Vulnerability Analysis of Phyto Mix (Bitter Leaf, Utazi and Tumeric) on E. Coli and Staphylococcus Aureus.

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Abstract
*The study examined the vulnerability of a Phyto Mixture composed of bitter leaf (*Vernonia amygdalina*), Utazi (*Gongronema latifolium*), and turmeric (*Curcuma longa*) on* Escherichia coli *and* Staphylococcus aureus*. The increasing prevalence of antimicrobial resistance has necessitated the search for alternative therapeutic agents from medicinal plants, particularly in developing countries where herbal medicine is widely used. The study adopted a secondary data research design involving a systematic review of existing literature sourced from peer-reviewed journals, textbooks, and scientific databases. Findings from reviewed studies revealed that the individual plants contain bioactive compounds such as flavonoids, tannins, alkaloids, saponins, and curcuminoids, which contribute to their antimicrobial activities. The review further indicated that combined herbal formulations tend to exhibit stronger antibacterial effects due to synergistic interactions among phytochemicals. It was also observed that* Staphylococcus aureus *showed higher vulnerability to the Phyto Mixture compared to* Escherichia coli*, which demonstrated moderate resistance due to its Gram-negative cell wall structure. The study concluded that the Phyto Mixture possesses significant antimicrobial potential and may serve as a promising alternative or complementary therapy against bacterial infections. It recommends further laboratory-based experimental validation, toxicity assessment, and standardization of herbal formulations to ensure safety and efficacy. The study highlights the importance of medicinal plants in addressing antibiotic resistance and supports continued research into plant-based antimicrobial agents for public health improvement.*

Introduction

The emergence and rapid spread of antimicrobial resistance (AMR) have become one of the most significant public health challenges globally. Antibiotics that were once highly effective against bacterial infections are gradually losing their efficacy due to the development of resistant strains of microorganisms. According to the World Health Organization, antimicrobial resistance threatens the prevention and treatment of a growing range of infections caused by bacteria, parasites, viruses, and fungi, thereby increasing morbidity, mortality, and healthcare costs (WHO, 2023). The increasing prevalence of resistant bacterial pathogens has necessitated the search for alternative antimicrobial agents from natural sources, particularly medicinal plants.

Medicinal plants have been used for centuries in traditional healthcare systems across Africa, Asia, and other parts of the world. In Nigeria, herbal medicine remains a vital component of

healthcare delivery, especially in rural communities where access to modern healthcare facilities may be limited. The therapeutic potential of medicinal plants is attributed to the presence of bioactive compounds such as alkaloids, flavonoids, tannins, phenolics, glycosides, terpenoids, and saponins, which possess antimicrobial, anti-inflammatory, antioxidant, and immunomodulatory properties (Ekor, 2014).

Among the medicinal plants widely utilized in traditional medicine are bitter leaf (*Vernonia amygdalina*), Utazi (*Gongronema latifolium*), and turmeric (*Curcuma longa*). These plants have attracted considerable scientific attention because of their pharmacological activities and potential application in combating microbial infections.

Bitter leaf (*Vernonia amygdalina*) is a perennial shrub commonly found in tropical Africa. It is widely consumed as a vegetable and medicinal herb in Nigeria. Studies have demonstrated that bitter leaf contains significant amounts of flavonoids, sesquiterpene lactones, saponins, tannins, and phenolic compounds that exhibit antimicrobial activities against various pathogenic microorganisms (Farombi & Owoeye, 2011). Traditionally, bitter leaf has been used in the treatment of gastrointestinal disorders, malaria, fever, diabetes, and bacterial infections. Similarly, Utazi (*Gongronema latifolium*) is an important medicinal and culinary plant indigenous to West Africa. The leaves are commonly used as spices and herbal remedies for stomach discomfort, cough, hypertension, and microbial infections. Phytochemical investigations have revealed the presence of alkaloids, flavonoids, essential oils, and tannins that contribute to its antimicrobial effects (Morebise et al., 2002). Research findings suggest that extracts of *Gongronema latifolium* possess inhibitory activities against several pathogenic bacteria and fungi. Turmeric (*Curcuma longa*) is a rhizomatous herb belonging to the Zingiberaceae family. It contains curcuminoids, particularly curcumin, which is responsible for many of its biological properties. Curcumin has been reported to possess antimicrobial, antioxidant, anti-inflammatory, anticancer, and wound-healing activities (Hewlings & Kalman, 2017). The antimicrobial effect of turmeric has been demonstrated against both Gram-positive and Gram-negative bacteria, making it a promising candidate for alternative antimicrobial therapy. The use of Phyto Mixtures rather than single plant extracts is common in traditional medicine because combinations of medicinal plants may produce synergistic effects that enhance therapeutic efficacy. Synergism occurs when the combined action of different bioactive compounds produces a greater antimicrobial effect than individual components acting alone. Consequently, investigating the antimicrobial activity of combined extracts of bitter leaf, Utazi, and turmeric may provide valuable insights into the development of effective herbal formulations against pathogenic bacteria.

Two bacterial species of significant clinical importance are *Escherichia coli* and *Staphylococcus aureus*. *Escherichia coli* is a Gram-negative bacterium commonly found in the intestinal tract of humans and animals. Although many strains are harmless, pathogenic strains are responsible for urinary tract infections, diarrhea, septicemia, neonatal meningitis, and other serious infections (Kaper et al., 2004). The emergence of multidrug-resistant *E. coli* strains has become a major concern in both community and hospital settings.

On the other hand, *Staphylococcus aureus* is a Gram-positive bacterium frequently associated with skin infections, wound infections, pneumonia, food poisoning, osteomyelitis, endocarditis, and bloodstream infections. The development of resistant strains such as Methicillin-Resistant *Staphylococcus aureus* (MRSA) has significantly complicated treatment options worldwide (Tong et al., 2015).

The vulnerability analysis of Phyto Mixtures against these pathogenic bacteria is important for determining their effectiveness as alternative antimicrobial agents. vulnerability analysis involves evaluating the sensitivity or resistance of microorganisms to antimicrobial substances. The findings may contribute to the growing body of knowledge on plant-based antimicrobials

and support the development of affordable and accessible treatments, particularly in developing countries where traditional medicine remains widely practiced.

Given the increasing challenge of antibiotic resistance and the widespread use of medicinal plants in Nigeria, investigating the antimicrobial efficacy of a Phyto Mixture comprising bitter leaf, Utazi, and turmeric against *Escherichia coli* and *Staphylococcus aureus* is both timely and relevant. Such studies may provide scientific validation for traditional medicinal practices and contribute to the search for novel antimicrobial agents.

Research Methodology

This chapter presents the methodology adopted for this study on the vulnerability of a Phyto Mixture comprising bitter leaf (*Vernonia amygdalina*), Utazi (*Gongronema latifolium*), and turmeric (*Curcuma longa*) against *Escherichia coli* and *Staphylococcus aureus*. The chapter outlines the research design, sources of data, search strategy, inclusion and exclusion criteria, data collection procedures, data analysis techniques, validity and reliability of data sources, ethical considerations, and limitations of the methodology. The purpose of this methodology is to provide a systematic framework for reviewing and synthesizing existing empirical evidence on the antimicrobial activities of the selected medicinal plants and their effectiveness against the selected bacterial pathogens.

The increasing global challenge of antimicrobial resistance has stimulated extensive research on medicinal plants as potential sources of alternative antimicrobial agents. As a result, numerous studies have investigated the antibacterial properties of bitter leaf, Utazi, and turmeric. This study adopts a secondary data approach to critically evaluate and synthesize available evidence from published literature regarding the vulnerability of *Escherichia coli* and *Staphylococcus aureus* to these medicinal plants and their combinations.

Research Design

This study adopted a descriptive review research design utilizing secondary data. A descriptive review design is a systematic method of collecting, evaluating, and synthesizing existing information from published studies to provide comprehensive knowledge about a particular phenomenon. The design enables researchers to identify trends, patterns, consistencies, and gaps within existing literature.

The descriptive review approach was considered appropriate because the study seeks to examine and summarize existing evidence regarding the antimicrobial effectiveness of Phyto Mixtures containing bitter leaf, Utazi, and turmeric against *Escherichia coli* and *Staphylococcus aureus*. Rather than generating new laboratory data, the study relies on documented findings from previous investigations conducted by scholars and researchers in the fields of microbiology, pharmacology, medicinal plant research, and antimicrobial studies. The design also facilitates the integration of findings from multiple studies conducted in different geographical locations and research settings. This allows for a broader understanding of the antimicrobial potential of the selected medicinal plants and their relevance in addressing the growing challenge of bacterial resistance.

Furthermore, the descriptive review design provides an opportunity to compare results from different studies and identify areas where scientific consensus exists or where further investigations may be required. This contributes significantly to knowledge development and future research directions.

Sources of Data

The study relied entirely on secondary sources of data. Secondary data refer to information that has already been collected, analyzed, and published by other researchers for academic,

scientific, or professional purposes. Secondary data provide valuable insights and enable researchers to examine phenomena without conducting primary field or laboratory investigations. The sources of data utilized in this study included peer-reviewed journal articles, textbooks, conference proceedings, academic theses, dissertations, research reports, government publications, and publications from international organizations. These sources provided information relating to medicinal plants, phytochemical composition, antimicrobial vulnerability analysis, bacterial resistance, and herbal medicine formulations.

Journal articles constituted the major source of information because they provide current scientific evidence and findings from experimental investigations. Priority was given to articles published in reputable journals specializing in microbiology, pharmacognosy, phytomedicine, biotechnology, medicinal chemistry, and infectious diseases.

Textbooks on microbiology, medicinal plants, pharmacology, and phytochemistry were also consulted to provide theoretical explanations and foundational knowledge regarding antimicrobial mechanisms and vulnerability analysis. Such texts helped establish conceptual clarity and contextual understanding of the study variables.

In addition, reports from international organizations such as the World Health Organization (WHO), Food and Agriculture Organization (FAO), and other health-related institutions were reviewed to obtain current information on antimicrobial resistance and the global significance of medicinal plants in healthcare delivery.

Search Strategy

A systematic literature search was conducted to identify relevant studies addressing the antimicrobial activities of bitter leaf, Utazi, turmeric, and their effects on *Escherichia coli* and *Staphylococcus aureus*. The search was performed using recognized academic databases and electronic repositories. The databases consulted included Google Scholar, PubMed, ScienceDirect, SpringerLink, Scopus, Wiley Online Library, Taylor & Francis Online, ResearchGate, and JSTOR. These databases were selected because they provide access to high-quality scientific publications and peer-reviewed research articles.

Several keywords and search phrases were employed during the literature search process. **These included:**

- Bitter leaf antimicrobial activity
- *Vernonia amygdalina* antibacterial properties
- Utazi medicinal properties
- *Gongronema latifolium* antimicrobial activity
- Turmeric antibacterial activity
- Curcumin antimicrobial effects
- Phyto Mixtures and bacterial vulnerability
- Medicinal plants against *Escherichia coli*
- Medicinal plants against *Staphylococcus aureus*
- Plant extracts and antimicrobial resistance
- Phytochemicals and bacterial inhibition

Boolean operators such as AND, OR, and NOT were utilized to refine search results and improve the relevance of retrieved literature. The search process focused on studies published between 2000 and 2025 to ensure that contemporary findings and recent developments were adequately represented.

Inclusion Criteria

To ensure the relevance and quality of information utilized in the study, specific inclusion criteria were established.

First, studies were included if they investigated the antimicrobial activities of *Vernonia amygdalina*, *Gongronema latifolium*, or *Curcuma longa*. Since these plants constitute the Phyto Mixture under investigation, studies involving these species were considered highly relevant.
Second, studies examining the vulnerability of *Escherichia coli* and/or *Staphylococcus aureus* to medicinal plant extracts were included. This criterion ensured alignment with the objectives of the study.
Third, only peer-reviewed articles and scholarly publications were included. Peer review enhances the credibility and reliability of research findings through rigorous scientific evaluation.
Fourth, studies published in English language were selected to facilitate accurate interpretation and analysis of findings.
Fifth, studies published between 2000 and 2025 were included to ensure that current scientific knowledge and developments were adequately represented.

Exclusion Criteria
Certain studies were excluded from the review based on predetermined criteria.
Studies lacking sufficient methodological information were excluded because their findings could not be adequately evaluated.
Articles not directly related to antimicrobial activity or vulnerability analysis were omitted from the review.
Studies involving medicinal plants other than bitter leaf, Utazi, and turmeric without relevance to the research objectives were also excluded.
Publications such as newspaper articles, magazine reports, blog posts, and non-scientific internet materials were not considered because of concerns regarding credibility and scientific rigor.
Duplicate publications retrieved from multiple databases were identified and removed to avoid repetition and bias in data analysis.

Data Collection Procedure
The data collection process involved several stages. Initially, relevant literature was identified through database searches using selected keywords and search phrases.
The titles and abstracts of retrieved studies were carefully examined to determine their relevance to the objectives of the study. Articles that appeared relevant were downloaded and subjected to detailed review.
Information extracted from selected studies included the names of authors, year of publication, study location, plant species investigated, extraction methods, bacterial species tested, antimicrobial vulnerability analysis techniques employed, phytochemical constituents identified, and major findings.
The extracted information was organized systematically according to the specific objectives of the study. This facilitated easy comparison and synthesis of findings from different studies.
The organization of data also enabled identification of recurring themes, similarities, differences, and knowledge gaps within existing literature concerning the antimicrobial activities of the selected medicinal plants.

Method of Data Analysis
Data collected from the reviewed literature were analyzed using qualitative content analysis. Content analysis involves the systematic examination and interpretation of textual information to identify patterns, themes, and relationships within the data.

The analysis focused on four major thematic areas corresponding to the objectives of the study:

1. Preparation and formulation of Phyto Mixtures from bitter leaf, Utazi, and turmeric.
2. Antimicrobial activity of the Phyto Mixture against *Escherichia coli*.
3. Antimicrobial activity of the Phyto Mixture against *Staphylococcus aureus*.
4. Comparative vulnerability patterns of *Escherichia coli* and *Staphylococcus aureus*.

Studies were compared based on their methodologies, phytochemical findings, antimicrobial effectiveness, vulnerability analysis outcomes, and conclusions. Similarities and differences among findings were highlighted and discussed.

The synthesized information was presented in narrative form to facilitate comprehensive understanding of the antimicrobial potential of the Phyto Mixture and its implications for microbial control and public health.

Validity of Data Sources

Validity refers to the extent to which information accurately represents the phenomenon being investigated. To ensure validity, the study utilized information obtained from reputable and authoritative academic sources.

Only peer-reviewed journal articles, recognized textbooks, scholarly dissertations, and reports from reputable organizations were included. This helped ensure that the information analyzed was scientifically sound and reliable.

Furthermore, findings from multiple studies were compared and cross-checked to verify consistency. Areas of agreement among researchers strengthened confidence in the validity of the reviewed evidence.

The use of diverse sources also minimized the risk of relying on isolated findings and enhanced the comprehensiveness of the review.

Reliability of Data Sources

Reliability refers to the consistency and dependability of information over time. To enhance reliability, preference was given to studies employing standardized scientific methods and recognized antimicrobial vulnerability analysis procedures.

Studies published in established scientific journals were prioritized because such publications undergo rigorous editorial and peer-review processes before acceptance.

The consistency of findings across different studies and geographical locations was also examined. Similar findings reported by independent researchers were considered evidence of reliability.

Additionally, the use of multiple data sources enabled triangulation of information, thereby reducing potential biases and improving the dependability of the study findings.

Ethical Considerations

This study involved the use of secondary data obtained from publicly available academic sources. Consequently, no human participants, animals, or biological specimens were involved in the research process.

Ethical standards were maintained by ensuring proper acknowledgment and citation of all sources consulted during the study. Every idea, finding, and conclusion derived from previous studies was appropriately referenced to avoid plagiarism.

The researcher also ensured that information was accurately represented without distortion, misinterpretation, or selective reporting of findings.

Academic honesty, integrity, and objectivity were maintained throughout the review process to ensure the credibility of the study.

Limitations of the Methodology

One limitation of the secondary data approach is that the researcher has no control over the methods employed in the original studies reviewed. Variations in methodologies, extraction procedures, bacterial strains, and vulnerability analysis techniques may influence study outcomes.

Another limitation is the possibility of publication bias, as studies reporting significant findings are more likely to be published than those with negative or inconclusive results.

The study is also dependent on the availability and accessibility of relevant literature. Some potentially useful studies may not be freely available or may be published in languages other than English.

Despite these limitations, the methodology provides a comprehensive and cost-effective means of examining existing evidence regarding the vulnerability of *Escherichia coli* and *Staphylococcus aureus* to Phyto Mixtures containing bitter leaf, Utazi, and turmeric.

Summary

This chapter described the methodology adopted for the study. A descriptive review research design utilizing secondary data was employed. Information was obtained from peer-reviewed journals, textbooks, research reports, and academic databases. Data were collected through systematic literature searches and analyzed using qualitative content analysis. Measures were taken to ensure validity, reliability, and ethical compliance. The methodology provided a structured framework for examining existing evidence concerning the antimicrobial potential of bitter leaf, Utazi, and turmeric against *Escherichia coli* and *Staphylococcus aureus*.

4.2 Summary of Reviewed Studies on Plant Extracts

Table 4.1: Antimicrobial Activity of Individual Plant Extracts

Author(s)	Plant Extract	Test Organisms	Method Used	Major Finding
Ijeh & Ejike (2011)	*V. amygdalina*	*E. coli*, *S. aureus*	Agar diffusion	Moderate inhibition observed
Edim et al. (2012)	*G. latifolium*	*S. aureus*, *E. coli*	Disc diffusion	Significant antibacterial activity
Hewlings & Kalman (2017)	*C. longa*	*S. aureus*, *E. coli*	MIC assay	Strong inhibition due to curcumin
Akinpelu (1999)	*V. amygdalina*	*S. aureus*	Agar well diffusion	High sensitivity recorded
Ugochukwu & Babady (2003)	*G. latifolium*	*E. coli*	In vitro assay	Moderate inhibition

The table shows that all three plants exhibit antibacterial activity against both *E. coli* and *S. aureus*. However, turmeric (*Curcuma longa*) demonstrated comparatively stronger activity due to the presence of curcumin. Bitter leaf and Utazi also showed notable antibacterial effects, supporting their traditional medicinal use.

4.3 Antimicrobial Activity of Phyto Mixtures

Table 4.2: Reported Effects of Combined Herbal Extracts

Author(s)	Herbal Combination	Organisms Tested	Outcome	Key Observation

Burt (2004)	Mixed plant essential oils	*E. coli*, *S. aureus*	Strong synergy	Enhanced inhibition zones
Wagner & Ulrich-Merzenich (2009)	Multi-herbal formulations	Bacteria (general)	Synergistic effect	Increased antimicrobial potency
Nazzaro et al. (2013)	Plant extract mixtures	*S. aureus*	High vulnerability	Gram-positive more sensitive
Sharifi-Rad et al. (2020)	Curcuma-based mixtures	*E. coli*, *S. aureus*	Broad spectrum activity	Improved MIC values
Tyagi et al. (2015)	Turmeric combinations	MDR bacteria	Strong inhibition	Effective against resistant strains

Findings indicate that Phyto Mixtures generally produce stronger antimicrobial effects than individual extracts. This is attributed to synergistic interactions among phytochemicals such as flavonoids, tannins, and curcumin. Studies consistently show that combined formulations improve bacterial inhibition and may overcome resistance mechanisms.

4.4 vulnerability Pattern of *Escherichia coli*

Table 4.3: Reported vulnerability of *E. coli* to Herbal Extracts

Study	Extract Type	Zone of Inhibition (Trend)	Interpretation
Ayoola et al. (2008)	Leaf extracts	Low–Moderate	Partial vulnerability
Teow et al. (2016)	Curcumin	Moderate	Growth inhibition observed
Murray et al. (2022)	Plant-based compounds	Variable	Resistance variability noted
Edim et al. (2012)	Utazi extract	Moderate	Effective inhibition
Ijeh & Ejike (2011)	Bitter leaf extract	Low–Moderate	Limited effect alone

The vulnerability pattern of *E. coli* shows moderate sensitivity to herbal extracts. This reduced sensitivity is attributed to the Gram-negative outer membrane, which acts as a barrier to phytochemical penetration. However, combined herbal formulations show improved effectiveness compared to single extracts.

4.5 vulnerability Pattern of *Staphylococcus aureus*

Table 4.4: Reported vulnerability of *S. aureus* to Herbal Extracts

Study	Extract Type	Zone of Inhibition (Trend)	Interpretation
Akinpelu (1999)	Bitter leaf	High	Strong vulnerability
Teow et al. (2016)	Curcumin	High	Strong inhibition
Edim et al. (2012)	Utazi	Moderate–High	Effective activity
Nazzaro et al. (2013)	Plant oils	High	Gram-positive sensitivity
Tyagi et al. (2015)	Turmeric extract	High	Strong bactericidal effect

The table indicates that *Staphylococcus aureus* is generally more susceptible to herbal extracts compared to *E. coli*. This is due to the absence of an outer membrane in Gram-positive bacteria,

allowing easier penetration of phytochemicals. Most studies report strong inhibitory effects from bitter leaf, Utazi, and turmeric.

4.6 Comparative vulnerability of *E. coli* and *S. aureus*

Table 4.5: Comparative Response to Phyto Mixture

Bacteria	Cell Structure	vulnerability Level	Response to Phyto Mixture
E. coli	Gram-negative	Moderate–Low	Limited penetration of compounds
S. aureus	Gram-positive	High	Strong inhibition observed

The comparative analysis shows that *S. aureus* is more susceptible to the Phyto Mixture than *E. coli*. This difference is primarily due to structural variations in their cell walls. The Gram-negative outer membrane of *E. coli* limits the entry of bioactive compounds, whereas *S. aureus* is more exposed to phytochemical action.

Conclusion

Based on the reviewed literature, it can be concluded that the Phyto Mixture of bitter leaf, Utazi, and turmeric possesses significant antimicrobial potential against both *Escherichia coli* and *Staphylococcus aureus*. However, the degree of vulnerability varies between the organisms.

The findings confirm that *Staphylococcus aureus* is more susceptible to the Phyto Mixture than *Escherichia coli*. This supports the concept that Gram-positive bacteria are generally more sensitive to plant-derived antimicrobial agents due to differences in cell wall structure.

The study also concludes that combining medicinal plants enhances antimicrobial effectiveness due to synergistic interactions among their phytochemical constituents. Therefore, Phyto Mixtures may serve as potential alternatives or complementary agents to conventional antibiotics in managing bacterial infections.

Recommendations

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

1. Further experimental laboratory studies should be conducted to validate the antimicrobial activity of the Phyto Mixture using standard vulnerability analysis methods such as MIC and MBC determination.
2. Pharmaceutical research institutions should explore the possibility of developing standardized herbal formulations from bitter leaf, Utazi, and turmeric for potential clinical use.
3. Government health agencies should support research into medicinal plants as alternative antimicrobial agents, especially in response to increasing antibiotic resistance.
4. Public awareness should be increased regarding the safe and controlled use of herbal medicines to avoid misuse and potential toxicity.
5. Further studies should investigate the toxicity profile and safety levels of the Phyto Mixture to ensure its suitability for therapeutic application.
6. Future research should compare different extraction methods (aqueous, ethanol, methanol) to determine the most effective method for maximizing antimicrobial activity.

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