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Antibiotic Susceptibility Profiles of Bacterial Isolates from Locally Produced Drinks in Birnin Kebbi Nigeria

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ABSTRACT
Locally produced ready-to-drink beverages may carry bacteria relevant to food safety and antimicrobial-resistance surveillance. This study described antibiotic susceptibility profiles of bacterial isolates recovered from zobo, ginger and tamarind drinks produced in Birnin Kebbi, Nigeria. Phenotypically characterized isolates were tested by disk diffusion on Mueller–Hinton agar after inoculum standardization to 0.5 McFarland. Seven antimicrobial disks were used: erythromycin, ciprofloxacin, gentamicin, chloramphenicol, amoxicillin–clavulanate (Augmentin), imipenem and ceftazidime. Inhibition zones were measured after incubation at 37°C for 18 h. The susceptibility table reported classifications for 12 taxa. Staphylococcus aureus and Escherichia coli were each reported as 71.43% resistant and 28.57% intermediate, with no susceptible classification across seven agents. Salmonella spp. and Serratia spp. were each reported as 57.14% susceptible. The study provides descriptive phenotypic susceptibility results for bacterial isolates from locally produced drinks.
Keywords: antimicrobial susceptibility; disk diffusion; local beverages; presumptive isolates; Nigeria

INTRODUCTION

Antimicrobial resistance is a global health concern because it can limit treatment options and complicate control of bacterial infections (World Health Organization, 2025). Surveillance depends on reliable organism identification, standardized susceptibility testing and transparent interpretation criteria. Food and beverage systems are relevant to a One Health understanding of resistance because bacteria encountered in products may reflect environmental and handling pathways, although a survey of drink isolates alone cannot establish transmission to humans.

Phenotypic antimicrobial susceptibility testing measures the inhibition of bacterial growth under laboratory conditions after exposure to defined antimicrobial agents. Disk diffusion remains a widely used approach for generating inhibition-zone diameters, with the standardized single-disk method described by Bauer et al. (1966). These measurements can support surveillance when the inoculum, medium, disk content, incubation and interpretation procedures are documented consistently.

Resistance surveillance also depends on separating observed measurements from their interpretation. A zone diameter is a direct laboratory measurement; a susceptible, intermediate or resistant category is assigned by applying an organism–drug breakpoint from a specified standard. An isolate's profile across agents is also distinct from pooled percentages calculated across multiple isolates or taxa. Clear reporting of both levels is necessary for comparison across studies.

Zobo, ginger and tamarind drinks are consumed in Nigeria and are often prepared outside large industrial processing systems. Previous work has described microbial quality and antibiotic susceptibility in local drinks, including zobo and other ready-to-drink products (Makwin et al., 2014; Uwandu et al., 2022). Phenotypic susceptibility tests provide an initial description of bacterial inhibition by selected antimicrobial agents. Standardized susceptibility testing supports comparison of the observed responses across bacterial isolates and beverage studies.

Antimicrobial susceptibility patterns from food and beverage isolates can contribute to local baseline surveillance, particularly where products are prepared and sold through informal channels. These results describe bacteria recovered from sampled products and provide an initial view of their in-vitro responses to the agents tested. They can be considered alongside surveillance from other parts of the food system.

The seven agents selected for the present investigation span different antimicrobial groups used in susceptibility testing. Reporting the individual inhibition zones alongside the categorical summary allows readers to see the measured response profile for each taxon and agent. This presentation is useful for subsequent comparison with other beverage studies that use similar organisms, disk contents and laboratory conditions.

The disk-diffusion approach originally described by Bauer et al. (1966) became a widely used standardized method, while contemporary laboratory practice requires current interpretive criteria and quality-control procedures. Molecular methods can identify genetic determinants of resistance and support epidemiological tracking (Anjum et al., 2017; Fluit et al., 2017), but they do not replace properly performed phenotypic testing. The interpretation of resistance patterns should also distinguish isolate-level resistance from the fraction of drugs to which a single isolate is resistant. A multidrug-resistant designation requires an explicit definition and a clear accounting of tested antimicrobial categories.

This study evaluated the reported antibiotic susceptibility profiles of bacterial isolates recovered from locally prepared drinks in Birnin Kebbi, Nigeria.

MATERIALS & METHODS

Isolates. Bacteria were recovered from 27 prepared drink formulations (12 zobo, 12 tamarind and three ginger) and characterized by culture, Gram staining and biochemical reactions. Susceptibility results are presented for 12 taxonomic groups.

Disk-diffusion testing. Purified isolates were adjusted to a turbidity equivalent to 0.5 McFarland, spread on Mueller–Hinton agar and allowed to stand for approximately 15 min. Disks containing erythromycin (15 µg), ciprofloxacin (5 µg), gentamicin (30 µg), chloramphenicol (10 µg), Augmentin (30 µg), imipenem (10 µg) and ceftazidime (30 µg) were applied. Plates were incubated at 37°C for 18 h, after which inhibition zones were measured with a ruler. Zone diameters were recorded after incubation, and the category labels are presented as listed in the study dataset.

Interpretation and analysis. “NZ” denotes no zone recorded and “NC” denotes no interpretive criterion listed in the study table. Percentages were calculated from the recorded S/I/R calls after excluding NC combinations; n denotes the number of classifiable drug combinations for each taxon.

RESULTS

The inhibition zones varied across taxa and antimicrobial disks (Table 1). The smallest recorded value was 9 mm for imipenem against S. aureus and E. coli, while several combinations were recorded as NZ. Salmonella spp. and Shigella spp. had no erythromycin zones in Table 1, while ciprofloxacin zones were 27 and 29 mm, respectively. S. aureus had zones of 10–16 mm for agents with measurable inhibition and NZ for Augmentin and ceftazidime. E. coli had zones of 9–16 mm and NZ for ceftazidime.

For the Gram-negative taxa, the largest reported ciprofloxacin zones were 29 mm for Shigella spp., 28 mm for Serratia spp. and 27 mm for Salmonella spp. In contrast, the reported ciprofloxacin zone for E. coli was 14 mm. Gentamicin zones ranged from 14 mm in E. coli to 22 mm in Proteus vulgaris. Chloramphenicol zones ranged from 14 mm in Serratia spp. to 22 mm in Micrococcus spp. These measurements are presented individually in Table 1.

Among the Gram-positive taxa, S. aureus had zones from 9 to 16 mm for agents with measurable inhibition, and no zones were recorded for Augmentin or ceftazidime. Staphylococcus epidermidis had zones between 11 and 25 mm across the seven agents. The Enterococcus entries ranged from 10 to 23 mm, while Bacillus subtilis zones ranged from 10 to 23 mm.

Table 1. Reported inhibition-zone diameters (mm) by taxon and antimicrobial disk

Taxon	E	CPX	CN	CH	AU	IMI	CAZ
Salmonella spp.	NZ	27	18	18	19	16	23
Shigella spp.	NZ	29	17	21	17	14	22
Staphylococcus aureus	16	15	10	14	NZ	9	NZ
Serratia spp.	NZ	28	21	14	23	17	NZ
Micrococcus spp.	18	26	18	22	15	13	18
Proteus vulgaris	16	25	22	21	19	15	17
Streptococcus spp.	17	17	19	21	15	22	14
Escherichia coli	16	14	14	15	16	9	NZ
Staphylococcus epidermidis	25	22	17	18	16	12	11
Enterococcus spp.	18	23	21	20	20	10	12
Aerobacter spp.	15	26	18	17	18	10	12
Bacillus subtilis	15	23	15	18	20	10	11

The recorded susceptibility categories for S. aureus and E. coli were each 71.43% resistant and 28.57% intermediate across seven classifiable agents. Salmonella spp. and Serratia spp. were each 57.14% susceptible, 14.29% intermediate and 28.57% resistant. Shigella spp. was 42.86% susceptible, 28.57% intermediate and 28.57% resistant. Streptococcus spp. had the largest intermediate proportion (42.86%). After excluding NC combinations, Proteus vulgaris was 33.33% susceptible, 33.33% intermediate and 33.33% resistant (n = 6); Staphylococcus epidermidis and Enterococcus spp. were each 75.00% susceptible and 25.00% intermediate (n = 4); and Aerobacter spp. was 50.00% susceptible, 16.67% intermediate and 33.33% resistant (n = 6). Micrococcus spp. and B. subtilis had no classifiable entries (Table 2).

Table 2. Categorical susceptibility profile by taxon (% of classifiable agent combinations)

Taxon	S (%)	I (%)	R (%)	n
Salmonella spp.	57.14	14.29	28.57	7
Shigella spp.	42.86	28.57	28.57	7
Staphylococcus aureus	0.00	28.57	71.43	7
Serratia spp.	57.14	14.29	28.57	7
Micrococcus spp.	NC	NC	NC	0
Proteus vulgaris	33.33	33.33	33.33	6
Streptococcus spp.	28.57	42.86	28.57	7
Escherichia coli	0.00	28.57	71.43	7
Staphylococcus epidermidis	75.00	25.00	0.00	4
Enterococcus spp.	75.00	25.00	0.00	4
Aerobacter spp.	50.00	16.67	33.33	6
Bacillus subtilis	NC	NC	NC	0

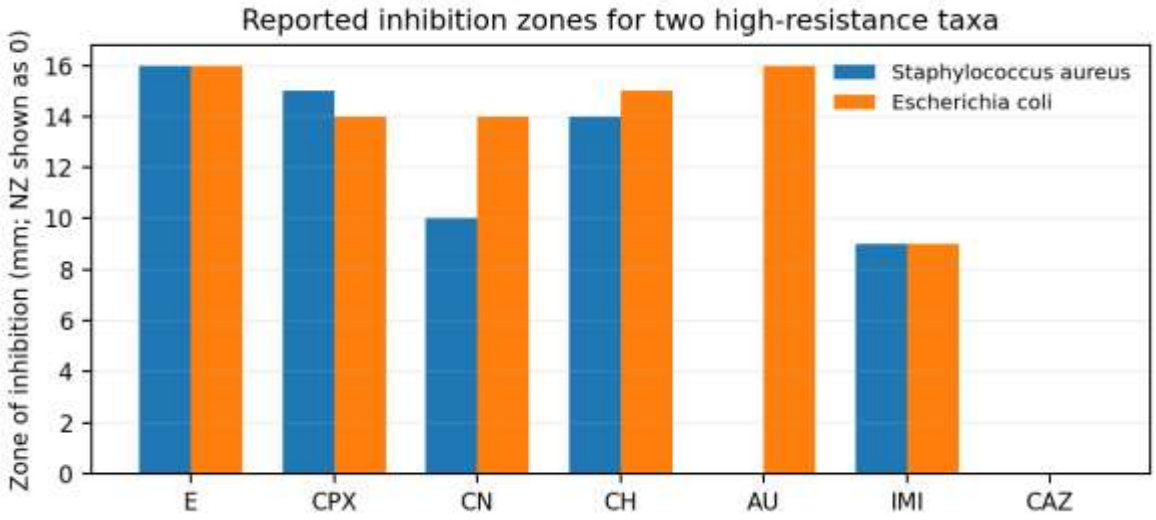

Figure 1. Zones of inhibition for S. aureus and E. coli. For display, no-zone values are shown at the zero baseline.

DISCUSSION

The reported inhibition zones and susceptibility categories varied across bacterial taxa and antimicrobial disks. The study summary identified S. aureus and E. coli as the taxa with the largest reported resistant fractions. Similar antibiotic susceptibility investigations of bacteria isolated from zobo and other Nigerian drinks have been reported (Makwin et al., 2014; Uwandu et al., 2022).

The observed differences across taxa illustrate why the susceptibility profile is best presented at the organism–agent level. Within the study dataset, some agents produced relatively large zones for one taxon and smaller zones for another. The tables therefore preserve the measured diameters and the study's categorical summary as separate results.

Previous Nigerian investigations have also reported antibiotic susceptibility patterns among bacteria isolated from zobo and other local drinks (Makwin et al., 2014; Uwandu et al., 2022). The present work adds results from zobo, ginger and tamarind formulations prepared in Birnin Kebbi. Comparisons across studies are most informative when isolate identification, disk contents, laboratory procedures and interpretation criteria are aligned.

The inhibition-zone measurements provide a descriptive profile of the responses recorded for the tested isolates. Variation in zone size was observed across the antimicrobial agents and taxonomic groups.

Across the 12 taxonomic groups listed in the susceptibility summary, the reported response patterns were not uniform. Several enteric Gram-negative taxa had larger ciprofloxacin zones than the values recorded for E. coli, while the Staphylococcus entries showed differing zone ranges across the tested disks. These contrasts reinforce the value of retaining the organism-specific measurements in addition to a summary percentage. A single pooled resistance estimate would obscure the differences visible in the table and would not indicate which organism–agent combinations contributed to the pattern. The reported categories therefore provide a compact overview, while the inhibition-zone table preserves the detailed observations needed for comparison with future local surveys. Sampling across all three beverage types also broadens the descriptive scope beyond studies focused exclusively on zobo. Further investigations using clearly defined isolate-level sampling and consistent reporting of antimicrobial agents could determine whether the patterns described here recur across production settings and batches.

The reported categorical profiles showed different proportions of susceptible, intermediate and resistant calls among the taxonomic groups. Micrococcus spp. and B. subtilis were listed as NC for all seven agents.

The study describes in-vitro susceptibility patterns for bacteria recovered from beverages. These data characterize the tested isolates and do not address clinical treatment outcomes.

CONCLUSIONS

The study recorded variable antibiotic inhibition zones and reported resistance classifications for bacterial isolates from locally produced drinks. S. aureus and E. coli had the largest reported resistant fractions. These findings provide preliminary descriptive information on phenotypic susceptibility patterns among the tested isolates.

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