

Bacterial and Fungal Contamination of Ice Blocks Sold For Public Consumption in Kano Metropolis, Nigeria

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ABSTRACT

Ice blocks are widely sold in Kano Metropolis, Nigeria, to cool drinks and food and are sometimes consumed directly, yet their microbial quality had not been reported. This study identified the bacteria and fungi present in ice blocks sold for public consumption and compared production sites with vendor locations. A laboratory-based cross-sectional design was used. Twelve ice-block samples (two per location) were collected from three production sites and three vendor locations between 6 and 15 July 2026 and examined by culture-based bacteriological and mycological methods. Total bacterial counts were expressed as CFU/mL, isolates were identified to genus level, and results were analysed descriptively. All 12 samples (100%) showed both bacterial and fungal growth. Total bacterial counts ranged from 5.2×10^3 to 2.1×10^4 CFU/mL and were higher in vendor samples (mean 1.6×10^4 CFU/mL) than in production-site samples (mean 8.5×10^3 CFU/mL); every vendor sample exceeded every production-site sample. Eight bacterial genera were isolated: *Escherichia coli* (91.7%), *Staphylococcus* spp. (83.3%), *Klebsiella* spp. (50.0%), *Enterobacter*, *Proteus* and *Pseudomonas* spp. (25.0% each), and *Salmonella* and *Shigella* spp. (16.7% each); *Salmonella* and *Shigella* were isolated only from vendor samples. Six fungal genera were isolated, led by *Aspergillus* spp. (58.3%) and *Penicillium* spp. (50.0%). Every ice-block sample was contaminated with bacteria and fungi, including faecal indicator bacteria, and contamination was heavier at vendor locations. The findings describe the selected locations and period and are not a test of compliance with a standard. They point to a possible public health hazard, especially for children and immunocompromised people, and support water treatment, equipment hygiene, covered storage and routine regulatory sampling of ice.

KEYWORDS

Ice blocks, microbial contamination, Escherichia coli, fungi, food safety, Kano Metropolis

I. INTRODUCTION

Ice is added to drinks and food and is often swallowed without any further treatment, so any microbes in it reach the consumer directly. Reviews of food ice show that it can carry bacteria, fungi and viruses, and that contamination is linked to source water, equipment, handlers and storage. Locally made ice is usually of poorer quality than industrial ice.

Surveys from several settings report high rates of contamination. In southern Italy, 45.5% of catering ice samples did not meet drinking-water requirements and fungi were found in

95.8% (Caggiano *et al.*, 2020). In Vietnam, *Escherichia coli* was found in 49.4% of edible ice samples from production plants (Tuyet Hanh & Hanh, 2020). In Manila, 25 of 28 ice blocks sold in wet markets (89.3%) were positive for *E. coli* (Salazar *et al.*, 2018). Yeasts and moulds in ice also survive in alcoholic and non-alcoholic drinks (Francesca *et al.*, 2018).

In Nigeria, source water is a particular concern. Groundwater is the main source of drinking water in Kano Metropolis, and borehole water in the metropolis has been reported to contain total coliforms and *E. coli* far above acceptable limits (Mshelia *et al.*, 2025; Musa *et al.*, 2026). Borehole water in Gusau contained *E. coli*, *Salmonella* Typhi and *Shigella* species (Okoye & Nyandjou, 2024). Food safety knowledge among vendors in Kano markets is also low (Ibrahim *et al.*, 2024). Ice made from untreated borehole water and sold on a small scale may therefore carry similar organisms. No study of the microbial quality of ice blocks in Kano Metropolis was found in the literature reviewed.

This paper reports findings from a larger dissertation study on microbial contamination and public health risks associated with ice blocks in Kano Metropolis, focusing on one of its objectives: to identify and describe the bacteria and fungi present in ice blocks produced and sold in the metropolis, to estimate total bacterial counts, and to compare production sites with vendor locations.

II. MATERIAL AND METHOD

A. Study Design and Area

A descriptive cross-sectional design with a laboratory-based microbiological component was used in Kano Metropolis, Kano State, Nigeria. Six locations were chosen on purpose so that both production and vending were represented: three ice-block production sites and three ice-block vendor locations, spread across four Local Government Areas (Table 1). Vendors do not make ice, so for them the water source is the reported source of the water used to make the ice they sell.

Table 1: Sampling Locations, Reported Water Source and Collection Dates

Location	Category	LGA	Reported water source	Collection dates (2026)
Production site A	Production site	Nasarawa	Borehole	6 and 13 July
Production site B	Production site	Kano Municipal	Tap	6 and 13 July
Production site C	Production site	Tarauni	Borehole	6 and 13 July
Vendor location A	Vendor	Gwale	Borehole	8 and 15 July
Vendor location B	Vendor	Nasarawa	Borehole	8 and 15 July
Vendor location C	Vendor	Tarauni	Borehole	8 and 15 July

B. Sample Collection

Two ice-block samples were collected from each location on separate occasions, giving 6 locations × 2 samples = 12 samples. Samples were collected aseptically into sterile, labelled containers with sterile gloves, placed in an insulated cold box and taken to the laboratory without delay. Each sample received a unique code linked to its location, category and

collection occasion. Samples were processed as soon as possible after arrival, using aseptic technique throughout. Samples that were unlabelled, damaged or spoiled in collection or transport were to be excluded.

C. *Bacteriological Examination*

Each sample was melted under controlled laboratory conditions. A 1 mL portion of the melted sample was used for bacterial culture, with serial dilutions in sterile diluent where needed for counting. Nutrient agar was used for total aerobic bacterial counts, MacConkey agar for Gram-negative enteric bacteria and Mannitol Salt Agar for *Staphylococcus* spp. After enrichment, *Salmonella-Shigella* (SS) agar and Xylose Lysine Deoxycholate (XLD) agar were used to recover *Salmonella* and *Shigella*. Plates were incubated at 37 °C for 24 hours. Representative colonies were purified by sub-culture and identified by colony appearance, Gram staining, microscopy and biochemical tests chosen according to the suspected organism: catalase, oxidase, coagulase, mannitol fermentation, indole, methyl red, Voges-Proskauer and citrate (IMViC) tests, urease, and triple sugar iron (TSI) reactions.

Bacterial concentration was calculated as $\text{CFU/mL} = (\text{number of colonies} \times \text{dilution factor}) \div \text{volume plated (mL)}$. For example, 86 colonies from 1 mL of a 10^{-2} dilution gives 8.6×10^3 CFU/mL. Only plates within the countable range were used.

D. *Mycological Examination*

A 100 mL portion of each melted sample was filtered through a 0.45 µm membrane filter, and the membrane was placed on Savoured Dextrose Agar (SDA). Plates were incubated at 25–28 °C for 3–7 days. Growth was examined by eye, and microscopic structures were examined in lacto phenol cotton blue (LPCB) preparations. Moulds were identified from colony appearance and microscopic features, and yeasts such as *Candida* spp. by suitable laboratory methods.

E. *Quality Assurance*

Sterile containers and instruments were used throughout. The same sample code was written on the container, worksheet, and culture plates and data sheet. Separate sterile materials were used for each sample and work surfaces were disinfected between samples. Media were prepared and quality-checked according to laboratory procedures, and media sterility checks and negative controls were used to separate laboratory contamination from organisms truly present in the samples. Only readable plates were used for counts, and every result could be traced to its original sample record.

F. *Data Analysis*

For each organism, percentage positive = $(\text{positive samples} \div 12) \times 100$. A sample could contain more than one organism, so percentages do not add to 100%. Counts were compared as arithmetic means by location and category. Because only 12 samples were examined (six per category), results are presented descriptively and no statistical test was applied.

G. Ethical Considerations

Ethical approval was obtained from the Kano State Ministry of Health before data collection began, and permission was obtained from the owners or managers of the selected locations. Samples were identified by codes.

III. RESULTS

All 12 samples (6 of 6 production-site and 6 of 6 vendor samples) showed both bacterial and fungal growth. No sample was free of microbial growth.

A. Total Bacterial Counts

Total bacterial counts ranged from 5.2×10^3 CFU/mL (Production site B, first collection) to 2.1×10^4 CFU/mL (Vendor location C, second collection) (Figure 1). The mean count was 8.5×10^3 CFU/mL for production-site samples and 1.6×10^4 CFU/mL for vendor samples, with an overall mean of 1.2×10^4 CFU/mL. The vendor mean was about 1.9 times the production-site mean, and every vendor sample (1.3×10^4 to 2.1×10^4 CFU/mL) had a higher count than every production-site sample (5.2×10^3 to 1.2×10^4 CFU/mL). Location means were lowest at Production site B (5.8×10^3 CFU/mL) and highest at Vendor location C (1.95×10^4 CFU/mL). The second collection gave a higher count than the first at all six locations, by about 15% (Vendor location B) to about 54% (Production site C).

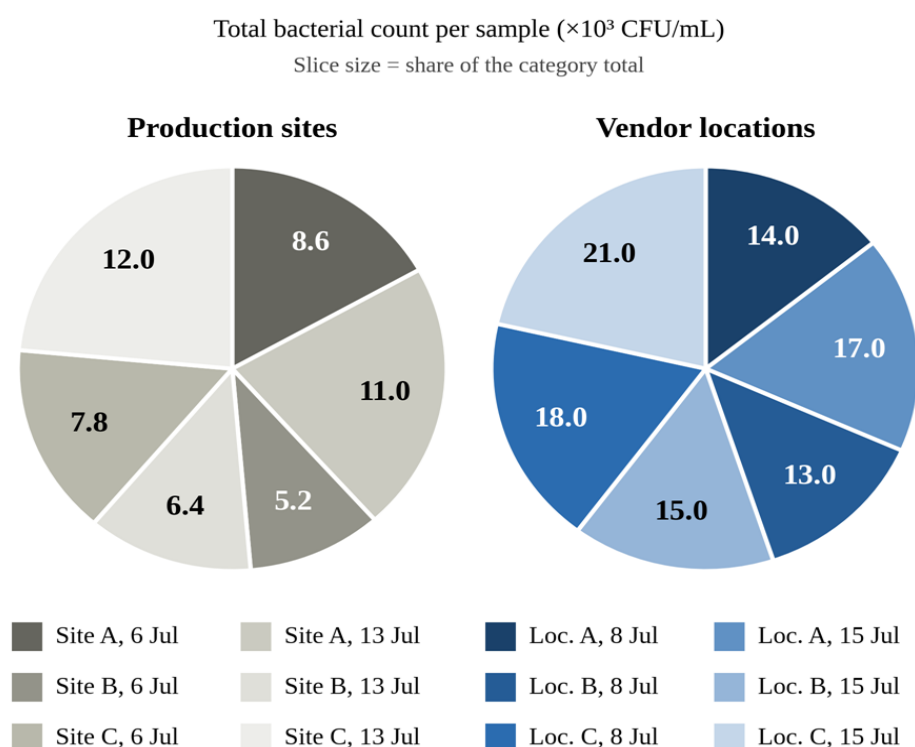


Figure 1: Total bacterial count of each ice-block sample ($n = 12$) by location and collection date, July 2026

B. Bacterial Isolates

Eight bacterial genera were isolated (Figure 2). Every sample carried two to five genera, and 11 of 12 samples (91.7%) carried three or more. Production-site samples carried 2.8 genera on average and vendor samples 3.8; all four samples with four or more genera (two from Vendor location a, two from Vendor location C) were vendor samples.

Escherichia coli was the most frequent isolate, found in 11 of 12 samples (91.7%): five of six production-site samples and all six vendor samples. The only sample without it was Production site B, first collection. *Staphylococcus* spp. followed (10 samples; 83.3%) and then *Klebsiella* spp. (6; 50.0%). *Salmonella* spp. were isolated from two vendor samples (Vendor locations A and C, first collection) and *Shigella* spp. from two vendor samples (Vendor location C, both collections); neither genus was isolated from any production-site sample. Of the 40 bacterial detections, 27 (67.5%) were Enterobacteriaceae (*E. coli*, *Klebsiella*, *Enterobacter*, *Proteus*, *Salmonella* and *Shigella*). Identification was to genus level only.

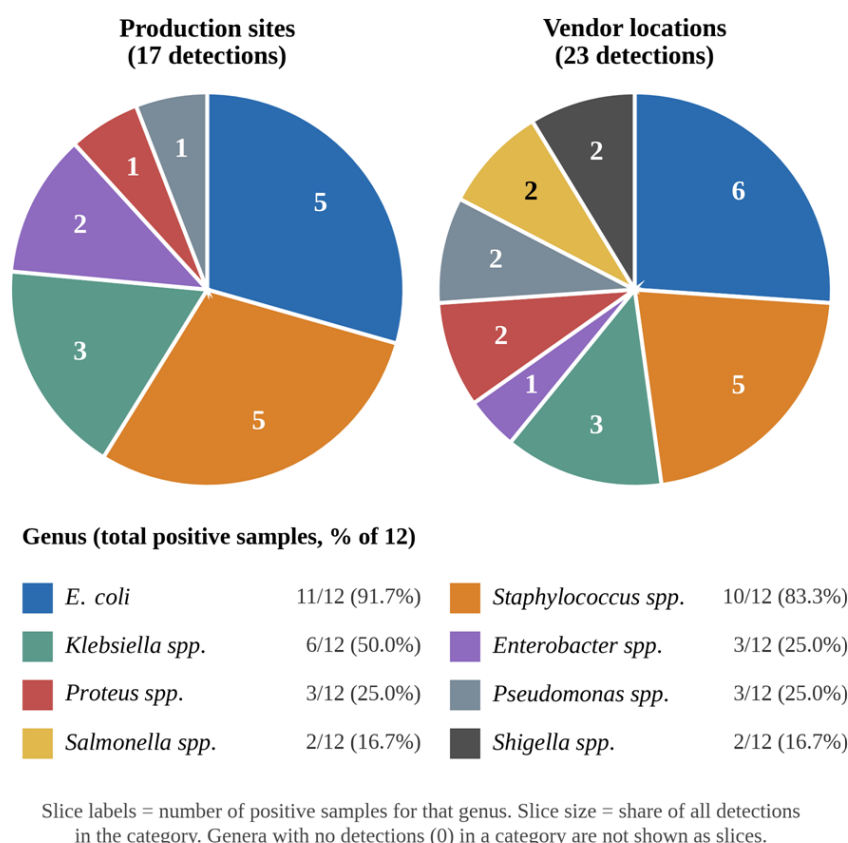


Figure 2: Bacterial Genera Isolated from Ice-Block Samples, by Location Category

C. Fungal Isolates

Six fungal genera were isolated (Figure 3). *Aspergillus* spp. were the most frequent (7 samples; 58.3%), followed by *Penicillium* spp. (6; 50.0%), *Rhizopus* spp. and *Candida* spp. (5 each; 41.7%), *Mucor* spp. (4; 33.3%) and *Fusarium* spp. (3; 25.0%). *Candida* is a yeast and the other five genera are moulds. There were 30 fungal detections in all: 13 in production-site samples (about 2.2 genera per sample) and 17 in vendor samples (about

2.8 per sample). Vendor samples had equal or higher frequencies for every genus, with *Penicillium* and *Mucor* equal in the two categories. Identification was based on colony and microscopic features and not taken to species level.

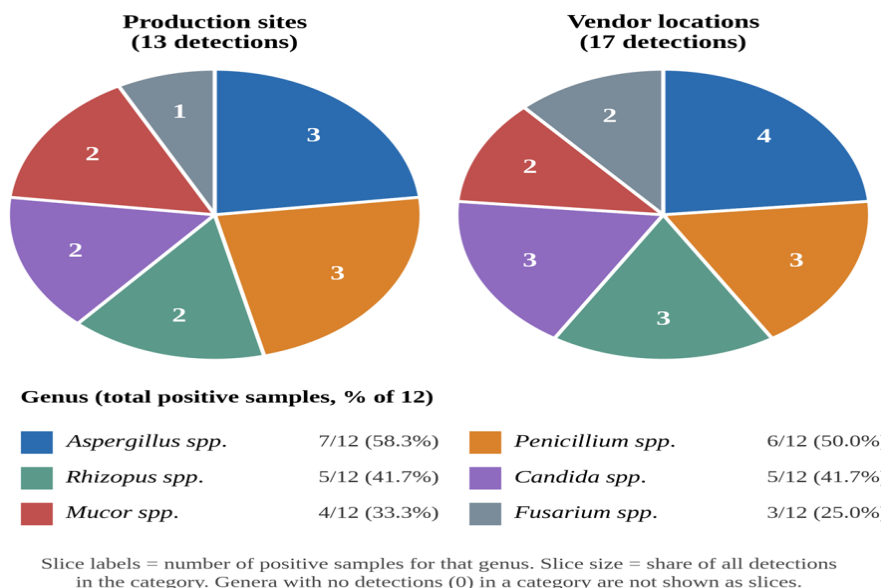


Figure 3: Fungal Genera Isolated from Ice-Block Samples, by Location Category

D. Production Sites Compared with Vendor Locations

Contamination was present in every sample from both categories, but it was heavier and more varied in vendor samples (Figure 4). No statistical test was applied because each category had six samples, and production and vendor locations were sampled on different dates.

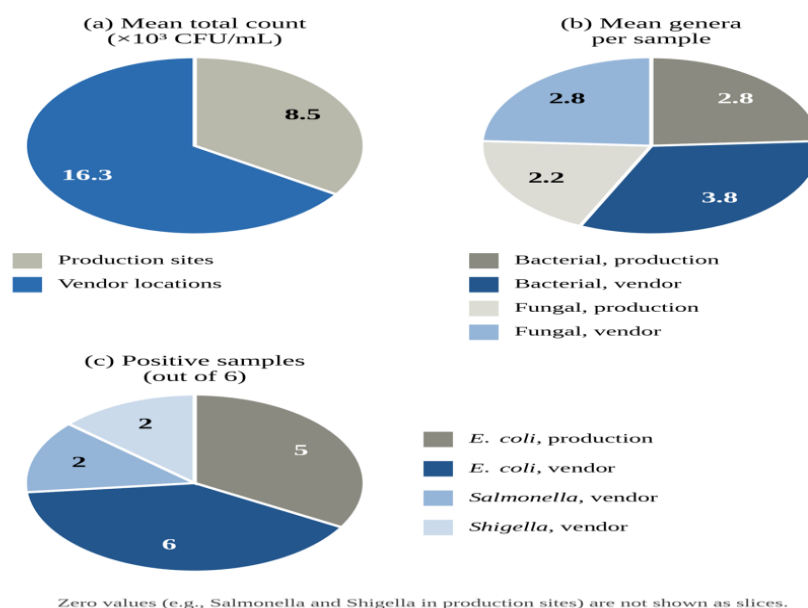


Figure 4: Summary of Contamination Indicators by Location Category

IV. DISCUSSIONS

Every one of the 12 ice-block samples carried bacteria and fungi, and *E. coli* was present in 11. This is the first microbiological description of ice blocks sold in Kano Metropolis that we know of, and it shows a heavy and mixed microbial load in a product that is added to drinks and consumed without further treatment. No standard for total bacterial count in ice blocks was found. For orientation only, a limit of 100 CFU/mL for the mean aerobic plate count of bottled water has been applied in Kano (Iliyasu *et al.*, 2018), and the counts here were roughly 50 to 200 times that figure. That standard is for a different product, so the comparison shows the size of the load and is not a judgement of compliance. Total counts reflect general hygiene (Caggiano *et al.*, 2020). The higher count at the second collection at all six locations should not be read as a trend: there were only two occasions, and production and vendor samples were taken on different dates.

The World Health Organization guideline for drinking-water is that *E. coli* should not be detectable in any 100 mL sample (World Health Organization, 2022). Melted ice is water, so finding *E. coli* in 91.7% of samples is consistent with faecal contamination. Our method identified *E. coli* in melted samples and did not use the 100 mL membrane-filtration procedure on which the guideline is based, so the result is evidence of faecal contamination and not a formal compliance test. The frequency is higher than most published figures. In Manila, 25 of 28 ice blocks from wet markets (89.3%) were positive for *E. coli*, the closest comparison because it also concerns ice blocks in a low- and middle-income setting (Salazar *et al.*, 2018). Reported figures are 49.4% of edible ice samples in Vietnam (Tuyet Hanh & Hanh, 2020), 45.5% of catering ice samples failing drinking-water requirements in southern Italy (Caggiano *et al.*, 2020) and 6.7% of ice samples from food businesses in Turkey (Hampikyan *et al.*, 2017). Machine-made ice from a public supply differs from blocks made by small producers, so these differences should not be over-interpreted.

Staphylococcus spp. (83.3%) are linked to skin and handling. *Klebsiella* spp. (50.0%) were also the most common isolates in groundwater in Kumbotso, Kano (Musa *et al.*, 2026), and *Pseudomonas* spp. are among the bacteria most often reported in ice (Triggiano *et al.*, 2024). Eleven of 12 samples carried three or more genera, a mixed pattern also reported elsewhere (Caggiano *et al.*, 2020). *Salmonella* and *Shigella* were found only in vendor samples (16.7% each of all samples). The same genera have been reported in borehole water in Gusau (Okoye & Nyandjou, 2024), and *Salmonella* has been found in food-contact ice in China (Liao *et al.*, 2023). Their restriction to vendor samples fits extra contamination during storage, transport or vending, but this study cannot show the cause. Because isolates were identified only to genus level, their presence does not prove that any isolate was a disease-causing strain or that any consumer became ill.

Fungal growth in 100% of samples is slightly higher than the 95.8% reported for catering ice in Apulia (Caggiano *et al.*, 2020) and agrees with evidence that yeasts and moulds contaminate ice and survive in drinks (Francesca *et al.*, 2018). *Rhizopus* has also been isolated from street-sold foods in Gombe, northern Nigeria (Ibrahim *et al.*, 2020). Moulds of these genera are common in air, dust and on surfaces, which fits exposure of ice to the production and vending environment. *Aspergillus* and *Candida* are of particular concern for people with weak immune systems (Caggiano *et al.*, 2025). Fungi are rarely studied in ice, so their presence in every sample is a useful contribution of this work.

Contamination was already present at production sites, so ice was contaminated before it reached vendors. Vendor samples nevertheless had higher counts, more bacterial and fungal genera per sample and were the only source of *Salmonella* and *Shigella*. This pattern fits contamination being added along the supply chain, and it parallels the Italian finding that ice was more contaminated than the water it was made from, with storage and machine maintenance as contributing factors (Caggiano *et al.*, 2025). Production site B, the only location reporting tap water, had the lowest mean count and the only *E. coli*-negative sample. This is an observation from two samples at one location with untested tap water, and the ice was still contaminated with bacteria and fungi.

Strengths of the study are the inclusion of both bacteria and fungi, quantitative counts, and sampling at each location on two occasions. Limitations are the small number of samples (12 from six purposively chosen locations), which allowed no statistical testing and limits generalisation; production and vendor samples taken on different dates; collection in July, the rainy season, when borehole contamination may peak (Mshelia *et al.*, 2025); no sampling of the water used to make the ice; genus-level identification without molecular confirmation or antibiotic susceptibility testing; no examination for viruses or chemical contaminants; and no data on illness or ice consumption, so the health risk is possible and not measured. Culture-based methods also detect only organisms that grow under the conditions used.

V. CONCLUSION AND RECOMMENDATIONS

All 12 ice-block samples from three production sites and three vendor locations in Kano Metropolis were contaminated with bacteria and fungi. Total bacterial counts ranged from 5.2×10^3 to 2.1×10^4 CFU/mL and were higher at vendor locations (mean 1.6×10^4 CFU/mL) than at production sites (mean 8.5×10^3 CFU/mL). Eight bacterial and six fungal genera were isolated. *E. coli* was found in 91.7% of samples, which is evidence of faecal contamination, and *Salmonella* and *Shigella* were isolated only from vendor samples. These are findings for the selected locations and period, not a formal test of compliance, and they identify genera and not disease-causing strains. They indicate a possible public health hazard, especially for children and people with weak immunity.

Based on these findings, it is recommended that: (i) producers and vendors treat the water used for ice with a method that kills microorganisms, clean and disinfect equipment daily, wash hands before handling ice and keep ice covered; and (ii) health authorities register, inspect and regularly sample ice producers and vendors, and consider a standard specific to ice blocks. Future studies should sample more locations in both the rainy and hot seasons, test the source water alongside the ice using 100 mL membrane filtration, identify isolates to species level with molecular confirmation and antibiotic susceptibility testing, and examine ice for viruses and chemical contaminants.

DECLARATIONS

Ethics approval: Ethical approval was obtained from Alhikma University Ilorin Kwara State department of Community Medicine and Public Health before the study began.

All the procedure involved such as data handling and analysis were conducted appropriately in accordance with academic and institutional guidelines.

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