FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 22, November, 2026, pp 272 – 279
DOI: https://doi.org/10.33003/fjs-2026-1022-6391

Physicochemical Quality, Bacteriological Profile and Antibiotic Susceptibility Patterns of Bacterial Isolates from Ogi (Pap) Sold in Ijebu-Jesa, Osun State, Nigeria

***[1]Akinwumi Isaac Tope and [2]Adeosun Tobi Isaiah**

[1]Department of Public Health, Faculty of Allied Health Sciences, Atiba University, Oyo State, Nigeria.
[2]Department of Science Laboratory Technology, Faculty of Sciences, Kanmi Alo Interlink Polytechnic, Osun State, Nigeria.

*Corresponding authors' email: itakinwumi2011@gmail.com Phone: +2348035010353
ORCID ID: https://orcid.org/0009-0004-6501-7038

Received: 06 Oct. 2026
Accepted: 28 Oct. 2026
Published: 01 Nov. 2026

ABSTRACT
Ogi is a traditionally fermented cereal-based food widely consumed in Nigeria, and its quality may vary depending on processing, fermentation and handling practices. This study evaluated the physicochemicalcharacteristics, bacteriological quality and antibiotic susceptibility patterns of bacterial isolates from ogi sold in Ijebu-Jesa, Osun State, Nigeria. Ten ogi samples were obtained from different vendors and analysed for pH, electrical conductivity, total dissolved solids (TDS), salinity and total titratable acidity (TTA). Bacterial isolation and identification were performed using conventional culture and biochemical techniques, while antibiotic susceptibility was assessed using the disk diffusion method. The pH, conductivity, TDS, salinity and TTA ranged from 2.31–3.95, 239–428 µS/cm, 120–217 mg/L, 118–216 mg/L and 0.036–0.396%, respectively. Strong positive correlations were observed among conductivity, TDS and salinity. Total heterotrophic bacterial counts ranged from no detectable growth to 1.0×10^3 CFU/mL. Biochemical characterization presumptively identified *Staphylococcus aureus*, *Escherichia coli*, *Bacillus cereus* and *Pseudomonas flexibilis*. Antibiotic susceptibility testing revealed variations in inhibition zones among the isolates. The findings demonstrated variations in the physicochemical and bacteriological characteristics of commercially available ogi and the occurrence of potentially pathogenic bacteria. Improved hygiene, standardized processing and routine microbiological monitoring are recommended to enhance the quality and safety of ogi sold for human consumption.

Keywords: Ogi; physicochemical properties; bacteriological quality; antibiotic susceptibility; fermented maize; food safety; Ijebu-Jesa

INTRODUCTION

Ogi (also called pap or akamu) is a traditionally fermented cereal gruel prepared from maize, sorghum or millet, and is widely consumed in Nigeria (Sanusi et al., 2024). It serves as a low-cost source of energy and is a dietary staple for infants during weaning, nursing mothers and adults alike (Sanusi et al., 2024). Its sour taste and smooth texture result from spontaneous fermentation driven largely by lactic acid bacteria and yeasts, and recent molecular work on Nigerian Ogi has identified *Lactobacillus and Lactococcus* as the main lactic acid bacterial genera involved (Ozabor et al., 2026). Because Ogi is eaten daily by large numbers of people, including nutritionally dependent infants, its microbiological quality has direct public health consequences.

The safety of Ogi is often assumed to rest on fermentation, since the organic acids produced during microbial metabolism inhibit spoilage organisms and food-borne pathogens (Sanusi et al., 2024). In practice, however, traditional fermentation is difficult to standardise, and its duration and outcome are unpredictable; the same microbial communities that drive fermentation may also include organisms associated with spoilage (Sanusi et al., 2024). Physicochemical indicators such as pH and total titratable acidity (TTA) therefore offer a first, practical check on whether a given product has reached the level of acidity expected of a well-fermented gruel. Conductivity, total dissolved solids (TDS) and salinity may further reflect the ionic load contributed by processing water, ingredients and handling. Together, these parameters describe the chemical environment in which any contaminating bacteria must survive, and they help to explain why products sold in the same locality can differ in microbiological quality.

Acidity, however, does not guarantee safety, and pathogenic bacteria have repeatedly been recovered from Ogi and similar foods. In a study of 80 fermented cereal (pap) samples from three markets in Calabar, *Staphylococcus aureus* and *Bacillus* cereus were isolated at 41.7% and 27.8%, respectively, and the authors called for improved sanitary measures during production and storage (Egbe, 2022). Closer to the present study area, Ozabor et al. (2023) examined ready-to-eat fried foods sold in Osogbo, Osun State, and recovered *Escherichia coli, Salmonella, Shigella, Klebsiella, Proteus* and *Staphylococcus* species, with 60% of the multidrug-resistant isolates carrying shiga toxin genes. These findings show that ready-to-eat foods in Osun State can carry clinically important bacteria, and they raise the question of which organisms may be present in Ogi sold in the same environment.

The organisms most often associated with such products are of recognised health concern. *Bacillus cereus* is frequently linked with starchy foods and is responsible for both diarrhoeal and emetic food-borne illness (Leong et al., 2023), while shiga toxin-producing *E. coli* and *toxigenic S. aureus* are established causes of food-borne disease (Ozabor et al., 2023). *Pseudomonas* species, though less often considered, are opportunistic pathogens that form biofilms and are increasingly regarded as underestimated contaminants of foods such as milk, meat, fruits and vegetables (Li et al.,

2023). Their presence in a food eaten without further cooking, and often by infants, therefore carries potential risk beyond spoilage.

The risk is compounded when contaminating bacteria are also antibiotic resistant. The Global Research on Antimicrobial Resistance project estimated that bacterial antimicrobial resistance was associated with 4.71 million deaths worldwide in 2021, of which 1.14 million were directly attributable to resistance, and that deaths associated with methicillin-resistant *S. aureus* roughly doubled between 1990 and 2021 (GBD 2021 Antimicrobial Resistance Collaborators, 2024). Food is one route by which resistant bacteria reach people. A recent scoping review of ready-to-eat street foods in Africa documented a high prevalence of resistant pathogens and reported 54 distinct resistance genes among them, stressing that such foods are often eaten without further treatment (Onohuean et al., 2025). Antibiotic susceptibility testing of bacteria isolated from commonly consumed foods thus provides evidence relevant to both food safety and antimicrobial stewardship.

This study assessed the physicochemical properties (pH, electrical conductivity, total dissolved solids, salinity and total titratable acidity) of Ogi sold in Ijebu-Jesa, Osun State, Nigeria; enumerated and presumptively identified the associated bacterial isolates; and evaluated their antibiotic susceptibility patterns. It was hypothesized that commercially available Ogi samples obtained from different vendors in Ijebu-Jesa would exhibit variations in their physicochemical characteristics and bacterial contamination levels, while the recovered bacterial isolates would exhibit varying antibiotic susceptibility patterns.

MATERIALS AND METHODS

Study Area and Sample Collection

This study was carried out in Ijebu-jesa, Osun State, Nigeria. Ijebu-Jesa is within Oriade local government area, Osun state. Ten (10) commercially available Ogi samples were randomly purchased from different vendors located within Ijebu-jesa. Immediately after purchase, the Ogi samples were assigned identification codes to ensure easy laboratory identification and traceability. The coded samples were aseptically transferred into sterile containers and placed in insulated ice boxes containing frozen ice packs for transportation immediately to the laboratory. Upon arrival, the samples were stored in a refrigerator at approximately 4°C and analyzed within twenty-four (24) hours of collection to minimize physicochemical deterioration and microbial changes before laboratory examination.

Determination of Physicochemical Parameters of Commercially Sold Ogi Samples in Ijebu-Jesa Metropolis

The physicochemical analyses of the Ogi samples were carried out according to the Official Methods of Analysis of AOAC International (2023). The parameters determined included pH, titratable acidity.

pH

The pH of the Ogi samples were determined using a digital pH meter (Extech Do 700). Prior to use, the pH meter was calibrated using standard buffer solutions of pH 4.00 and pH 7.00 according to the manufacturer's instructions. Approximately 20 mL of each thoroughly homogenized Ogi sample was transferred into a clean 50 mL beaker, after which the electrode of the pH meter was immersed directly into the sample. The reading was allowed to stabilize before the pH value was recorded. After each determination, the electrode was rinsed thoroughly with distilled water and carefully wiped dry using lint-free tissue paper before being used for another sample to prevent cross-contamination. All measurements were carried out at room temperature, and the average value obtained from triplicate determinations was recorded (AOAC International, 2023).

Electrical Conductivity (µS/cm)

Electrical conductivity of the Ogi samples was done with the aid of a multi digital meter (Extech model Do 700). The electrode was immersed into the Ogi sample placed in a beaker. The conductivity readings were carefully read and recorded, the electrode was carefully wiped before and after each electrical measurement (Fubara *et al.,* 2022).

Temperature (°C)

Temperature measurement was done with the aid of a multi digital meter (Extech model Do 700). The electrode was immersed into the Ogi sample placed in a beaker. The temperature readings were carefully read and recorded. The electrode was carefully wiped before and after each measurement (Fubara *et al.,* 2022).

Total Dissolved Solid

Total dissolved solids measurement was done with the aid of a multi digital meter (Extech model Do 700). The electrode was immersed into the Ogi sample placed in a beaker. The total dissolved solid values were carefully read and recorded. The electrode was carefully wiped before and after each measurement (Fubara *et al.,* 2022).

Salinity (%)

Salinity was measured with the aid of a multi digital meter (Extech model Do 700). The electrode was immersed into the Ogi sample placed in a beaker. The salinity readings were carefully read and recorded. The electrode was carefully wiped before and after each measurement (Fubara *et al.,* 2022).

Determination of Titratable Acidity

Total Titratable acidity of the Ogi samples was determined using titrimetric method described by AOAC International (2023). Ten milliliters (10 mL) of each homogenized Ogi sample was measured into a clean conical flask, followed by the addition of 10 mL of distilled water to facilitate mixing. Three drops of phenolphthalein indicator were added, and the mixture was titrated against standardized 0.1 N sodium hydroxide (NaOH) solution until a faint pink color persisted for approximately 30 seconds. The volume of NaOH used was recorded, and titratable acidity was calculated as percentage lactic acid using the equation below:

$$\%\ lactic\ acid = \frac{V\ x\ N\ x\ 0.09\ x\ 100}{W}$$

V = Volume of 0.1 N NaOH used (mL), N = Normality of NaOH, W = Weight (g) or volume (mL) of Ogi sample analyzed and 0.09 = Equivalent weight of lactic acid

Isolation of Bacteria from Ogi Samples

Isolation of bacteria from the Ogi samples was carried out using the spread plate technique as described by APHA (2023). The spread plate method was selected because it permits the enumeration of viable aerobic bacteria and facilitates the isolation of discrete colonies for subsequent identification. (WHO, 2022).

Each Ogi sample was thoroughly mixed to ensure an even distribution of microorganisms before serial dilution. Serial

dilution was performed by aseptically transferring 1 mL of the Ogi sample into a sterile test tube containing 9 mL of sterile distilled water to obtain a 10^{-1} dilution. The suspension was mixed thoroughly using a vortex mixer. Subsequently, 1 mL was transferred into another sterile test tube containing 9 mL of sterile distilled water to obtain a 10^{-2} dilution. This process was repeated successively until a 10^{-5} dilution was achieved (APHA, 2023).

Following serial dilution, 100 µL (0.1 mL) of the 10^{-1} dilution was aseptically dispensed onto the surface of previously prepared and solidified Nutrient Agar (NA), mannitol salt agar and Eosin Methylene Blue (EMB) agar plates. The inoculum was evenly spread over the agar surface using a sterile glass spreader (hockey stick) sterilized with 70% ethanol and flamed before use (Cheesbrough, 2022).

The inoculated plates were appropriately labelled and incubated in an inverted position at 37°C for 24 hours. Following incubation, visible bacterial colonies were counted manually, and the bacterial population was expressed as colony-forming units per milliliter (CFU/mL) using the formula:

$$\text{CFU/mL} = \frac{\text{Number of colonies x Dilution factor}}{\text{Volume inoculated (mL)}}$$

Distinct colonies exhibiting different cultural characteristics such as colony size, color, elevation, margin, texture, opacity, and pigmentation were selected and repeatedly sub-cultured on freshly prepared Nutrient Agar plates using the streak plate method to obtain pure cultures (Cappuccino and Welsh, 2023). Purity of the isolates was confirmed by observing uniform colony morphology after repeated streaking.

Pure bacterial isolates were preserved on double-strength Nutrient Agar slants prepared in sterile bijou bottles. The slants were incubated at 37 °C for 24 hours to allow adequate growth before storage at 4 °C for subsequent morphological, biochemical, antibiotic susceptibility, and molecular analyses (Cheesbrough, 2022).

Morphological and Bacteriological Characterization of Bacterial Isolates collected from Ogi Samples Sold within Ijebu-Jesa, Osun State

Gram Staining

A sterile inoculating loop was used to pick a thin smear from the distinct colony on the media and placed on a clean grease-free slide containing a drop of sterilized water introduced aseptically. The smear was allowed to dry and heat fixed gently by passing it over blue gas flame as described by Cheesbrough (2006). The heat fixed smear was then flooded with crystal violet solution for 60 seconds and rinsed with distilled water. The smear was again flooded with Lugol's iodine for 60 seconds and rinsed with distilled water, 95 % alcohol was poured on the slide until crystal violet was completely washed off; it was then counterstained with Safranin for another 30 seconds and was air dried. The smear was observed under oil immersion objective of the microscope as described by Olusola-Makinde, (2026).

Urease Test

Three ml of sterile Christensen's (modified) urea broth was prepared in Bijou bottle with the aid of sterilized inoculating loop; the Bijou bottle was heavily inoculated with the test organism according to the method of Cheesbrough (2022). The preparation was incubated at 37 °C for 2 days. A pink coloration indicates positive urease test due to break down of urea by enzyme to give ammonia and carbon-dioxide, the release of ammonia makes the medium alkaline as shown by change in color of the indicator pink-red.

Catalase Test

Three drops of 3% hydrogen peroxide was added to the test bacterium on a clean glass slide according to the method of Cheesbrough (2022). Effervescence, bubble formation indicated a positive catalase test.

Indole Test

Three milliliters of tryptone water was placed into different test tubes after which a loopful of the bacterial isolate was inoculated into test tubes, leaving one of the test tubes un-inoculated to serve as control. The test tubes were then incubated at 37 °C for 48 hours. After incubation 0.5 ml of Kovac's reagent was added, it was to stand for 20 minutes. A red ring indicated a positive result while yellow coloration of the surface layer indicated a negative result (Olusola-Makinde, 2026).

Oxidase Test

A piece of filter paper was soaked with few drops of oxidase reagent. A colony of the test organism was smeared on the filter paper using the inoculating loop according to the method of Cheesbrough (2022). If the organism is oxidase producing the reagent will be oxidized to a deep purple color.

Sugar Fermentation Test

Sugar fermentation test was carried out to determine the ability of organism to ferment sugars with the production of acid and/or gas. Sugar indicator broth prepared using peptone water medium containing 0.5% fermentable sugar and 0.01% phenol red to note color change. Ten milliliters of prepared sugar indicator broth dispensed into the test tubes each and Durham tube which would trap gas if produced was inverted carefully into each of the test tubes in such a manner that no air bubble was found. Each of the test tubes was properly covered. The test tubes were sterilized in the autoclave at 121 °C for 15 minutes. After sterilization a loop full of 24 hours' culture of the test organisms was introduced aseptically into the test tube, a test tube was assigned to each labelled organism with respect to assigned sugar. A test tube that was not inoculated with the test organism served as control. The set up was incubated at 37 °C and observed for acid and gas production as described by Cheesbrough, (2022). Yellow coloration indicated acid production while gas production was indicated by displacement of the medium in Durham tube. The sugars used were glucose, fructose and maltose.

Coagulase Test

To differentiate *Staphylococcus aureus* from other *staphylococcal* species, coagulase test was performed using standard laboratory protocols. A loopful of each isolate was emulsified in sterile saline and tested for clumping with rabbit plasma to detect bound coagulase; isolates negative on slide testing were further evaluated using a tube coagulase test (Nakandi *et al.,* 2025).

Citrate Utilization Test

The citrate utilization test was conducted to assess the ability of bacterial isolates to use citrate as the sole carbon and energy source. Simmons' citrate agar slants were inoculated lightly with test isolates and incubated at 35 °C for 24 hours. A positive result was indicated by a color change in the medium from green to blue due to an alkaline shift resulting from citrate metabolism, aligning with biochemical testing principles outlined for bacterial identification (Olusola-Makinde, 2026).

Antibiotic Susceptibility Testing

Antibiotic susceptibility of isolates was determined using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar, following the Clinical and Laboratory Standards Institute (CLSI) guidelines. Bacterial suspensions were standardized to 0.5 McFarland turbidity and uniformly swabbed onto Mueller–Hinton agar plates. Antibiotic-impregnated disks were aseptically placed on the inoculated surface and incubated at 35 °C for 24 hours. After incubation, the diameters of zones of inhibition around the disks were measured in millimeters and interpreted as susceptible, intermediate, or resistant in accordance with CLSI performance standards (Bayot and Bragg, 2024).

RESULTS AND DISCUSSION

Physicochemical Characteristics of the Ogi Samples Sold within Ijebu-Jesa, Osun State.

Table 1.0 shows the pH, electrical conductivity, total dissolved solids (TDS), salinity and total titratable acidity (TTA) of the ten Ogi samples. The pH values ranged from 2.31 to 3.95, indicating that all the samples were acidic. OGI 5 had the highest pH value of 3.95, closely followed by OGI 1 (3.93), while OGI 3 recorded the lowest pH of 2.31. Other pH values were 2.93, 2.64, 2.43, 3.43, 3.20, 3.23 and 3.50 for OGI 2, OGI 4, OGI 6, OGI 7, OGI 8, OGI 9 and OGI 10, respectively.

Electrical conductivity ranged from 239 to 428 µS/cm. OGI 9 recorded the highest conductivity (428 µS/cm), followed by OGI 4 (414 µS/cm) and OGI 3 (371 µS/cm). The lowest conductivity was recorded for OGI 5 (239 µS/cm). Conductivity values for OGI 1, OGI 2, OGI 6, OGI 7, OGI 8 and OGI 10 were 261, 353, 365, 317, 351 and 307 µS/cm, respectively.

The TDS values ranged from 120 to 217 mg/L. The highest TDS was observed in OGI 9 (217 mg/L), while OGI 5 recorded the lowest value (120 mg/L). OGI 4 also had a relatively high TDS of 208 mg/L, followed by OGI 3 (185 mg/L) and OGI 6 (181 mg/L). The remaining values were 126, 172, 158, 176 and 152 mg/L for OGI 1, OGI 2, OGI 7, OGI 8 and OGI 10, respectively.

Salinity ranged from 118 to 216 mg/L, with OGI 9 recording the highest value (216 mg/L) and OGI 5 the lowest (118 mg/L). OGI 4 recorded 207 mg/L, while OGI 3 and OGI 6 recorded 186 and 183 mg/L, respectively. Salinity values of 149, 173, 159, 177 and 154 mg/L were obtained for OGI 1, OGI 2, OGI 7, OGI 8 and OGI 10, respectively.

TTA showed considerable variation among the samples, ranging from 0.036% to 0.396%. OGI 9 recorded the highest TTA (0.396%), whereas OGI 7 had the lowest (0.036%). OGI 2 and OGI 4 each recorded a TTA of 0.198%, followed by OGI 8 (0.162%) and OGI 6 (0.144%). OGI 1 and OGI 3 both had TTA values of 0.108%, while OGI 5 and OGI 10 each recorded 0.090%.

Table 1: Physicochemical Properties of Different Ogi (pap) Samples Sold within Ijebu-Jesa, Osun state

Sample	pH	Conductivity (µS/cm)	TDS (mg/L)	Salinity (mg/L)	TTA (%)
OGI 1	3.93	261	126	149	0.108
OGI 2	2.93	353	172	173	0.198
OGI 3	2.31	371	185	186	0.108
OGI 4	2.64	414	208	207	0.198
OGI 5	3.95	239	120	118	0.090
OGI 6	2.43	365	181	183	0.144
OGI 7	3.43	317	158	159	0.036
OGI 8	3.20	351	176	177	0.162
OGI 9	3.23	428	217	216	0.396
OGI 10	3.50	307	152	154	0.090

TDS: Total dissolved solids, TTA: Total titratable acidity

Relationship between pH and Total Titratable Acidity

Figure 1.0 compares the pH and TTA values of the ten Ogi samples. The pH values ranged between 2.31 and 3.95, while TTA ranged from 0.036% to 0.396%. OGI 5 had the highest pH (3.95) but a relatively low TTA (0.090%), whereas OGI 9 had a pH of 3.23 and recorded the highest TTA (0.396%). OGI 3 had the lowest pH (2.31) with a TTA of 0.108%, while OGI 7 had a pH of 3.43 and the lowest TTA (0.036%). These results demonstrate that variations in pH were not accompanied by a uniform inverse change in TTA across all samples. The figure presents these two acidity-related measurements across the individual samples.

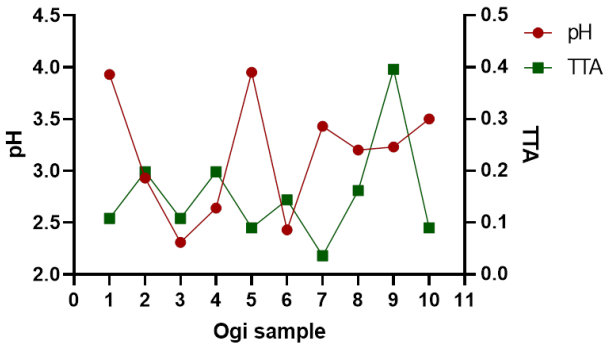


Figure 1: Relationship between pH and total titatable acidity of different Ogi samples sold within Ijebu-Jesa, Osun State

Correlation among Physicochemical Characteristics of the Ogi Samples

The Pearson correlation analysis revealed varying degrees of association among the physicochemical parameters. A strong negative correlation was observed between pH and conductivity (r = -0.75), while pH also showed strong negative correlations with TDS (r = -0.74) and salinity (r = -0.70). In contrast, the relationship between pH and TTA was weak and negative (r = -0.12) and was indicated as non-significant (ns) in the correlation matrix.

Very strong positive relationships were observed among conductivity, TDS and salinity. Conductivity and TDS showed a perfect/near-perfect positive correlation (r = 1.00), while conductivity and salinity had a correlation coefficient of r = 0.98. Similarly, TDS and salinity were strongly positively correlated (r = 0.98). The figure indicates statistical significance for these strong associations.

TTA showed moderate positive correlations with conductivity (r = 0.59), TDS (r = 0.60) and salinity (r = 0.61); however, these relationships were labelled non-significant (ns) in the figure. Thus, conductivity, TDS and salinity exhibited the strongest positive interrelationships among the physicochemical parameters, whereas increasing pH was associated with lower conductivity, TDS and salinity values.

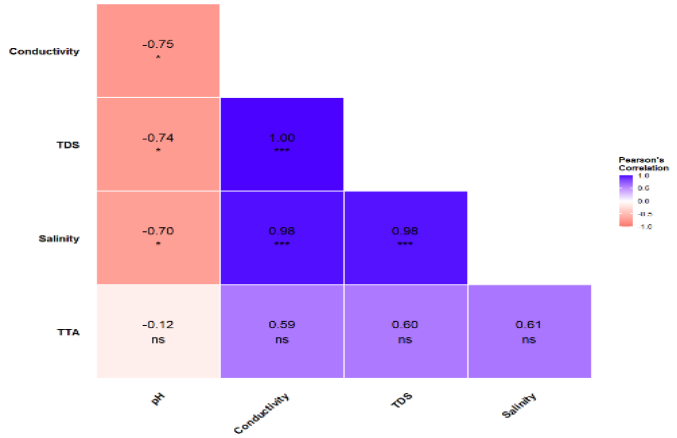


Figure 2: Correlation matrix of physicochemical properties of Ogi samples sold within Ijebu-jesa, Osun State

Bacterial Counts of the Ogi Samples

The bacterial counts of the ten Ogi samples are presented in Table 2.0. Total heterotrophic bacterial count (THBC) varied among the samples, ranging from no detectable growth in OGI 10 to 1.0 × 10^3 CFU/mL in OGI 5 and OGI 7. OGI 1 and OGI 2 each recorded a THBC of 2.0 × 10^2 CFU/mL, while OGI 3 and OGI 4 each recorded 4.0 × 10^2 CFU/mL. OGI 6 had a THBC of 8.0 × 10^2 CFU/mL, whereas OGI 8 and OGI 9 each recorded 5.0 × 10^2 CFU/mL. No THBC was recorded for OGI 10.

For TSC, bacterial growth was detected in only three of the ten samples. OGI 4 recorded 2.0 × 10^2 CFU/mL, OGI 6 recorded the highest TSC of 5.0 × 10^2 CFU/mL, while OGI 8 recorded 3.0 × 10^2 CFU/mL. No detectable TSC was reported for OGI 1, OGI 2, OGI 3, OGI 5, OGI 7, OGI 9 and OGI 10. For TFC, detectable counts were recorded in OGI 7, OGI 8 and OGI 9, each with a count of 4.0 × 10^2 CFU/mL. No detectable TFC was recorded in OGI 1–OGI 6 or OGI 10. Notably, OGI 10 showed no detectable bacterial growth for any of the three bacterial-count categories reported in the study.

Table 2: Total Bacterial Counts of Different Ogi (Pap) Sold within Ijebu-Jesa, Osun State

Samples	THBC (CFU/ML)	TSC (CFU/ML)	TFCC (CFU/ML)
OGI1	2.0 x 10^2	00	00
OGI2	2.0 x 10^2	00	00
OGI3	4.0 x 10^2	00	00
OGI4	4.0 x 10^2	2.0 x 10^2	00
OGI5	1.0 x 10^3	00	00
OGI6	8.0 x 10^2	5.0 x 10^2	00
OGI7	1.0 x 10^3	00	4.0 x 10^2
OGI8	5.0 x 10^2	3.0 x 10^2	4.0 x 10^2
OGI9	5.0 x 10^2	00	4.0 x 10^2
OGI10	00	00	00

THBC: Total heterotrophic bacterial count; TSC: Total staphylococcal count and TFCC: Total faecal coliform count

Biochemical Characteristics and Probable Identity of Bacterial Isolates

Table 3.0 presents the biochemical characteristics used for the probable identification of bacterial isolates recovered from the Ogi samples. Four probable bacterial species were identified: *Staphylococcus aureus, Escherichia coli, Bacillus cereus* and *Pseudomonas flexibilis.* Isolates recovered from OGI 1 and OGI 2 were Gram-positive and positive for catalase, glucose, fructose, maltose, coagulase and citrate tests but negative for oxidase and indole tests. Based on this biochemical profile, the isolates were presumptively identified as *Staphylococcus aureus*. Similarly, isolates

obtained from OGI 5 and OGI 6 showed the same biochemical characteristics and were also presumptively identified as *S. aureus*. Thus, *S. aureus* was associated with four of the samples: OGI 1, OGI 2, OGI 5 and OGI 6. The isolate recovered from OGI 3 was Gram-negative, catalase-positive, oxidase-negative, fermented glucose, fructose and maltose, was negative for coagulase and citrate, and positive for indole. Based on these characteristics, it was presumptively identified as *Escherichia coli*.

The isolate from OGI 4 was Gram-positive and positive for catalase, oxidase, glucose, fructose, maltose and citrate but negative for coagulase and indole. It was presumptively identified as *Bacillus cereus*. Isolates obtained from OGI 7 and OGI 8 were Gram-negative and positive for catalase, oxidase and citrate but negative for glucose, fructose and maltose fermentation, coagulase and indole tests. Based on the biochemical profile reported in the study, these isolates were presumptively identified as *Pseudomonas flexibilis*.

Table 3: Biochemical Properties of Bacterial Isolates from different Ogi Samples Sold within Ijebu-Jesa, Osun State

				Sugar Fermentation						
Isolate Code	**Gram's Reaction**	**Catalase**	**Oxidase**	**Glucose**	**Fructose**	**Maltose**	**Coagulase**	**Citrate**	**Indole**	**Probable Organism**
OGI1, OGI2	+	+	-	+	+	+	+	+	-	*Staphylococcus aureus*
OGI3	-	+	-	+	+	+	-	-	+	*Escherichia coli*
OGI4	+	+	+	+	+	+	-	+	-	*Bacillus cereus*
OGI5, OGI 6	+	+	-	+	+	+	+	+	-	*Staphylococcus aureus*
OGI7, OGI8	-	+	+	-	-	-	-	+	-	*Pseudomonas flexibilis*

Antibiotic Susceptibility Pattern of Gram-Negative Bacterial Isolates

The antibiotic susceptibility patterns of the Gram-negative bacterial isolates, *Escherichia coli* and *Pseudomonas flexibilis,* are presented in Table 4. The inhibition values obtained for E. coli ranged from 0.00 ± 0.00 to 5.00 ± 0.00. The highest inhibition value was recorded against Augmentin (AU), 5.00 ± 0.00, followed by Pefloxacin (PEF), 4.50 ± 0.00. Tarivid (OFX), Ceporex (CEP) and Ciprofloxacin (CPX) each produced inhibition values of 4.00, while Gentamicin (CN) produced 3.00 ± 0.00. Ampicillin (PN) recorded 2.50 ± 0.50, Nalidixic acid (NA) 2.00 ± 0.00, and Streptomycin (S) 1.50 ± 0.50. No inhibition was recorded for Septrin (SXT), with a value of 0.00 ± 0.00.

For *Pseudomonas flexibilis,* the inhibition values ranged from 6.00 ± 0.00 to 17.50 ± 0.50. The highest value was recorded against Ampicillin (PN), 17.50 ± 0.50, followed by Augmentin (AU), 16.50 ± 0.50, Ceporex (CEP), 15.00 ± 0.00, and Gentamicin (CN), 14.50 ± 0.50. Ciprofloxacin (CPX) produced an inhibition value of 12.00 ± 0.00, while Pefloxacin (PEF), Nalidixic acid (NA) and Septrin (SXT) recorded 11.50 ± 0.50, 10.00 ± 0.00 and 8.50 ± 0.50, respectively. Tarivid (OFX) produced 6.50 ± 0.50, while Streptomycin (S) recorded the lowest value of 6.00 ± 0.00.

Table 4: Antibiotic Susceptibility Patterns of Gram-Negative Bacterial Isolates Obtained from different Ogi (pap) samples sold in Ijebu-jesa, Osun State

Bacterial isolates	**OFX (10 mcg)**	**CEP (10 mcg)**	**PN (30 mcg)**	**S (30 mcg)**	**SXT (30 mcg)**	**CPX (30 mcg)**	**AU (30 mcg)**	**CN (10 mcg)**	**PEF (10 mcg)**	**NA (10 mcg)**
E. coli	4.00±0.50	4.00±0.00	2.50±0.50	1.50±0.50	0.00±0.00	4.00±0.00	5.00±0.00	3.00±0.00	4.50±0.00	2.00±0.00
Pseudomonas flexibilis	6.50±0.50	15.00±0.00	17.50±0.50	6.00±0.00	8.50±0.50	12.00±0.00	16.50±0.50	14.50±0.50	11.50±0.50	10.00±0.00

Key: Tarivid (OFX), Ceporex (CEP), Ampicillin (PN), Streptomycin (S), Septrin (SXT), Ciprofloxacin (CPX), Augmentin (AU), Gentamicin (CN), Pefloxacin (PEF), Nalidixic acid (NA)

Antibiotic Susceptibility Pattern of Gram-Positive Bacterial Isolates

Table 5 presents the antibiotic susceptibility patterns of the Gram-positive isolates, *Staphylococcus aureus* and *Bacillus cereus.* For *S. aureus*, the inhibition values ranged from 2.00 ± 0.00 to 19.50 ± 0.50. The highest inhibition value was recorded against Chloramphenicol (CH), 19.50 ± 0.50, followed by Levofloxacin (LEV), 16.50 ± 0.50, and Ciprofloxacin (CPX), 15.50 ± 0.50. Erythromycin (E) produced an inhibition value of 11.50 ± 0.50. Nalidixic acid (NA) and Streptomycin (S) each produced 8.00 ± 0.00, while Amoxicillin (AMX), Rifampicin (RD) and Ampiclox (APX) recorded 6.00 ± 0.00, 4.00 ± 0.00 and 3.00 ± 0.00, respectively. The lowest inhibition value was observed with Gentamicin (CN), at 2.00 ± 0.00.

For *Bacillus cereus*, the highest inhibition value was obtained with Streptomycin (S), 16.00 ± 1.00, while Ciprofloxacin (CPX) and Amoxicillin (AMX) each produced inhibition values of 12.00 ± 0.00. Levofloxacin (LEV) recorded 11.00 ± 0.00, Nalidixic acid (NA) 10.50 ± 0.50, Gentamicin (CN) 9.50 ± 0.00, and Erythromycin (E) 9.00 ± 0.00. Rifampicin (RD) produced an inhibition value of 7.00 ± 0.00, Ampiclox (APX) 6.00 ± 0.00, while Chloramphenicol (CH) produced the lowest value of 5.00 ± 0.00.

The results therefore demonstrate variation in the inhibition values of the Gram-positive isolates across the different antibiotics tested. *Staphylococcus aureus* showed its largest inhibition value with chloramphenicol, whereas *Bacillus cereus* showed its largest inhibition value with streptomycin

Table 5: Antibiotics susceptibility patterns of Gram-positive bacterial isolates recovered from different Ogi (pap) samples sold in Ijebu-Jesa, Osun State

Bacterial Isolates	CH (30 mcg)	CPX (10 mcg)	E (30 mcg)	LEV (20 mcg)	CN (10 mcg)	APX (20 mcg)	RD (20 mcg)	AMX (20 mcg)	S (30 mcg)	NA (10 mcg)
Staphylococcus aureus	19.50±0.50	15.50±0.50	11.50±0.50	16.50±0.50	2.00±0.00	3.00±0.00	4.00±0.00	6.00±0.00	8.00±0.00	8.00±0.00
Bacillus cereus	5.00±0.00	12.00±0.00	9.00±0.00	11.00±0.00	9.50±0.00	6.00±0.00	7.00±0.00	12.00±0.00	16.00±1.00	10.50±0.50

Key: Chloramphenicol (CH), Ciprofloxacin (CPX), Erythromycin (E), Levofloxacin (LEV), Gentamicin (CN), Ampiclox (APX), Rifampicin (RD), Amoxicillin (AMX), Streptomycin (S), Nalidixic acid (N)

The pH values of the Ogi samples examined in this study ranged from 2.31 to 3.95, with OGI 3 having the lowest pH of 2.31 and OGI 5 recording the highest value of 3.95. This finding is comparable with that of Sanya et al. (2023), in which the reported pH values ranged from 3.1 to 4.2 for traditionally processed maize Ogi in Benin.

The acidic pH observed in all the samples was consistent with Owuno et al. (2024), in which pH values ranging from approximately 3.91–4.09 were reported for maize Ogi supplemented with tigernut extract.

The total titratable acidity (TTA) obtained in the present study ranged from 0.036 to 0.396%, with OGI 7 recording the lowest value of 0.036% and OGI 9 recording the highest value of 0.396%. These values were lower than those reported by Itaman and Nwachukwu (2021), in which the obtained titratable acidity values ranged from 0.75% to 1.30%. Similarly, Owuno et al. (2024) reported titratable acidity values of approximately 0.60–0.78% lactic acid in Ogi containing different levels of tigernut extract, which were also higher than the 0.036–0.396% obtained in the present investigation.

The differences in TTA between the present study and these previous reports could be associated with differences in fermentation conditions, formulation and analytical procedures. The comparison is particularly important because the previous studies involved experimentally produced or fortified Ogi, whereas the present study examined Ogi obtained directly from different vendors. Consequently, the products may have been at different stages of fermentation when purchased.

The present study further showed a weak negative correlation between pH and TTA (r = -0.12). Although the relationship was weak and non-significant, its negative direction is consistent with the general trend reported by Itaman and Nwachukwu (2021), in which the pH of fermented Ogi decreased from 4.8 to 4.2, while TTA increased from 0.75 to 1.30%.

Electrical conductivity ranged from 239 to 428 µS/cm, with OGI 5 recording the lowest value and OGI 9 the highest. TDS similarly ranged from 120 to 217 mg/L, while salinity ranged from 118 to 216 mg/L. OGI 9 recorded the highest conductivity (428 µS/cm), TDS (217 mg/L) and salinity (216 mg/L), whereas OGI 5 recorded the lowest values of 239 µS/cm, 120 mg/L and 118 mg/L, respectively.

pH showed negative correlations with conductivity (r = -0.75), TDS (r = -0.74) and salinity (r = -0.70). Thus, samples with lower pH tended to have higher concentrations of dissolved ionic constituents. Recent Ogi studies do not appear to have reported these exact correlation coefficients, so these relationships represent a useful additional observation from the present study rather than something that should be falsely presented as having been reproduced by another researcher.

Staphylococcus aureus was identified in some Ogi samples making it the most widely distributed of the four probable bacterial species identified in the samples. This finding is consistent with the findings of Itaman and Nwachukwu (2021) in which *Staphylococcus aureus* was also isolated from fermented maize Ogi fortified with *Pentaclethra macrophylla*. It also agrees with the study of retail Ogi from Umuahia, in which *Staphylococcus aureus* was among the bacterial species recovered from commercially sold Ogi. The repeated detection of *S. aureus* in food products is not restricted to Ogi. Beshiru et al. (2024) examined 400 ready-to-eat food samples from Delta State, Nigeria and detected methicillin-resistant *Staphylococcus aureus* in 57 samples (14.25%). Although their study specifically investigated MRSA and therefore cannot be used to classify the isolates in the present work as MRSA, it supports the occurrence of *Staphylococcus aureus* in foods handled and sold to consumers (Darlington et al., 2024).

Escherichia coli was presumptively identified in OGI 3. This agrees with the findings of Itaman and Nwachukwu (2021), which also documented the isolation of *Escherichia coli* from fermented maize Ogi. Similarly, *Escherichia coli* was among the organisms isolated from retail Ogi samples examined in Umuahia. The finding is also consistent with more recent Nigerian food-safety studies. Makinde et al. (2026) recovered *E. coli* from ready-to-eat foods sold in Lagos, including cereal-based foods, although the organism had a relatively low overall occurrence in their study. Furthermore, a recent investigation of ready-to-eat foods sold in Akure, Ondo State detected *E. coli* and reported that 68.42% of the recovered *E. coli* isolates were ESBL producers. These findings support the broader food-safety relevance of detecting E. coli in foods sold for human consumption.

Bacillus cereus was presumptively identified from OGI 4. The occurrence of *Bacillus* in Ogi is consistent at the genus level with Itaman and Nwachukwu (2021), in which *Bacillus subtilis* and *Bacillus licheniformis* were recovered from fermented Ogi. Similarly, Bello *et al.* (2024) detected *Bacillus subtilis* in unfortified maize Ogi during their investigation of the effects of *Sorghum bicolor* leaf stalk on the bacterial quality of Ogi.

Pseudomonas flexibilis was presumptively identified in OGI 7 and OGI 8. This finding is consistent at the genus level with the findings of Itaman and Nwachukwu (2021), in which *Pseudomonas aeruginosa,* among other bacterial isolates, was recovered from fermented Ogi.

The generally small inhibition zones recorded for *E. coli* are consistent with recent evidence of reduced antimicrobial susceptibility among food-associated *E. coli in* Nigeria. Makinde (2026) reported that *E. coli* recovered from ready-to-eat foods in Lagos showed 100% resistance to ampicillin and ampicillin/clavulanic acid, while 50% were resistant to gentamicin. This is broadly consistent with the relatively small inhibition zones obtained for ampicillin (2.50 ± 0.50) and gentamicin (3.00 ± 0.00) in the present investigation.

The variable response of *Staphylococcus aureus* to different antimicrobial agents was consistent with Beshiru et al. (2024), in which substantial antimicrobial resistance was documented among food-associated *Staphylococcus aureus* in Nigeria. In their study, 83.54% of MRSA isolates were multidrug resistant, and resistance determinants including *tetM, ermC, mecA* and *mecC* were detected.

Conclusion

This study revealed the variations in the physicochemical and bacteriological quality of Ogi sold by different vendors in Ijebu-jesa, Osun State. All the samples were acidic, while conductivity, TDS, salinity and total titratable acidity varied among the samples. The isolation of *Staphylococcus aureus, Escherichia coli, Bacillus cereus* and *Pseudomonas flexibilis* indicates differences in bacterial quality of the products. The bacterial isolates also exhibited varying inhibition responses to the antibiotics tested. These findings emphasize the need for improved hygiene, standardized processing and appropriate microbiological monitoring during Ogi production, handling and sale to ensure product quality and safety.

REFERENCES

Akintayo, O. A., Balogun, M. A., Bolarinwa, I. F. (2020). Potentials of rice as a suitable alternative for the production of Ogi (a cereal-based starchy fermented gruel). *Journal of Food Science,* 85(8): 2380–2388. https://doi.org/10.1111/1750-3841.15334

Bello, M. O., Teria, R. A., Marcus-Bello, O. A., Gbadamosi, T. A., Adegbehingbe, K. T. (2024). The effects of *Sorghum bicolor* leaf stalk (SBLS) on the bacterial quality of Ogi produced from maize (*Zea mays*). *International Journal of Science and Research Archive*, 11(2): 1405–1413. https://doi.org/10.30574/ijsra.2024.11.2.0584

Beshiru, A., Isichei-Ukah, B. O., Igbinosa, E. O. (2024). Prevalence, characterization, and implications of methicillin-resistant *Staphylococcus aureus* (MRSA) in ready-to-eat foods from Delta, Nigeria: A concern for consumer safety. *Sustainable Microbiology*, 1(1), qvae007. https://doi.org/10.1093/sumbio/qvae007

Cheesbrough, M. (2006). District laboratory practice in tropical countries (2nd ed., Part 2). Cambridge University Press

Darlington, P., Eruteya, O. C., Akomah-Abadaike, O. N. (2024). Occurrence of virulence genes of *Staphylococccus aureus* and *Escherichia coli* in vended foods in selected motor parks in Obio/Akpor, Rivers state. *FUDMA Journal of Sciences*. 8(2):5-14. https://doi.org/10.33003/fjs-2024-0802-2326

Egbe, T. (2022). Bacteriological analysis of fermented cereal flour sold in markets in Calabar Metropolis, Southern Nigeria. *Journal of Infectious Diseases & Travel Medicine, 6*(2), 1–5. https://doi.org/10.23880/jidtm-16000170

GBD 2021 Antimicrobial Resistance Collaborators. (2024). Global burden of bacterial antimicrobial resistance 1990–2021: A systematic analysis with forecasts to 2050. *The Lancet,* 404(10459):1199–1226. https://doi.org/10.1016/S0140-6736(24)01867-1

Itaman, V. O., Nwachukwu, E. (2021). Bacteriological and nutritional assessment of fermented maize (Ogi) fortified with ugba (*Pentaclethra macrophylla*). *Nigerian Journal of Microbiology,* 35(2), 5906–5917. https://doi.org/10.67614/njm.2021.uiblcrpq

Leong, S. S., King, J. H., Korel, F. (2023). *Bacillus cereus*: A review of "fried rice syndrome" causative agents. *Microbial Pathogenesis, 185*, Article 106418. https://doi.org/10.1016/j.micpath.2023.106418

Li, X., Gu, N., Huang, T. Y., Zhong, F., Peng, G. (2023). *Pseudomonas aeruginosa*: A typical biofilm forming pathogen and an emerging but underestimated pathogen in food processing. *Frontiers in Microbiology, 13*, Article 1114199. https://doi.org/10.3389/fmicb.2022.1114199

Makinde, O. M., Akinyemi, M. O., Bezuidenhout, C., Adeleke, R. A., Ezekiel, C. N. (2026). Antibiogram of isolated bacteria and overview of resistome and virulome of multi-drug resistant *Escherichia coli* from ready-to-eat foods vended in Lagos, Nigeria. *BMC Microbiology*. https://doi.org/10.1186/s12866-025-04694-x

Owuno, F., Echem, O., Chisa, P., Ogunbanwo, A. (2024). Effect of tigernut (*Cyperus esculentus*) extract on the physicochemical, nutrient composition and sensory attributes of Ogi. *International Journal of Food Science and Nutrition,* 9(1):25-36

Onohuean, H., Olot, H., Onohuean, F. E., Bukke, S. P. N., Akinsuyi, O. S., Kade, A. (2025). A scoping review of the prevalence of antimicrobial-resistant pathogens and signatures in ready-to-eat street foods in Africa: Implications for public health. *Frontiers in Microbiology, 16*, Article 1525564. https://doi.org/10.3389/fmicb.2025.1525564

Ozabor, P. T., Olumakinde, T. S., Oluokun, T. E., Oladele, J. O., Fadahunsi, I. F. (2026). Biochemical and molecular identification of lactic acid bacteria and yeasts with technological qualities from Ogi (a cereal-based fermented food in Nigeria). *BioTechnologia,* 107(1): 45–56. https://doi.org/10.5114/bta/214383

Ozabor, T., Oluwajide, O., Oni, J., Owolabi, C., Ajani, A., Jayeola, S., Ayoade, F., Olaitan, J. (2023). Bacteriological assessment of fried-ready-to eat (RTE) vended foods sold in Osogbo, Osun State, Nigeria. *Food and Environment Safety,* 22(4):238–247.

Sanusi, J. O. F., Oni, E. O., Fashogbon, R. O., Abdulganiy, S., Badmos, A. O., Olayemi, R. A. (2024). Characterization of fungi (*Aspergillus aculetus*) isolated from fermented Ogi (*Zea mays*) and sorghum (*Sorghum vulgare*) fortified with tigernut (*Cyperus esculentus*). *Journal of Food Safety and Hygiene,* 10(4): 340–355. https://doi.org/10.18502/jfsh.v10i4.19397

Sanya, A. K. C., Madode, Y. E., Schoustra, S. E., Smid, E. J., Linnemann, A. R. (2023). Technological variations, microbial diversity and quality characteristics of maize Ogi used for akpan production in Benin. *Food Research International,* 170, 113038. https://doi.org/10.1016/j.foodres.2023.113038

©2026 This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International license viewed via https://creativecommons.org/licenses/by/4.0/ which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is cited appropriately.