OPEN ACCESS

International Journal of Applied Medical and Health Sciences

Int J Appl Med Health Sci | Vol-1, Iss-2, Sept-Oct., 2026
e-ISSN: XXXX-XXXX
Homepage: https://ioasdpublisher.com/ijamhs

Evaluation of Several Herbal Medications Supplied in Owerri, Imo State for Microorganism

Dunga Kingsley Excel[1*], Onyenama, Amarachi Chisom[1], Ezeagwula, Treasure Divine Chinyere[2], Rita Chinenye Asianuba[1], Julius Oforji Amarachukwu[3], and Okoro Chinyere Ihuarulam[4]

[1]Department of Medical Laboratory Science, Kingsley Ozumba Mbadiwe University, Ogboko, Imo State Nigeria.
[2]Department of Public Health, Clifford University, Owerrinta, Ihie Campus, Abia State
[3]Department of Medical Laboratory Science, Rhema University, Aba Abia State
[4]Federal University Teaching Hospital Owerri, Imo State

Corresponding Author: Dunga Kingsley Excel

ABSTRACT

Herbal medications are used commonly for the management of a range of health disorders including typhoid fever, sexually transmitted infections, haemorrhoids, stomach aches, diabetes, headache, skin infections and toothache and for weight reduction. Despite their medicinal relevance and widespread use, herbal medicines may be subject to microbial contamination due to insufficient preparation, handling, storage and packing. This study was undertaken to analyse the microbiological quality of some selected herbal medications sold in Owerri, Imo State, Nigeria. Forty (40) samples of packaged herbal medication were randomly acquired from the vendors of herbal medicine at some specified places, Wetheral Road, Mbaise Road, Douglas Road and Okigwe Road, all within Owerri metropolis. Microbiological investigation of the samples was done using MacConkey agar, Nutrient agar and Sabouraud Dextrose Agar and incubated at optimum temperature. Isolates were identified on the basis of cultural, morphological and biochemical characteristics. The results revealed that some of the herbal remedies were contaminated with the bacteria and fungi. Interviews with sellers showed that some of the preparations were diluted with water after boiling which may create a chance for microbial contamination after manufacture. Other risks of infection include unclean or non-sterile containers, packing materials, handling during vending and prolonged exposure to ambient conditions. The presence of bacteria in herbal remedies after boiling indicates that contamination may happen after the thermal treatment, especially by addition of water, sugars, preservatives and other ingredients or by poor handling and storage. The study stresses the need for more hygienic preparation, adequate packaging, safe water use, proper storage and routine microbiological quality control of herbal medicines to safeguard customers and assure their safety and therapeutic quality.

Keywords: Microbial contamination, Herbal medications, Bacteria, Fungi, Microbiological quality, Owerri, Nigeria.

Original Research Article

Article History
Received: 06-07-2026
Accepted: 31-08-2026
Published: 14-09-2026

INTRODUCTION

Herbal medicine, also known as botanical medicine or phytotherapy, is the use of plant-derived materials (such as seeds, berries, roots, barks, leaves and flowers) for the prevention and treatment of diseases. Plants have always been key sources of therapeutics and still contribute greatly to modern medicine. Many traditional pharmacological substances have been derived from medicinal plants, for example morphine from the opium poppy, chemicals related to aspirin from willow bark, ephedrine from Ephedra species and cardiac glycosides from foxglove (Digitalis) species. Herbal therapy has long been practiced outside the regular healthcare systems but rising scientific examination of medicinal plants has led to increasing interest in their therapeutic potential [1].

The use of herbal remedies for prevention and cure is as old as human civilisation and has made a significant contribution to the advancement of contemporary pharmacology and medicine. Herbal medicines continue to be an essential aspect of health care in many underdeveloped nations, not least because they are generally accessible, culturally accepted and often less expensive than Western pharmaceuticals. According to the World Health Organization, a substantial fraction of the population in poor countries uses traditional and complementary medicine for some aspects of healthcare [2].

Herbal medicinal treatments are widely used, yet serious public health concerns over their quality, safety and efficacy remain. The quality of the herbal medicines is of crucial importance for their reproducible medicinal action and safety. Therefore, the quality of the raw plant material, the techniques of processing and the end preparations must be strictly regulated. The increasing consumption of herbal medicines and the

expanding worldwide herbal medicine business have led to worries about contamination, adulteration and the existence of potentially dangerous residues among health authorities and consumers. Various pollutants that may affect the safety and quality of herbal products, have been described [3].

Medicinal plants can be contaminated by germs from soil, air, water, animals, humans and contaminated equipment during the stages of cultivation, harvesting, transportation, processing and storage. Environmental elements including temperature, relative humidity and rainfall during pre- and post-harvesting periods may affect the microbiological quality of medicinal plant materials. In addition, the handling procedures, processing processes, storage conditions and the hygiene of the individuals involved in production can significantly impact the microbiological quality of the finished product [4].

Microbial contamination of herbal remedies is of particular importance as some germs may be hazardous to human. Microorganisms present in non-sterile pharmaceutical products can lead to the degradation of the product, decrease or complete loss of therapeutic action and, depending on certain conditions, significant health effects in users. Spoilage can also be caused by fungal contamination and, in the case of toxigenic species, the formation of potentially toxic compounds. Therefore, appropriate control of microbiological contamination is necessary for the quality, safety and efficacy of herbal medical products [5].

Herbal medicinal goods are complicated formulations based on biological material, which makes the reproducibility of the microbiological quality difficult. Plant materials are subjected to a variety of collection, transport, processing, packaging and storage conditions which might have profound effects on the microbiological properties of the finished products. Contamination can also arise during preparation by the use of polluted water, inadequately cleansed containers, additions or unclean handling. Therefore, makers and distributors of herbal medicines must use good hygienic procedures and ensure that the raw ingredients, processing equipment, packaging materials and final products fulfil acceptable microbiological quality standards [6].

The microbiological safety of herbal medicines is of particular concern when these products are offered by informal vendors where standardised manufacturing techniques, quality assurance systems and controlled conditions of storage may not be followed. Boiled herbal medications may initially have lower microbial loads, however recontamination might occur after addition of water or other ingredients, transfer into improperly sterilised containers and exposure during vending. The microbiological quality of the final preparation may be affected by contamination during postproduction [7].

Therefore, routine microbiological examination of herbal medications is required to establish their safety and possible sources of contamination. Basic requirements of quality assurance of herbal medicines are cleanliness in harvesting and preparation, appropriate processing processes, safe use of water, adequate cleaning and sterilisation of containers, good storage and routine microbiological quality check. Good Manufacturing Practices (GMP) and proper quality control procedures can further aid to minimise microbiological contamination and assure the safety, consistency and efficacy of herbal medicinal products [8].

In the light of the above, the present study is an assessment of selected herbal medications sold in Owerri, Imo State, Nigeria for microbial contamination. The study also looked into various sources of contamination related to the production, packaging, handling and vending of these items.

MATERIALS AND METHOD

The research was carried out in Owerri, Imo State, southeastern Nigeria. Owerri is the capital of Imo State and is the major commercial and administrative center of the state. The city contains a big population of civil servants, traders, students and other occupational groups. The selection of the study region was based on the usage and availability of herbal medicinal remedies offered by vendors in the metropolis.

Sampling

Forty (40) bottles of beautifully wrapped samples of herbal medication were randomly obtained from hawkers of herbal medicines at designated sites inside Owerri city. The sampling locations were Wetheral Road, Mbaise Road, Douglas Road and Okigwe Road. The herbal remedies were said to be used to cure a number of health ailments including typhoid fever, sexually transmitted diseases, haemorrhoids, stomach aches, diabetes, headaches, skin infections and toothache, among others. The samples were aseptically collected into sterile containers when required and correctly labelled according to their purchasing locations and delivered to the laboratory for microbiological investigation.

Sample Preparation and Inoculation

A 10−1 dilution was prepared by aseptically adding ten millilitres (10 mL) of each liquid herbal medicine sample to 90 mL of sterile peptone water. Following the standard microbiological procedures (Pelczar, 1977) ten-fold serial dilutions were prepared aseptically to obtain a dilution of 10-8. From the correct dilutions, 0.1 ml aliquots of the fourth and fifth dilutions were plated on MacConkey agar and Nutrient agar respectively. An aliquot of 0.1 mL from the fifth dilution

was additionally inoculated onto Sabouraud Dextrose Agar (SDA) to isolate fungus. Inocula were equally disseminated on the corresponding media surface with sterile spreaders. The inoculation plates were incubated under the suitable temperature and time for the recovery of bacterial and fungal organisms (Beishir, 2017).

Preparation of Media

Media Preparation for Nutrient Agar

Weighed 28 g of commercially produced Nutrient Agar and dissolved in 1,000 mL of distilled water in a conical flask. The preparation was blended well and sterilised by autoclaving at 121°C for 15 min. The medium was sterilised and allowed to cool to about 45°C, then aseptically poured into sterile Petri dishes. The plates were allowed to harden, labelled and stored at roughly 4°C until necessary for use.

Sabouraud Dextrose Agar Preparation

Twenty-eight point five grams (28.5g) of commercially prepared Sabouraud Dextrose Agar was weighed and dissolved in 1000mL of distilled water in a conical flask. The medium was mixed well until fully dissolved and then sterilised by autoclaving at 121°C for 15 min. After sterilisation, the medium was allowed to cool to about 45–50°C before being aseptically poured onto sterile Petri plates. The plates were allowed to harden and stored suitably until needed. MacConkey agar was prepared as per the directions of the manufacturer and was used for the selective isolation of Gram-negative enteric bacteria.

Isolation and characterisation of strains

After incubation, bacterial and fungal colonies were counted manually. Microbial load was quantified as colony-forming units per millilitre (CFU/mL) of the liquid herbal medication samples. Representative colonies of bacteria were subcultured on suitable media to obtain pure culture. The isolates were characterised by their colony morphology, Gram staining characteristics, microscopic appearance and biochemical reactions using standard microbiological procedures (Harrigan, 2020). The isolates were identified with reference to conventional bacteriological manuals and identification guides (Barnett, 2018).

Biochemistry Tests

Biochemical tests were carried out for the identification and validation of the bacterial isolates. The tests performed were catalase, coagulase, oxidase, motility, indole, citrate utilisation and Kligler Iron Agar (KIA). These assays were used to identify and confirm suspected bacterial isolates including Staphylococcus aureus, Escherichia coli, Salmonella spp. and Pseudomonas spp.

Catalase Test

The catalase test was employed to identify catalase producing bacteria from non-catalase producing species. Catalase catalyses the decomposition of hydrogen peroxide to oxygen and water.

Procedure: Two drops of hydrogen peroxide were deposited on a clean, dry glass slide. A little quantity of the test colony was emulsified in the hydrogen peroxide using a sterile applicator stick. The formation of bubbles was detected shortly after the preparation. Rapid production of bubbles was viewed as a positive catalase reaction and was indicative of an organism manufacturing catalase. Gram positive cocci that were catalase positive were regarded presumptive for Staphylococcus spp.

Test for Coagulase

Coagulase test was done to identify between coagulase producing Staphylococcus aureus and other Staphylococcus species.

Procedure: A drop of sterile normal saline was placed on a clean, grease-free glass slide and a piece of the test colony was emulsified in it. Plasma was added to the suspension and stirred gently. Visible agglutination or clumping of the preparation was noticed within around 10 seconds. Formation of visible clumps was read as positive coagulase reaction and considered compatible with Staphylococcus aureus when substantiated by the other identification tests.

Test for Oxidase

The oxidase test was used to identify organisms with cytochrome c oxidase and to discriminate oxidase-positive organisms such as Pseudomonas spp., from members of the Enterobacteriaceae, which are usually oxidase negative.

Procedure: A piece of Whatman filter paper was inserted into a sterile petri dish. A filter paper was spotted with two drops of new oxidase reagent. One fraction of the test colony was spread across the area treated with reagent using a sterile applicator. A positive oxidase reaction was indicated by the appearance of a rich purple colour within seconds. The absence of the distinctive hue change was noted as a negative reaction.

Test for Motility (Hanging-drop method)

The motility of the bacterial isolates was determined by the hanging-drop method.

Procedure: A little ring of plasticine about 2 cm in diameter was made on a clean, grease-free glass slide. A drop of broth culture of the test organism was placed on a clean cover slip. The coverslip was then gently placed over the plasticine ring on the slide so that the drop was in the center of the ring. The slide was rotated so that the cover slip was at the top. The preparation was studied microscopically with the ×40 objective. The positive motility reaction was considered to be the directional movement of bacterial cells excluding Brownian motion.

Indole assay

Indole test was performed to examine the capacity of bacterial isolates to generate indole from tryptophan. Escherichia coli is normally indole positive.

Procedure: The test organism was inoculated in a bijou bottle containing about 3 ml of sterile peptone water and incubated aerobically at 37°C for 24 hours. After incubation, a few drops of Kovac's reagent were added and stirred gently. The surface of the soup was observed for the formation of a crimson or cherry-red ring. A positive indole reaction was taken as a crimson ring developing on the surface.

Citrate Utilisation Test

Citrate utilisation test was performed to examine the ability of bacterial isolates to utilise citrate as a sole carbon source.

Procedure: The surface of a prepared Simmons citrate agar slope was inoculated with a sterile wire loop with a light inoculum of the test organism. The infected media was incubated at 37°C for up to 48 h. A shift of the medium from green to vivid blue with apparent growth was regarded as a positive citrate utilisation reaction.

Kligler Iron Agar (KIA) Medium

Kligler Iron Agar was used to discriminate enteric bacteria on the basis of glucose and lactose fermentation, hydrogen sulphide and gas production.

Procedure: The KIA slope was inoculated by piercing the butt and streaking the slant with a sterile wire loop. The medium was incubated at 37 0 C for approximately 24-48 hours. The slant and butt were tested for change in colour, gas generation and hydrogen sulphide formation after incubation. The pattern of reaction was compared with established identifying features for presumptive identification of the isolate.

Isolation of Bacteria Preservation

Representative isolates were stored on Nutrient Agar slants following identification and confirmation biochemical tests. The detected organisms were sub-cultured as pure colonies on the correctly designated Nutrient Agar slants and incubated to establish viable growth. The cultures were then maintained in refrigerated conditions until required for further examination.

Antimicrobial susceptibility profile of bacterial isolates

The antibiotic susceptibility pattern of bacterial isolates were investigated by disc diffusion technique. In brief, standardised solutions of the bacterial isolates were plated onto appropriate agar plates for susceptibility testing. The inoculated agar surfaces were inoculated Aseptically with commercially manufactured antibiotic discs with known doses of selected antimicrobial agents. The plates were incubated under suitable conditions and the zones of inhibition around the antibiotic discs were measured in mm. Results were interpreted using the applicable standard antibiotic susceptibility criteria.

Preparation of McFarland Standard

Concentration of bacterial samples was standardised against a McFarland turbidity standard prior to antibiotic susceptibility testing. The turbidity of each bacterial solution was evaluated visually to the McFarland standard to achieve a generally homogenous inoculum concentration for susceptibility testing.

Antifungal Susceptibility Testing

Fungal isolates were preserved on Potato Dextrose Agar (PDA). The in vitro antifungal activity of the test extracts was studied by agar well diffusion technique. PDA was made, poured into sterilised Petri dishes, and allowed to set. Wells of approximately 6 mm diameter were aseptically drilled in the agar. Different concentrations of the test extracts (30, 40 and 50 µL) were added to the wells using a sterile micropipette. Plates were left to stand for ~ 60 minutes to allow diffusion of the extracts into the agar. The plates were then incubated at 28°C for 48 hours. After incubation, the zones of inhibition around the wells were measured in millimetres and recorded. The larger the zone of inhibition, the more inhibitory action against the fungal isolates in question."

RESULTS

Table 1: Showing the distribution of bacteria isolated from herbal medicine sold at different location in Owerri.

Location	No. of Sample	No. of Positive Cases (%)	No. of Negative cases (%)
Mbaise road	10	6(60)	4(40)
Douglas	10	8(80)	2(20)
Okigwe road	10	7 (70)	3(30)
Weathral road	10	7(70)	3(30)
Total	**40**	**28(70)**	**12(30)**

Table 1 Showing the Distribution of bacteria isolated from herbal medicine sold in different locations in Owerri Municipal with Okigwe road and Weatheral road having the highest number of microorganisms followed by that purchased from Mbaise and Douglas Road have the least number of microorganisms.

Table 2: Showing the occurrence of microorganism isolated from herbal medicine sold in Owerri Municipal

Microorganisms	Number of Isolates	Percentage Occurrence
Salmonella species	6	13%
Escherichia coli	15	31%
Staphylococcus aureus	10	21%
Aspergillus species	6	13%
Pseudomonas species	5	11%
Candida species	5	11%
Total	**47**	**100**

Table 2 Showing the percentage occurrence of bacteria isolated from herbal medicine sold from different locations in Owerri, Escherichia coli has the highest percentage occurrence of 15(31%) followed by *Staphylococcus aureus* 10(21%), *Salmonella spp* has the least percentage occurrence of 6(13%) followed by *Pseudomonas aeruginosa* 5(1 l%), among the fungi organisms Aspergillus species has the highest number of occurrences 6(13%), followed by Candida species which is 5 (11%).

Table 3: Showing the percentage distribution of bacteria isolated at different locations

Location	*E.coli* (%)	*S.aureus (%)*	*Salmonella spp* (%)	*P. aeruginosa* (%)	(%)
Mbaise road	5(33)	3(30)	3(50)	0(0)	11(30%)
Douglas	4(27)	2(20)	0(0)	0(0)	6(17%)
Okigwe road	3(20)	5(50)	3(50)	3(60)	14(39%)
Weathral road	3(20)	0(0)	0(0)	2(40)	5(14%)
Total	**15(100)**	**10(100)**	**6(100)**	**5(100)**	**36(100%)**

Table 4: Showing the percentage distribution of fungi isolated at different lcoations.

Location	No. of Sample	No. of Positive Cases (%)	No. of Negative cases (%)
Mbaise road	2(33)	2(40)	4(36%)
Douglas	4(67)	0(0)	4(36%)
Okigwe road	0(0)	3(60)	3(28%)
Weathral road	0(0)	0(0)	0(0%)
Total	**6(100)**	**5(100)**	**11(100%)**

Table 5: Showing the antimicrobial susceptibility test of *Staphylococcus aureus.*

Antibiotics	No of isolates=10 (S%)	Resistance (R%)
S	10(100)	0(0)
AMX	6(60)	4(40)
RD	7(70)	3(30)
CN	9(90)	1(10)
LEV	8(80)	2(20)
E	5(50)	5(50)
CPX	6(60)	4(40)
CH	1(10)	9(90)
APX	3(30)	7(70)
NB	0(0)	10(100)

KEY

S= Streptomycin, LEV= Levofloxacin, CN= Gentamycin, CH= Chloramphenicol, RD= Rifampicin, AML= Amoxil, APX= Ampiclox, CPR= Ciprofloxacin,
E= Erythromycin, NB= Norfloxacin

Table 6: Showing the antimicrobial susceptibility test of *E.coli, Salmonella spp* and *Pseudomonas aeruginosa.*

Antibiotics	*E. coli* =15		*Salmonella spp*=6		*P. aeruginosa* =5	
	(S %)	(R %)	(S %)	(R %)	(S %)	(R%)
S	13(87)	2(13)	5(83)	1(17)	5(100)	0(0)
OFX	6(40)	9(60)	2(33)	4(67)	3(60)	2(40)
PEF	11(73)	4(27)	6(100)	0(0)	4(80)	1(20)

Antibiotics	*E. coli* =15		*Salmonella spp*=6		*P. aeruginosa* =5	
	(S %)	(R %)	(S %)	(R %)	(S %)	(R%)
NA	9(60)	6(40)	5(83)	1(17)	5(100)	0(0).
SXT	11(73)	4(27)	5(83)	1(17)	3(60)	2(40)
AU	12(80)	3(20)	6(100)	0(0)	' 4(80)	1(20)
CEP	7(47)	8(53)	5(83)	1(17)	3(60)	2(40)
CPX	15(100)	0(0)	6(100)	0(0)	4(80)	1(20)
PN	8(53)	7(47)	5(83)	1(17)	2(40)	3(60)
CN	10(66)	5(34)	6(100)	0(0)	0(0)	5(100)

KEY

S= Streptomycin, CEP= Ceporex, OFX= Tarivid, AU= Augmentin, CN= Gentamycin, NA= Nalidixic acid, SXT= Septrin, PEF= Reflacine, PN= Ampicillin, CPX= Ciprofloxacin.

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
s	Between Groups	754.687	5	145.533	21.330	.001
	Within Groups	41.000	6	6.877		
	Total	786.687	11			
OF X	Between Groups	435.547	5	87.133	19.036	.001
	Within Groups	20.000	6	3.987		
	Total	455.547	11			
PE F	Between Groups	525.667	5	111.138	19.196	.001
	Within Groups	36.000	6	6.373		
	Total	561.667	11			
NA	Between Groups	345.637	5	87.983	48.967	.000
	Within Groups	14.000	6	3.000		
	Total	359.637	11			
SX T	Between Groups	467.767	5	Q3.533	26.560	.000
	Within Groups	20.000	6	3.653		
	Total	497.767	11			
AU	Between Groups	771.667	5	165.333	74.847	.000
	Within Groups	16.000	6	2.876		
	Total	787.667	11			
CE P	Between Groups	491.657	5	96.333	19.267	.001
Within Groups Total		27.000 518.657	6 11	5.000		
CP	Between X Groups	771.647	5	176.333	105.80 0	.000
	Within Groups Total	10.000 871.647	6 11	1.767		
PN	Between Groups	431.867	5	68.333	13.667	.003
	Within Groups Total	35.000 466.867	6 11	5.000		
CN	Between Groups	865.987 36.000	5 6	181.136 6.000	24.182	.001
	Within Groups	901.987	11			
Total						

DISCUSSION

The study was carried out to determine the microbiological quality of some selected herbal medications offered in Owerri, Imo State Nigeria. The results indicated that a high percentage of the analysed products were infected with microorganisms and raised major issues about their microbiological safety and quality. Microbial contamination was found in 28 (70.0%) of the 40 herbal medicines tested. The relatively high risk of contamination indicates that some of the herbal medicines supplied to customers may be contaminated during preparation, processing, packaging, shipping, storage or vending.

The presence of microorganisms in herbal medicines is of public health concern as contamination may degrade product quality and, depending on the organisms involved and the level of contamination, may provide a potential harm to users. However, the presence of microorganisms does not mean that intake of the items was injurious or that the products have no therapeutic value. However, it shows poor microbiological quality and emphasises the importance of improving hygienic standards and quality control during production and distribution [9,10]. The most frequent bacterial isolates obtained were Escherichia coli, Staphylococcus aureus, Salmonella spp. and Pseudomonas aeruginosa. Of

particular importance is the preponderance of E. coli, which is often used as a sign of faecal contamination and may indicate contamination of the herbal preparations through water, raw materials, equipment, containers or handling procedures. The presence of Salmonella spp. is also of great public health concern since some species of this genus are key sources of food- and waterborne illnesses [11]. Similarly, the presence of S. aureus could be a sign of contamination from human handling, especially as the bacterium is frequently found on the skin and mucous membranes. Although P. aeruginosa was recovered less frequently in the present investigation, it is an opportunistic pathogen and its isolation from medicinal formulations is indicative of poor microbiological control.

Aspergillus spp. were the most common fungal isolates followed by Candida spp. Fungi in herbal remedies may arise from environmental exposure, contaminated raw materials, inadequate drying, high moisture content, poor storage conditions and unclean handling. Some species of Aspergillus are able to produce mycotoxins under appropriate environmental circumstances and their detection in medicinal formulations requires adequate quality-control methods. The presence of Candida spp. might also be an indication of contamination during handling or processing [12].

Antimicrobial susceptibility data demonstrated different responses of bacteria isolates to the tested drugs. Streptomycin was shown to be most effective drug against Staphylococcus aureus where 100% isolates were sensitive. This is in line with 100% susceptibility reported by [13]. The susceptibility observed implies that streptomycin was still active against the S. aureus isolates collected in this study. However, antimicrobial susceptibility patterns may vary according to geographical location, prior antimicrobial exposure and features of individual isolates. Therefore, results of susceptibility testing should be interpreted according to the circumstances surrounding the study population.

E. coli was 100% susceptible to ciprofloxacin among Gram-negative bacteria. Salmonella spp. was highly susceptible to pefloxacin, Augmentin, ciprofloxacin and gentamicin. Similarly, P. aeruginosa was found to be mostly susceptible to streptomycin and nalidixic acid with 100% susceptibility reported for the tested isolates. Gentamicin exhibited relatively low resistance among the tested medicines. The findings showed that the bacterial contaminants were not uniformly susceptible to all antibiotics tested, thus highlighting the significance of antimicrobial susceptibility testing when bacterial isolates are collected from possibly contaminated pharmaceutical items [14].

The microbial contamination discovered may be attributed to the use of water in the production and dilution of the herbal remedies. The majority of the sellers interviewed stated that water was sometimes added to the herbal medicines after boiling. Boiling can lower the microbial load greatly, however, recontamination of the product may occur with the addition of contaminated or improperly treated water subsequently. The microbiological safety of the finished preparation thus depends on the quality of the water used in the dilution, filtration or other stages of processing.

Additional contamination may occur through packaging and storage procedures. Bottles and other containers that are not washed properly or sterilised correctly might introduce bacteria into herbal products after processing. Repeated use of containers without proper washing and disinfection may increase the danger of contamination further. In addition, herbal medications hawked are exposed to dust, air, handling and changing environmental conditions which may result in microbial growth [15].

The result of this investigation was in agreement with the results of [16] where the authors found contamination of hawked herbal medications and cited contaminated water and incorrect reuse of containers as probable sources of contamination. Also, it was stated that the presence of microorganisms in herbal products prepared by boiling can be a consequence of postproduction contamination due to the inclusion of water, sugars, preservatives and other chemicals [17]. From these observations it may be concluded that the microbiological safety of herbal medicinal products cannot be assured by heat treatment alone, if post-processing is not carried out under suitable hygienic conditions.

The results stress the need to implement good hygiene measures along the chain of production and distribution of herbal medicines. Vendors and producers should use potable water, keep hygienic preparation surroundings, clean and sterilise containers adequately, minimise unnecessary handling and keep finished items in appropriate conditions. Routine microbiological testing should also be promoted to guarantee that the herbal medicinal preparations fulfil the acceptable microbiological quality criteria before they are made available to the customers [18].

CONCLUSION

The present investigation showed high level of microbial contamination among the herbal medications studied in Owerri, Imo State. Microbial contamination was detected in 28 (70.0%) of the 40 samples examined. The bacterial contamination was Escherichia coli, Staphylococcus aureus, Salmonella spp and Pseudomonas aeruginosa whereas the major fungal contaminants were Aspergillus spp and Candida spp.

The presence of enteric bacteria, especially E. coli and Salmonella spp., suggests possible contamination via water, raw materials, equipment or handling and raises a potential microbiological safety

issue. The presence of fungi also indicates that exposure to the environment and poor storage or handling may be a contributing factor to the degeneration of herbal medical goods.

The study consequently emphasises the need for greater cleanliness in the manufacture, packing, storage and distribution of herbal medicines. Producers and vendors should use potable water for preparation and dilution, clean and sterilise packaging containers appropriately, minimise post-production handling and adopt suitable storage methods. The manufacture and monitoring of herbal medical products should also include regular testing of microbiological quality.

Natural additions such as ginger or lime may have antibacterial effects, but they should not be considered to replace basic sanitation, proven preservation procedures and microbiological quality control. Further studies are necessary to assess the antibacterial properties, concentrations and safety of such additions under standardised circumstances.

REFERENCES

1. Abbaet, D., Inabo, H. I., Yakubu, S. E., & Olontola, S. O. (2019). Contamination of herbal medicinal product marketed in Kaduna metropolis with selected pathogenic bacteria. *African Journal of Traditional, Complementary and Alternative Medicine, 6*(1), 10–11.
2. Coon, J. T., Ernest, E., & Parax, G. (2022). A systematic review of adverse effects and drug interaction. *Drug Safety, 5*, 323–344.
3. World Health Organization. (2020). *Regulatory situation of herbal medicine: A worldwide review* (pp. 238–272).
4. Fasoyiro, E. W., Roberts, C. E., Pearsall, N. N., Anderson, D. G., & Nester, M. T. (2018). *Microbiology: A human perspective* (2nd ed., pp. 434–435). WBC/McGraw-Hill.
5. Adeleye, I. A., Okogi, G., & Ojo, E. O. (2015). Microbial contamination of herbal preparation in Lagos, Nigeria. *Journal of Health, Population and Nutrition, 23*(3), 296–297.
6. Prescott, L. M., Harley, J. P., & Klein, D. A. (2019). *Isolation of pure bacterial culture from specimen: Microbiology international* (4th ed.). WCB.
7. Attitalla, I. H., Sulaiman, G. M., & Alnafea, M. A. (2026). Molecular Detection and Characterization of Antimicrobial Resistance Genes among Multidrug-Resistant Gram-Negative Bacteria Isolated from Clinical Specimens. *International Journal of Applied Medical and Health Sciences, 1*(1), 49-57.
8. Brazilian Pharmacopoeia. (2020). Quality of some herbal medicine in Brazil. *Annals of Modern Medicine, 30*, 90–93.
9. Nwaoguike, M. J., Chan, E. C. S., & Krieg, N. R. (2008). Microbiology: Concepts and applications (1st ed.). *Journal of Microbiology, 2*, 100–105.
10. Okunlola, A., Babatunde, A. A., & Oluwatoyin, A. O. (2017). Evaluation of pharmaceuticals and microbial quality of some herbal medicinal product in South Western Nigeria. *Tropical Journal of Pharmaceutical Research, 61*(1), 661–670.
11. Pelczar, M. J., Jr., Chan, E. C. S., & Krieg, N. R. (2016). *Microbiology* (5th ed., pp. 37–50, 133–146). McGraw-Hill Book Co.
12. Castleman, M. (2011). *The new healing herbs: The classic guide to nature's best medicine featuring the top 100 time-tested herbs*. Rodale.
13. Forest, J. (2004). *Faecel coliforms: Hygienic laboratory manual* (Vol. 36, pp. 2–4). University of Lowa.
14. Tapsel, L. C., Hemphill, I., & Cobiac, L. (2016). Health benefits of herbs and spices. *Medical Journal of Austria, 185*, 14–16.
15. Harrigan, F. W., & MacCance, M. E. (2020). *Laboratory methods in food and dairy microbiology* (8th ed., pp. 7–23, 286–303). Academic Press.
16. Nwachukwu, M. J., & Chan, E. C. S. (2017). Laboratory exercise in microbiology. *Journal of Microbiology, 10*(5), 23–24.
17. Arena, F., & Hazen, K. (2015). Antimicrobial susceptibility, aerobic bacteria. *Journal of Health, 342*(6), 243–255.
18. Barret, B. J., Kafer, D., & Rabago, D. (2019). Assessing the risk and benefits of herbal medicine and overview of scientific evidence. *Alternative Health Medication, 4*, 40–49.