



ANALYSIS OF THE BIOACTIVE AND MICROBIOLOGICAL CONTENTS OF HERBAL MIXTURES SOLD IN ANAMBRA STATE, NIGERIA

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ABSTRACT

Herbs mixtures form an inseparable part of traditional medicine in Anambra State of Nigeria and are used due to their therapeutic potential and flavonoids and alkaloids compounds properties. However, microbiological contamination caused by unregulated preparation and storage is of great health risk. This paper examines the bioactive and microbiological composition of the 50 herbal mixture products in the markets in Onitsha, Awka and Nnewi in order to determine their safety and therapeutic potentials. Applying High-Performance Liquid Chromatography (HPLC) and Gas Chromatography-Mass Spectrometry (GC-MS) as a bioactive analysis medium as well as standard plate count methods to determine microbial loads, the study determines the significant compounds, quantifies the microbial loads and assesses the effects of preparation methods on contamination. Flavonoids and alkaloids were found in a high percentage of the samples (82%), but with respective varying concentrations (0.7-4.5 mg/g). Microbiologically, 58 percent of samples recorded unsafe levels and, Escherichia coli (48%) as well as Staphylococcus aureus 32) were recorded, which can be attributed to poor hygienic practices ($r = 0.71$, $p < 0.01$). Recommendations comprise unified preparation directions and government controls to make them safer. The results provide information to the stakeholders in public health that favors the Nigerian traditional medicine system and consumer protection.

Keywords: Herbal Mixtures, Bioactive Compounds, Microbiological Safety, Traditional Medicine, Quality Control.

Study Background and Problems

Natural products, and herbal mixtures in particular, are an important part of traditional medicine in Nigeria, based on a cultural idea of the primacy of natural medicine. The World Health Organization (2021) reckons that 80 percent of the Nigerians rely on traditional medicine due to formula availability, low cost, and perceived effectiveness. In Anambra State, a business centre in South East Nigeria, the use of herbal concoctions to treat diseases ranging between infections and debilitating conditions is readily available in the markets at Onitsha, Awka and Nnewi. These



combinations are suspected to hold medicinally active substances alkaloids, flavonoids, phenolic compounds and antioxidants. Their microbiological safety is however of concern given their potential to become contaminated during their harvesting, preparation or storage, which is aggravated by ineffective regulatory control. The historical research identifies the pharmacological aspect of herbal medicine, although, in terms of bioactive properties, certain noticeable discrepancies arise that are attributed to the differences in plants, preparation techniques and environmental conditions. Recent studies underscore the necessity to have standardised quality control, since the presence of microbial contamination such as *Escherichia coli* and *Staphylococcus aureus* is health hazardous. In an Anambra State where usage of herbal mixtures forms an essential component of healthcare, there is little research on its safety and efficacy and thus there is an urgent need to investigate it and safeguard its citizens as well as prove its efficiency.

Blind cultural trust and economic need propel the high consumption of herbal mixtures in Anambra State, but their efficacy and safety remain ill-informed. Inadequate standardization gives rise to unreliable therapeutic bioactive content due to variations, and the risk of microbial contamination by unhygienic preparation and storage practices. Researchers like Adebayo et al. (2020) have reported the presence of pathogens in herbal products and this should caution the use of such products, especially on vulnerable populations. Lack of research on the chemical and microbiological characterization of these mixes makes it difficult to regulate them and maintain quality control on the basis of evidence. The lack of adequate data about herbal mixtures in Anambra and the hustle and bustle in the many markets in the state makes this study essential in promoting consumer safety and the role of traditional medicine in the healthcare system of Nigeria.

The overall aim of this project is to examine the bioactive and microbiological contents of herbal mixtures being used in Anambra State of Nigeria to evaluate their efficacy and safety. Specific objectives are to identify and measure bioactive compounds, estimation of microbial loads and isolation and identification of pathogens, an estimation of the correlation between the preparation methods and the level of contamination and propose some recommendations concerning quality control and regulatory requirements. This scope of study will involve capturing conditions in key markets of the state of Anambra since the state is host to several markets nationally that become focal points pertaining to the problem.

The importance of this study is that it can help to fill the gaping knowledge components relating to the safety and effectiveness of herbal mixtures in Nigeria. The present study offers evidence that may be presented to policymakers, herbal practitioners, and health officials in general. The standardized preparation protocols, associated with the proposed regulatory guidelines, as well as standardized protocols and the new proposed regulatory models of quality control can ensure the improvement of consumer safety, facilitate the inclusion of traditional medicine into the healthcare system of Nigeria. The results can also help fill the knowledge gap related to the safety of herbal medicine worldwide, as requested by the World Health Organization that stipulates the need to enhance traditional medicines regulation.

Herbal combinations are made of natural substances that have bioactive elements such as alkaloids, flavonoids, terpenoids, and phenolic compounds possess antioxidant, antibacterial, and anti-



inflammatory reduced effects (Ekor, 2014). These substances are the basis of the therapeutic content of herbal medicines, and they have shown their benefits against infections, diabetes, and cardiovascular diseases (Sofowora, 2019). Bioactive content, however, is highly variable, depending on species of plants, the environmental conditions, and the preparation. According to a 2021 study in the *Journal of Ethnopharmacology*, the concentration of flavonoids in herbal combinations was between 0.5 and 5 mg/g indicating the variability leading to inconsistent therapeutic effects (Okwu & Uchegbu, 2021). In another example, a 2023 study in the *African Journal of Traditional Medicine* also reported an alkaloid variation of 30 50% across vendors regarding the purchase of herbal mixtures in Nigerian (Nwafor et al., 2023).

Microbiological safety is also a matter of particular concern to herbal medicines, since contamination incurs the risks of disease by transmission of pathogens. Adebayo et al. (2020) published a study on contaminants in herbal mixtures sold in the municipal markets of Nigeria in the *African Journal of Microbiology Research* and estimated the contamination percentage of *Escherichia coli*, *Staphylococcus aureus*, or *Salmonella* spp. to be substantial (65 percent). World Health Organization (2021) observed that microbial contamination of the products is a major cause of undesired health outcomes, especially in developing nations that have lax control systems. A 2022 review in *Journal of Herbal Medicine* indicated that non-sterile conditions of preparations were related to herbal mixtures where the microbial loads reached greater than 10⁵ CFU/g (Iwu & Obiora, 2022). In Nigeria, where there is no formal standardized quality control, these risks are increased because most herbal mixtures are unsophisticatedly prepared by vendors who are not highly trained.

Empirical studies also point towards the necessity of the in-depth consideration of herbs combinations. Researchers concluded that 70 percent of the herb sellers in Onitsha had not received any formal education on how to make or store the products, posing a danger due to contamination (Eze & Okonkwo, 2019). Likewise, a 2021 article published in *Journal of Medicinal Plants Research* found that herbal mixtures had an additional 40 percent of fungus contaminants due to improper drying and storage (Obi et al., 2021). There has also been a paucity of research on bioactive content and much of it has been on individual plant species and not complex mixtures. As an example of the analysis of bioactive content, Okeke et al. (2018) viewed the bioactive content of mixtures with *Moringa olei*, but did not study microbial safety. Few published and integrated studies on both bioactive and microbiological are available, especially in Anambra state where the sale of herbal mixture dominates the markets in informal health care.

Through the National Agency for Food and Drug Administration and Control (NAFDAC), regulatory activity is present in Nigeria and targets registered herbal products, but not the informal mixtures that prevail in Anambra State. A 2020 report by NAFDAC indicated that the unregistered herbal products in the Nigerian markets far outnumber the registered ones at 15 percent (NAFDAC, 2020). In other countries such as India and South Africa, simpler quality control regulations have been enacted on herbal medicines which outline microbial safety and bioactive profiling (Mukherjee, 2019; Van Wyk, 2022). These models can give lessons to Nigeria where there is a lag in regulatory gaps towards consumer safety. The literature recommends that context-



specific researchers are necessary to guide quality control measures in contexts where people in Anambra State engage in prolific herbal medicine markets and make consumers vulnerable.

Theoretical Briefing

Theoretical models are used to give a user a clearer idea of obstacles to the safety of herbal mixtures. The phytochemical theory argues that the effectiveness of herbal medicines has its origin in the bioactive compounds in the medicine but only through consistent preparation and quality control does its potency become agreeable (Sofowora, 2019). The contamination risk model shows that environmental and human causes, including low-grade hygiene and inappropriate storage place, enhance microbial loads within herbal products (WHO, 2021). Such frameworks are very applicable to Anambra State, where there are lively markets that can sell herbal mixtures but can never be able to control their safety. The systems theory also believes that due to differences in the value chain, herbal medicine (growing, harvesting, preparation, and distribution) should be integrated to promote quality control to guarantee safety and efficacy (Okeke et al., 2020).

Methods

Three major markets in Anambra State, Nigeria Onitsha Main Market, Nnewi Nkwo Market, and Awka Eke Market, were selected because of large number of herbal mixture sales in them and the diversity of the vendor profile. Sample size was obtained in 50 herbal sample mixtures of 25 vendors (two samples per vendor) in these markets with targeted sales of mixtures directed to common maladies like malaria, infection, and digestive problems. The sampling was done aseptically in sterile containers with permission of the vendor and the samples were shipped into the laboratory under controlled conditions (4o C) to avoid degradation. The mixed-methods used in the study can analyze bioactive and microbiological contents, and this design provides a comprehensive analysis of safety and efficacy.

Analysis of bio-actives was done by High-Performance Liquid chromatography (HPLC) and Gas Chromatography-Mass spectrometry (GC-MS) in order to identify and quantify compounds like alkaloids, flavonoids, and phenolic compounds. Analysis by HPLC was done, using a C 18 column loaded with methanol/water (70:30 v / v) at 280nm and at 254nm, respectively, as the detection wavelengths of flavonoids and alkaloids. GC-MS employ the DB-5 column to detect volatile compounds and the carrier gas was helium. In order to have accuracy, the calibration curves were prepared by the use of standard compounds (e.g., quercetin in flavonoids, caffeine in alkaloid) and the limit of detection was 0.01 mg/g. Microbiological analysis included routine plate-count techniques to determine total, aerobic bacteria and fungi (using Plate Count Agar (PCA) and Sabouraud Dextrose Agar (SDA) respectively. Identification of pathogens was performed on selective media (MacConkey agar to be used as selective media of Escherichia coli, Mannitol Salt agar as selective agar of Staphylococcus aureus). The loads of microbes were compared with WHO safety limits (<10⁵ CFU/g education utc wiki for bacteria, <10³ CFU/g education utc wiki for fungi).

The vendors were interviewed using a unique research document on a semi-structured basis on specific information concerning their practices (preparations, drying techniques, use of sterile water, hygiene, storage conditions (use of containers, temperature, workspace sanitation)). In



SPSS (Version 26), ANOVA was used to check the variability of bioactive content and microbial loads among the samples of quantitative data analysis. The correlation analysis carried out by Pearson explained the association between the preparation methods and the level of contamination. Interview data were coded thematically with NVivo (Version 12) to discover the reoccurring themes in vendor practices. This was conducted over a period of five months (March-July 2025) of research with ethics clearance granted by Nnamdi Azikiwe University Ethics Committee. Total expenditure including the analysis in lab conditions, the collection of samples, and other information was estimated to cost 4 million Naira.

Safety and Efficacy Indicators of Herbal Mixtures

According to the bioactive analysis 82 percent of the 50 herbal mixture samples showed the presence of flavonoids, alkaloids and phenolic compounds with wide simplicity in concentration values. Their flavonoids contents were 0.7 to 4.5 mg/g (mean = 2.6 mg/g, SD = 0.8), their alkaloids were 0.4 to 3.9 mg/g (mean = 2.2 mg/g, SD = 0.7), and their phenolic compounds were 0.9 to 5.3 mg/g (mean = 3.1 mg/g, SD = 1.0). Table 1 gives an overview of the bioactive content between the samples. Flavonoid contents were higher in mixtures produced at Onitsha (2.9 mg/g) compared to Awka (2.4 mg/g) and Nnewi (2.5 mg/g) as a result of the difference in plant procurement and expertise of the vendors. The ANOVA results have shown that there has been significant variation in bioactive content ($F = 7.12, p < 0.01$) and reasons attributed to this variability in the preparation of the different samples have been suggested, including variation in extraction method and drying time.

Table 1: Bioactive Compound Concentrations in Herbal Mixtures (mg/g)

Compound	Mean	Standard Deviation	Range
Flavonoids	2.6	0.8	0.7–4.5
Alkaloids	2.2	0.7	0.4–3.9
Phenolic Compounds	3.1	1.0	0.9–5.3

Source: Field Survey, 2025 (Analyzed using HPLC and GC-MS)

Microbiological examination demonstrated that 58 percent of samples surpassed WHO safety limits regarding microbial loads, 48 percent of samples contained *Escherichia coli*, and 32 percent of the samples were found to contain *Staphylococcus aureus*. The counts of aerobic bacterial load were between 10^3 and 10^7 CFU/g (mean = $10^{5.6}$ CFU/g), whereas fungal counts were between 10^2 and 10^4 CFU/g (mean = $10^{3.1}$ CFU/g). The microbial load varies in different markets as presented in Table 2. Samples of Onitsha showed the largest counts of bacteria (mean = $10^{5.9}$ CFU/g) due to the conditions of the crowded market and lack of sufficient facilities to store the items. Pearson correlation analysis found that there is a strong positive correlation between unhygienic preparation practices (i.e., use of un-sterile water, absence of handwashing) and microbial contamination ($r = 0.71, p < 0.01$). It was also observed that storage in non-airtight containers would result in higher fungal loads ($r = 0.65, p < 0.01$).



Table 2: *Microbial Loads in Herbal Mixtures (CFU/g)*

Market	Bacterial Count (Mean)	Fungal Count (Mean)	Pathogens Detected (% Samples)
Onitsha	$10^{5.9}$	$10^{3.3}$	E. coli (52%), S. aureus (36%)
Awka	$10^{5.4}$	$10^{3.0}$	E. coli (44%), S. aureus (28%)
Nnewi	$10^{5.5}$	$10^{3.1}$	E. coli (48%), S. aureus (32%)

Source: Field Survey, 2025 (Analyzed using Standard Plate Count Methods)

Qualitative data generated during the interviews of the vendors identified the main activities that contribute to contamination. Only one-fifth vendors used sterile water to prepare mixtures, and 60 percent of vendors used non-complete containers that were kept in humid conditions. Hygiene was not followed well, with 70 percent of vendors testifying they had no habit of handwashing or sanitizing of their working space. Thematic analysis pointed to three key themes, namely, lack of training about hygienic preparation (80 percent of vendors), absence of proper storage facility (65 percent), and poor awareness of the dangers of microbes (55 percent). The results correspond with quantitative data, in that, poor practices are a major cause of contamination.

Contextual Analysis

The results indicate that Anambra State herbal mixtures embraced bioactive compounds that could be therapeutically useful since flavonoids and alkaloids were found in 82 percent of the samples. Such discrepancy in concentrations (e.g., flavonoids: 0.7-4.5 mg/g) confirms the assumption made by Okwu and Uchegbu (2021) about low quality products, which are prepared in an unstandardized way. This inter-individual fluctuation decreases therapeutic consistency, since reduced levels of the drug can cause reduced effectiveness. The variation in phenolic content (mean = 3.1 mg/g) indicated the possible presence of antioxidants, in line with the argument presented by Sofowora (2019) that phenolics help in the fight against oxidative stress-related illnesses.

With more than half of the samples harboring high microbial loads and pathogens such as *Escherichia coli* and *Staphylococcus aureus*, one can speak of high safety risks in regard to Adebayo et al. (2020) findings in regards to the contamination of herbal products in Nigeria. The relation between the unhygienic practices and contamination ($r = 0.71$) highlights the necessity to improve the training and storage situations of vendors, which is highlighted in the Journal of Herbal Medicine (Iwu & Obiora, 2022). The analysis given under the contamination risk model resounds these results and underlines the influence of human and environmental factors on the microbial growth. The increased bacterial levels in Onitsha can be attributed to the busy market condition in this city, which has been reported in other Nigerian studies as well (Eze & Okonkwo, 2019).

This study has implications to the health policies and the public. The presence of pathogens is risky to the consumers especially to the immunocompromised ones and thus management quality control is needed. Robust preparation and storage procedures can also limit contamination of food by the vendors through education about best practices, and standard procedures can be implemented to assure consistent bioactive contents. NAFDAC policymakers can use such findings to open up model guidelines to medicate herbal mixtures similar to those used in India and South Africa (Mukherjee, 2019; Van Wyk, 2022). These suggested measures-sterile



preparation procedures, airtight storage, and frequent microbial testing can provide practically effective advice to increase safety and efficacy.

Weaknesses include the size of the sample (50 samples) which might not be representative of the various herbal markets in Anambra, as well as the fact that vendor-reported practices were relied upon which could result in bias. A bigger sample, longitudinal microbial documentation, and clinical efficacy of specific compounds identified as bioactive could be studied in future. The research focus on Anambra State can be generalized to the rest of Nigeria to implement traditional medicine in the country with the goal of incorporating it into the national health sectors.

Conclusion

This paper indicates that herbal mixtures in Anambra State have valuable bioactive compounds, but many are contaminated by microbes that are well above the recommended WHO safety limits required to make medicines. (58%). Fluctuation in bioactive and high pathogen-level, owing to poor hygienic preparation and storage methods, justifies the importance of quality control standards. The suggested outline of activities, sterile preparation schemes, and regulation policies will provide the means to maximize the quality and the effectiveness of the herbal mixes. Future studies should further investigate clinical effectiveness, continue to monitor the microbes, and apply the provided framework in other parts of Nigeria. By mitigating these issues, the stakeholders will be able to reinforce the role of traditional medicine in the Anambra State and the overall Nigerian healthcare system and position it closer to public health interests and the safety of the consumers.

Recommendations

To improve the safety and efficacy of herbal mixtures in Anambra State, this study makes a series of recommendations directed to the stakeholders. On the one hand, government regulators such as NAFDAC must devise and implement sector-specific standards pertinent to the production of herbal mixtures, including compulsory microbiological testing in addition to standard operating procedures to reduce contamination possibilities. Second, local universities, and training institutions should partner with local health departments to develop training opportunities relevant to herbal vendors regarding clean preparation of herbs, proper storage, and attention to quality control to minimize microbial loads and consistency of active components. Third, regularity of sanitation audits and the supply of affordable airtight storage containers that can help vendors keep sell their products without causing pollution of the environment should be undertaken by the market associations within Onitsha, Awka and Nnewi. Fourth, policymakers need to subsidize lab testing services among small-scale vendors in a bid to make routine quality checks a foreseeable task to informal market operators. Lastly, there is need to create awareness by sending community health workers to inform the consumer and the vendors about the dangers of contaminated herbal mixtures and the safety of standardized ones to promote trust to products that have been regulated. Such measures will make the integration of traditional medicine in Nigeria healthcare system safe and consumer protection measures will be put in place even as cultural practices are allowed to thrive. These suggestions provide an all-inclusive strategy in enhancing the quality of herbal mixtures in the state of Anambra and beyond, through preparation, storage, regulation, training and awareness.



REFERENCES

- Abdullahi, A. A. (2020). Trends in the use of herbal medicines in Nigeria. *Journal of Herbal Medicine*, 22, 100–108.
- Adebayo, O., Olagunju, A., & Akintunde, O. (2020). Microbial contamination of herbal mixtures in Nigerian markets. *African Journal of Microbiology Research*, 14(5), 123–130.
- Adeyemi, O. S., & Olaleye, M. T. (2021). Antioxidant activities of Nigerian medicinal plants. *Journal of Natural Products*, 14(2), 67–75.
- Afolayan, A. J., & Wintola, O. A. (2020). Dietary supplements from medicinal plants: Safety and efficacy. *South African Journal of Botany*, 128, 23–30.
- Agbor, A. M., & Naidoo, S. (2019). Microbial safety of herbal medicines in developing countries. *Journal of Microbiology and Biotechnology*, 29(5), 45–53.
- Akerele, O. (2019). Traditional medicine and its role in African healthcare systems. *Journal of African Health Sciences*, 19(2), 45–56.
- Anukam, K. C., & Reid, G. (2021). Probiotics and herbal medicines: Synergies and challenges. *Journal of Alternative and Complementary Medicine*, 27(3), 89–97.
- Asuzu, I. U. (2021). Pharmacological evaluation of African herbal medicines. *African Journal of Pharmaceutical Sciences*, 12(3), 89–97.
- Balogun, F. O., & Ashafa, A. O. (2020). Antioxidant properties of African medicinal plants. *South African Journal of Botany*, 130, 45–53.
- Chikezie, P. C., & Ojiako, O. A. (2020). Herbal medicine and oxidative stress: A review. *Journal of Medicinal Food*, 23(4), 345–353.
- Edeoga, H. O., & Eriata, D. O. (2019). Alkaloid content of Nigerian medicinal plants. *Plant Products Research Journal*, 23(1), 12–19.
- Ekor, M. (2014). The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. *Frontiers in Pharmacology*, 4, 177.
- Elujoba, A. A., Odeleye, O. M., & Ogunyemi, C. M. (2020). Traditional medicine in Nigeria: Current status and future prospects. *Journal of Tropical Medicine*, 18(2), 56–64.
- Eze, J. I., & Okonkwo, C. C. (2019). Vendor practices and microbial safety of herbal medicines in Onitsha markets. *Nigerian Journal of Natural Medicine*, 13(1), 34–42.
- Ezuruike, U. F., & Prieto, J. M. (2021). The use of plants in African traditional medicine. *Journal of Ethnopharmacology*, 260, 112–120.
- Falodun, A., & Imieje, V. (2020). Antimicrobial activity of Nigerian medicinal plants. *Journal of Medicinal Plants Studies*, 8(3), 45–52.
- Farnsworth, N. R. (2018). Ethnopharmacology and drug discovery. *Journal of Ethnopharmacology*, 215, 12–19.
- Gamani, K. S. (2019). Safety assessment of herbal medicines in Nigeria. *African Journal of Pharmacy and Pharmacology*, 13(4), 78–86.
- Gurib-Fakim, A. (2020). Medicinal plants: Traditions of yesterday and drugs of tomorrow. *Molecular Aspects of Medicine*, 27(1), 1–93.
- Igoli, J. O., & Alexander, N. R. (2021). Bioactive compounds from African medicinal plants. *Journal of Natural Products Research*, 17(2), 34–42.
- Iweala, E. E., & Obidoa, O. (2020). Antioxidant and antimicrobial properties of herbal mixtures. *Journal of Food Biochemistry*, 44(6), 123–130.



- Iwu, M. M., & Obiora, C. (2022). Microbial contamination in herbal medicines: A global perspective. *Journal of Herbal Medicine*, 30, 100–110.
- Kasilo, O. M., & Trapsida, J. M. (2021). Regulation of traditional medicine in Africa. *African Health Monitor*, 18, 25–31.
- Katerere, D. R., & Luseba, D. (2019). Ethnobotanical studies and quality control of African herbal medicines. *Journal of Ethnobiology and Ethnomedicine*, 15(1), 23–30.
- Liu, Y., & Zhang, X. (2020). Bioactive compounds in herbal medicines: Analytical challenges. *Analytical Chemistry Letters*, 10(4), 456–467.
- Mukherjee, P. K. (2019). Quality control of herbal medicines: An Indian perspective. *Journal of Pharmaceutical Sciences*, 108(6), 1923–1933.
- NAFDAC. (2020). Report on herbal product regulation in Nigeria. National Agency for Food and Drug Administration and Control.
- Nwafor, C. C., Okoronkwo, N. E., & Ude, G. B. (2023). Variability in alkaloid content of Nigerian herbal mixtures. *African Journal of Traditional Medicine*, 20(2), 56–64.
- Obi, E., Okeke, M., & Eze, C. (2021). Fungal contamination in Nigerian herbal medicines. *Journal of Medicinal Plants Research*, 15(4), 89–97.
- Okeke, M. I., Iroegbu, C. U., & Eze, E. N. (2018). Bioactive compounds in *Moringa oleifera*-based herbal mixtures. *African Journal of Biotechnology*, 17(10), 234–241.
- Okigbo, R. N., & Mmeka, E. C. (2021). Microbial contamination of herbal preparations in Nigeria. *African Journal of Biotechnology*, 20(4), 89–96.
- Okwu, D. E., & Uchegbu, R. I. (2021). Flavonoid content variability in Nigerian herbal mixtures. *Journal of Ethnopharmacology*, 270, 113–122.
- Olorunnisola, O. S., & Afolayan, A. J. (2020). Herbal medicines and their safety in Nigeria. *Journal of Medicinal Plants Research*, 14(5), 56–63.
- Oyebode, O., & Kandala, N. B. (2021). Traditional medicine use in Nigeria: A public health perspective. *Journal of Public Health in Africa*, 12(1), 45–53.
- Sofidiya, M. O., & Awolesi, A. A. (2020). Phytochemical screening of Nigerian herbal medicines. *Journal of Pharmacognosy and Phytochemistry*, 9(3), 34–41.
- Sofowora, A. (2019). *Medicinal plants and traditional medicine in Africa* (3rd ed.). Spectrum Books.
- Ukwueze, S. E., & Okoye, C. O. (2021). Quality control challenges in Nigerian herbal medicines. *African Journal of Pharmaceutical Research*, 17(2), 67–75.
- Van Wyk, B. E. (2022). Quality control frameworks for herbal medicines in South Africa. *South African Journal of Botany*, 145, 78–86.
- WHO. (2020). *Guidelines on safety monitoring of herbal medicines*. World Health Organization.
- World Health Organization. (2021). *WHO global report on traditional and complementary medicine*. WHO Publications.