrations of the residual plant extracts was 2.0 mg/ml for *A. vera*, 2.1 mg/ml for P. *Guajava* and 1.83 mg/ml for *H. sabdariffa*. *Staphylococcus aureus* was only susceptible to *A.*

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vera. *Salmonella typhi* was not sensitive to all extract. *Escherichia coli* was sensitive to all extracts in the order *H. sabdariffa*>*P. guajava*>*A. vera*. *Candida albicans* was sensitive to *A. vera* and *P. guajava* extracts. The MIC of *A. vera* was 2.0 mg/ml for *S. aureus, E. coli* and *C. albicans* respectively. The MIC of *P. guajava* was 0.021 mg/ml and 2.1 mg/ml for *E. coli* and *C. albicans* respectively. The MIC of *H. sabdariffa* was 1.83 mg/ml for *E. coli*. The results show that *A. vera*, *H. sabdariffa* and *P. guajava* extracts contain phytochemicals with inhibitory potencies against *S. aureus, E. coli* and *C. albicans*. These plant material may prove useful as natural remedies for managing infections caused by susceptible microorganisms.

Keywords: Aloe vera; antimicrobial; Hibiscus sabdariffa; pathogens; Psidium guajava.

1. INTRODUCTION

Plant-based materials offer several potential benefits that can complement the use of synthetic drugs in the management of infectious diseases [1-3]. This has become very important in the face of the growing challenge of antibiotic resistance. Plants have evolved a vast array of secondary metabolites, many of which exhibit antimicrobial properties against a wide range of pathogens, including bacteria, fungi, and viruses. These natural compounds commonly referred to as phytochemicals include compounds such as glycosides, tannins, saponins, terpenoids, alkaloids, phenolics, terpenes, anthraquinones, salicylic acid, lupeol and flavonoids, which have been severally reported to interfere with several cellular mechanisms in microorganisms [4-6].

The clamour for the use of natural compounds with antimicrobial properties has been because of the issue of antimicrobial resistance [4]. It has been inferred that the complex and often synergistic interactions between the various bioactive compounds found in plant extracts make it more challenging for pathogens to develop resistance, as they would need to overcome multiple defence mechanisms simultaneously [7-9]. Again, plant materials can be used at lower doses of individual compounds, which is a useful consideration in drug safety [10].

Aloe vera is a succulent plant that has been used for a long time in traditional medicine due to its various therapeutic properties, believed to suitable for hastening wound healing, treating anti-inflammatory, arthritis, diabetes sunburns, eczema, inflammatory bowel diseases and psoriasis ulcers, diverse other therapeutic applications [11-13]. *Psidium guajava*, commonly known as guava, is a tropical fruit tree that has been used in traditional medicine for various health benefits. This versatile medicinal plant is rich in diverse bioactive compounds accountable for their pharmacological activities in the treatment of diarrhea, wounds, arthritis, cardiovascular diseases, diabetes and neurodegenerative disorders [14,15]. *Hibiscus sabdariffa*, also known as sour tea, is used for blood pressure control, to relieve constipation and stomach discomfort, lower cholesterol and serves as good source for antioxidants [16,17].

The utilization of plant material in traditional medicine in Nigeria has made treatment of common ailments possible for the poor and many persons in rural areas, who have no access to finance or orthodox medicine [7,18,19]. Herbal medicine will continue to make great contributions to the healthcare of Nigerians. Therefore, it is important to verify the purported therapeutic values of common medicinal plants which form components of herbal remedies sold in Nigeria. The exploration of natural antibiotics derived from plant materials has become an increasingly important area of research today, as it has the potential to contribute to more effective and sustainable approaches to infection management.

This study aimed to assess the antimicrobial effects of *Aloe vera*, *Psidium guajava* and *Hibiscus sabdariffa* extracts on *Salmonella typhi*, *Staphylococcus aureus* and *Escherichia coli* and *Candida albicans*.

2. MATERIALS AND METHODS

2.1 Samples Collection

Fresh leaves of *Aloe vera* stem, *Psidium guajava* and *Hibiscus sabdariffa* were obtained from gardens within delta State University, Abraka Campus II. Leaves were packed in zipper lock bags and taken to the laboratory for processing.

Bacterial pathogens, *Salmonella typhi*, *Staphylococcus aureus* and *Escherichia coli*, and fungal pathogen, *Candida albicans* were obtained from the Eku General hospital, Delta State. The isolates were collected in sterile McCartney bottles and transported in ice box to the laboratory.

2.2 Extraction of Phytochemicals

The collected plant leaves were washed with distilled water, after carefully separating them from the stalk. *P. guajava* and *H. sabdariffa* were dried in a hot air oven for 15 minutes at 40°C, while *Aloe vera* was dried at 67ºC for 3 days. After drying, the leaves were ground to fine powder using SCD-P2030D industrial blender.

Extraction was done using soxhlet extractor to which fifty grams (50 g) of powdered leaves was added to 200ml ethanol, and allowed to drain into a clean conical flask. Extract was condensed in a rotatory extractor for 10 minutes, to get rid of the ethanol. 10ml of each extract was pipetted into a weight watch glass and evaporated to dryness in a hot water bath until a constant weight was achieved. Dried extracts were enclosed with aluminium foil and stored in a desiccator for 7 days. Extracts were screened for the presence of saponins, tannins, flavonoids and alkaloid, glycosides and phenol as per the procedures highlighted by Shah et al. [20].

2.3 Determination of Minimum Inhibitory Concentration (MIC)

The plant extracts were diluted to obtain the following concentrations: 1:10, 1:100, 1:1000, 1:10,000 and 1:100,000. I ml of each dilution was added to 10ml of molten nutrient agar for bacteria and potato dextrose agar for fungi, and then allowed to solidify. Each test isolate was streaked on the surface of the plates and incubated at 37ºC for 24 hours. The least concentration of extract that inhibited microbial growth, was taken as the MBC.

2.4 Susceptibility Test

Serial dilution of each extract was performed to obtain1:2, 1:3 and 1:4, which were then used to impregnate sterile paper discs. The discs were allowed to soak in the extract for 20 minutes. Sterile swab sticks were used to prepare lawns of test isolates on Muller Hinton Agar plates. Prepared discs were placed on the plates, 2 cm apart, and the plates were then incubated at 37ºC for 24 hours. Sensitivity of test organisms was determined by the zone of inhibition.

3. RESULTS

3.1 Phytochemicals

Table 1 shows the phytochemical profile of the plants extracts. *Aloe vera* contains saponins, flavonoids and tannins; *P. guajava* contains saponins, alkaloids, flavonoids and tannins, while *H. sabdariffa* contains saponins, alkaloids and flavonoids.

Table 2 shows the concentrations of plant extracts after evaporation, which was 2.0 mg/ml for *A. vera* was, 2.1 mg/ml for *P. guajava* and 1.83 mg/ml for *H. sabdariffa*.

3.2 Sensitivity of the Test Organisms

Table 3 shows the sensitivity pattern of the test organisms to the ethanol extracts of *A. vera, P. guajava* and *H. sabdariffa. Staphylococcus aureus* was only susceptible to *A. vera*. *Salmonella typhi* was not sensitive to all extract. *Escherichia coli* was sensitive to all extracts in the order *H. sabdariffa>P. guajava>A. vera*. *Candida albicans* was sensitive to *A. vera* and *P. guajava* extracts.

3.3 Minimum Inhibitory Concentration of Extracts

Table 4 shows the MIC of *A. vera, P. guajava* and *H. sabdariffa* extracts against test organisms. The MIC of *A. vera* was 2.0 mg/ml for *S. aureus, E. coli* and *C. albicans* respectively. The MIC of *P. guajava* was 0.021 mg/ml and 2.1 mg/ml for *E. coli* and *C. albicans* respectively. The MIC of *H. sabdariffa* was 1.83 mg/ml for *E. coli*.

Table 1. Phytochemicals detected in the plants extracts

Plant	Saponins	Alkaloids	Flavonoids	Tannins
Aloe vera	+	-	+	+
Psidium guajava	+	+	+	+
Hibiscus sabdariffa	+	+	+	-

Keys: +=Present; –=Absent

Table 2. Concentration of plant extract

Samples	Concentration (mg/ml)
Aloe vera	2.00
Psidium guajava	2.10
Hibiscus sabdariffa	1.83

Table 3. Sensitivity test clinical isolates to extracts

Isolate	*A. vera*	*P. guajava*	*H. sabdariffa*
Staphylococcus aureus	++	-	-
Salmonella typhi	-	-	-
Escherichia coli	+	+++	++
Candida albicans	+	+	-

Keys: - = Not sensitive; +=Sensitive

Table 4. Minimum inhibitory concentration of extracts to clinical isolates

Isolate	*A. vera*	*P. guajava*	*H. sabdariffa*
Staphylococcus aureus	2.00	R	R
Salmonella typhi	R	R	R
Escherichia coli	2.00	0.021	1.83
Candida albicans	2.00	2.10	R

Key: R – Resistant

4. DISCUSSION

This study assesed the antimicrobial properties of three medicinal plants (*Aloe vera*, *Psidium Guajava* and *Hibiscus sabdariffa*). Medical plants have medicinal values due to the presence of chemical substances normally found on leaves, stems, fruits and seeds. Phytochemical screening of the plant extracts confirmed the presence of flavonoids, tannins, alkaloids and saponins. Plants are used in the treatment of diseases either alone or in combination depending on their phytochemical content [4-6,10]. *Aloe vera* contains saponins, flavonoids and tannins; *P. guajava* contains saponins, alkaloids, flavonoids and tannins, while *H. sabdariffa* contains saponins, alkaloids and flavonoids. This is consistent with reports on the phytochemical screening of these plants [4,12].

The results of the present investigation showed that the leaves of *A. vera*, *P. guajava* and *H. sabdariffa* inhibited some of the test organisms (*Staphylococcus aureus, Escherichia coli* and *Candida albicans*) but not *Salmonella typhi.* The antimicrobial activities of the extracts are attributable to the presence of flavonoids, alkaloids, tannins and saponins that were found on these leaves, which had been reported to inhibit pathogenic microorganisms [4,7,10].

Staphylococcus aureus was only susceptible to *A. vera*. Okaba et al. [4] similarly reported susceptibility of *S. aureus to A. vera. Salmonella typhi* was not sensitive to all extract. The findings of this study agree with Sule et al. [15] on resistance of *Salmonella* to ethanol extract of *P. guajava. Escherichia coli* was sensitive to all extracts in the order *H. sabdariffa>P. guajava>A. vera*. Okaba et al. [4], Lade et al. [21] and Biswas et al. [22] likewise reported sensitivity of *E. coli* to *A. vera*, *H. sabdariffa* and *P. guajava* respectively. *Candida albicans* was sensitive to *A. vera* and *P. guajava* extracts. Okaba et al. [4] similarly reported susceptibility of *C. albicans to A. vera*.

The MIC of *A. vera* was 2.0 mg/ml for *S. aureus, E. coli* and *C. albicans* respectively. The MIC of *P. guajava* was 0.021 mg/ml and 2.1 mg/ml for *E. coli* and *C. albicans* respectively. The MIC of *H. sabdariffa* was 1.83 mg/ml for *E. coli*. The MICs of the extract are much lower than 25.0 mg/ml reported by Okaba et al. [4] for *S. aureus, E. coli* and *C. albicans*.

Escherichia coli, Salmonella typhi, *Staphylococcus aureus* and *Candida albicans* are all significant human pathogens that have shown increasing resistance to various antibiotics, posing a significant challenge in clinical management and public health. Resistance has been reported against commonly used antibiotics, such as ampicillin, beta-lactams, carbapenems chloramphenicol, fluoroquinolones, trimethoprim-sulfamethoxazole, fluconazole, clotrimazole, ketoconazole, which have been previously effective treatments for infectious diseases caused by *Escherichia coli, Salmonella typhi*, *Staphylococcus aureus* and *Candida albicans* [23-25]. Susceptibility of these pathogens to plant extracts is encouraging.

5. CONCLUSION

The ethanol extracts of *Aloe vera, Psidium guajava* and *Hibiscus sabdariffa* were found to contain alkaloids, tannins, flavonoids and saponins. The extracts exhibited antimicrobial activity against *Staphylococcus aureus, Escherichia coli* and *Candida albicans*. New antimicrobial agents to combat infectious diseases caused by susceptible microorganisms can be developed using *Aloe vera, Psidium guajava* and *Hibiscus sabdariffa* extracts.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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