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Original Research Article

Microbial assessment of surfaces of canned drinks sold within Federal University of Technology, Owerri, Imo State, Nigeria and its associated health implications

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The qualitative assessment of microorganisms on the surfaces of canned drinks sold within FUTO environment and their health implications were evaluated in this study. A total of twenty canned drinks were collected from the refrigerator and the packs of the retailer's shop. Standard microbiological methods were adopted using Gram staining, biochemical tests, and lactophenol cotton blue staining. Sterile Amies swab sticks, aseptically soaked with tryptone soya broth (Oxoid) were used to swab the upper surfaces of canned drinks which comes in direct contact with the mouth (with an approximate 10cm^2 area). The canned drinks from the refrigerator showed total viable bacterial count which ranged from 2.0 ×10 ^{1} CFU/10cm^2 to 1.4×10^2 CFU/10cm^2 while total fungal count ranged from 2.0× 10 ^{1} CFU/10cm^2 to 4.0 ×10 ^{1} CFU/10cm^2 were recorded. The canned drinks from the packs showed total viable bacterial count ranged from 2.0×10 ^{1} CFU/10cm^2 to 4.0 ×10 ^{2} CFU/10cm^2, total coliform count recorded ranged from 1.0×10 ^{1} CFU/10cm^2 to 4.0 ×10 ^{1} CFU/10cm^2, while total Staphylococci count ranged from 1.0 × 10^1 CFU/10cm^2 to 4.0 × 10^1 CFU/10cm^2. *Corynebacterium, Pseudomonas, Bacillus, Klebsiella* were resistant to Norfloxacin while *Micrococcus species* were resistant to chloramphenicol, Norfloxacin and streptomycin. *Penicillium and Aspergillus* species were resistant to both ketoconazole and fluconazole. The implications of antibiotic resistance on healthcare systems are enormous as resistance leads to the limitation of treatment options. This research demonstrated that no relationship exists between the physical appearance of canned drinks sold at FUTO and its microbial load.

Key words: Canned drinks, microbial contamination, health implications.

INTRODUCTION

A drink can (or beverage can) is a metal container designed to hold a fixed portion of liquid such as carbonated soft drinks, alcoholic drinks, fruit juices, teas, herbal teas, energy drinks, etc. (The Canmaker, 2021). Some drink cans are made of aluminum (75% of worldwide production) or tin-plated steel (The Canmaker, 2021). The spread of infectious diseases is influence by various steps in human civilization such as the canning of drinks. This is because cans which are exposed to various environments during production, storage and transportation may be contaminated with disease causing microorganisms such as *E coli.* Beverages in aluminum cans are readily available,

and for convenience, drinks are often consumed directly from such can. During drinking, one's mouth comes in direct contact with the can lid allowing possible transfer of microorganisms. Infectious diseases are the major cause of human suffering in terms of both morbidity and mortality throughout human history. Infection can be defined as the multiplication of microbes (from viruses to multicellular parasites) in the tissues of the host (Michael, 2012).

Microbes adapt better to new environments than humans (Weiss, 2015). Poor food preparation or preservative methods can enhance microbial growth in such food and apparently infect potential victim. *Escherichia coli* persist in food products such as unpasteurized fruit juice or undercooked meat. The bacteria infection may have fatal consequences in people who are vulnerable, particularly children and the elderly. Each year, millions of people around the world become ill from eating foods or taking drinks that are contaminated (Weiss, 2015). Microbes can cause these illnesses, some of which may be fatal if they have not been treated appropriately (Weiss, 2015). Micro-organisms may be classified into the following large biological groups: Algae, Protozoa, Slime moulds, Fungi, Bacteria, Archaea and Viruses (Pitt &Barer 2012). They can survive under all types of environments, ranging from ice cold climates to hot springs and deserts to marshy lands. Some microbes are acquiring new properties to resist drug treatments that were once effective at destroying them. Drug resistance has become a serious issue around the world today.

Jace (2018) tested soda cans for bacteria and found pretty gross result. The cans tested came from a variety of places, including grocery stores, convenience stores, vending machines and cans stored domestically. It was discovered that all the cans tested had molds. The highest mold count was 6×10^2 colonies of mold and the cans were from a grocery store. A study conducted by Dawson et al. (2018) used ATP- bioluminescence (ATP-B) swabs to test the levels of contamination on the surface of aluminum can lids, as the presence of ATP can indicate the presence of bacteria. Out of the 194 randomly selected cans, 90 (46.39%) had Relative Light Units (RLU) readings of greater than 30 which is in the dangerous unsanitary category, 60 (30.93%) had RLU between 10 and 30 which were considered cautionary and 44 (22.68%) had an RLU of <10 and were categorized as clean. Another study was carried out by Ezemba et al. (2021) to isolate and identify microorganisms from the surfaces of canned and bottled drinks. Out of 64 sample cans not washed, 28 samples were found to contain *Leptospira spp*, by the formation of circular haze or disc formation known as Dinger's ring. Other pathogenic bacteria such as *E. coli (*71.8%,*), Klebsiella (*43.6%*), Enterobacter (*30.9%), *Salmonella (*39.4%) *and Shigella* (22.3%) were also isolated and identified (Ezemba et al., 2021).

The present study to assess the microbial contamination of surface of canned drinks was carried out in a school environment. The findings could therefore help in sensitization and provide knowledge awareness to curtail some disease sources suffered by students of higher institutions resulting from canned drinks.

METHODOLOGY

Study design

Descriptive design study was used for this study where a total of twenty (20) canned drinks comprising (both alcoholic and non-alcoholic brands) were sampled.

Study area:

The study was carried out in Federal University of Technology Owerri (FUTO), Imo State Nigeria.

Data Collection:

Samples of canned drinks were randomly collected at shops within the FUTO environment. For every store or shop, two samples were obtained; each from the refrigerator and the packs. Samples were randomly sourced from ten (10) shops randomly selected within the school premises. Sterile Amies swab sticks, aseptically soaked with tryptone soya broth (Oxoid) were used to swab the upper surfaces of canned drinks which come in direct contact with the mouth (with an approximate $10cm^2$ area). The swab sticks were properly labeled, aseptically packaged and taken to the laboratory for analysis.

All the glasswares used were sterilized using a laboratory hot air oven at temperature of 160°C for 1 hour and the media used was sterilized using the autoclave at a temperature of 121°C at 15psi for 15 minutes. The media were poured into the Petri-dishes when cooled to 45°C and were allowed to solidify. This method was adopted from the work of Cheesebrough (2008).

Isolation of microorganisms from can surface

Culture technique

The damped swab sticks in tryptone soya broth were introduced into a test-tube containing sterile nutrient broth and properly labeled. Each of the test-tubes was shaken and loosely capped. All the samples were prepared using the same procedure. Thereafter, each sample was streaked onto Nutrient agar, MacConkey agar, Eosin methylene blue agar and Mannitol salt agar plates successively.

Inoculation of plates

The swab sticks were introduced into a test-tube containing sterile nutrient broth and properly labeled. Each of the test-tubes was shaken and loosely capped. All the samples were prepared using the same procedure. Thereafter, each of the swabs was streaked onto freshly prepared Nutrient agar (for total viable bacterial count), MacConkey agar and Eosin

methylene blue agar (for total coliform count) and Mannitol salt agar (for total *Staphylococci* count) plates.

Incubation of Cultured Plates and Microbial Plate Count

Bacteria plates were incubated for 24 hours at 37°C for bacterial growth while fungi plates were incubated for 3-7 days at 28°C. After incubation, the colonies that developed on the plates were counted using a hand tally and magnifying lens. Spread plate technique was employed to enumerate coliform, fungi and Staphylococci count. The numbers of colonies counted were expressed as Colony-Forming Unit (CFU/cm^2).

Identification of isolated microorganisms

Colonial Morphology Identification

The method described by Cheesbrough (2008) was adopted in the colonial morphology identification. Presumptive identification of the colonies was done by observing their shape, colour, elevation, edge, surface, consistency and appearance on the media used for isolation.

Purification and Preservation of Isolates

After the Colony counts, bacterial isolates were picked with a wire loop based on their cultural and morphological characteristics. The picked colonies were sub-cultured onto freshly prepared nutrient agar plates to obtain pure cultures. They were further incubated for 24hrs at 37°C. After incubation, pure cultures were stored in McCartney Bottle slants and refrigerated.

Biochemical Test

A serial biochemical test was carried out for the motility test, catalase test, coagulase test, indole test, oxidase test, sugar fermentation test and citrate utilization test.

Health implication of the bacterial isolated form the surfaces of the canned drinks using Antibiogram Technique

Antibiotics susceptibility testing using commercially available antibiotics disk diffusion assay was done for the bacterial isolates. The antibiotic discs containing the following antibiotics were used: chloramphenicol (30 µg), norfloxacin (10 µg), ciprofloxacin (10 µg), amoxicillin (30µg), erythromycin (30 µg), gentamycin (10 µg), levofloxacin (20 µg), streptomycin (30 µg) reflacine (10µg), tarivid (10µg) and ceporex (10µg). The discs were aseptically placed on the surface of Mueller-Hinton agar (MHA) plates that were already seeded with 0.5 McFarland standard of the test isolates and were incubated at 37°C for 18-24hrs.

For the fungal isolates, antifungal susceptibility profiles of the fungal isolates were evaluated using agar well diffusion assay with antifungal drugs such as; Ketoconazole® (200 mg) and Fluconazole® (200 mg). Each of the fungal isolates was carefully streaked onto the surface of Mueller-Hinton agar (MHA) plates supplemented with glucose that has already being seeded with 0.5 McFarland standard of the test isolates. Thereafter, 6 mm cork borer was used to make a 6 mm agar well in the streaked petri-dishes containing the test fungal isolates. 0.1 ml each of the antifungal drug suspensions was pipetted and dropped into each of the wells made. The plates were labeled accurately and incubated at 30±2 °C for 5 days.

After incubation, diameters of zone of inhibitions were observed and measured in millimeters accordingly. The interpretation of the measurement as sensitive and resistant was made according to the manufacturer's standard zone size interpretative table (NCCLS, 2004).

Statistical Analysis

The obtained data in this research were exposed to version 21.0 of SPSS statistical package. Descriptive statistics were employed to both determine the level of contamination as well as the susceptibility profile of obtained isolates.

RESULTS

Microbial plate count of the surfaces of the canned drinks

Table 1 showed the results of the microbial plate count from the surfaces of the canned drinks sold within the Federal University of Technology, Owerri. All the samples showed total viable bacterial count. Out of twenty (20) samples analyzed, four (4) had coliform and Staphylococci counts while fourteen (14) had fungal counts. For the canned drinks from the refrigerator, the total viable bacterial count ranged from 1.4 x 10^2 CFU/10cm^2 to 6.0 x 10^1 CFU/10cm^2. There was no coliform count and total Staphylococci count recorded. Total fungal count ranged from 2.0 x 10^1 CFU/10cm^2 to 4.0 x10^1 CFU/10cm^2. For the canned drinks from the packs, the total viable bacterial count ranged from 1.0 x 10cm^2 CFU/10cm^2 to 8.0 x 10^1 CFU/10cm^2. Total coliform count recorded ranged from 1.0 x 10^1 CFU/10cm^2 to 4.0 x 10^1 CFU/10cm^2 while total Staphylococci count ranged from 1.0 x 10^1 CFU/10cm^2 to 4.0 x 10^1 CFU/10cm^2. Total fungal count ranged from 2.0 x 10^1 CFU/10cm^2 to 8.0 x10^1 CFU/10cm^2.

Cultural morphology, Gram staining and biochemical characterization of the bacterial isolates from the surfaces of the canned drinks

From Table 2, the cultural morphology, Gram staining and biochemical characteristics of the bacterial isolates from the canned drinks were shown. A total of seven (7) bacterial isolates, comprising four (4) Gram-positive and three (3) Gram-negative bacteria were isolated. The Gram-

Table 1. Microbial plate count of the surfaces of the canned drinks

Samples/Vendors	TBVC (CFU/cm^2)	TSC (CFU/cm^2)	TCC (CFU/cm^2)	TFC(CFU/cm^2)
Non-alcoholic (From Refrigerator)				
A	2.0×10^2	NG	NG	NG
B	6.0×10^1	NG	NG	NG
C	1.2×10^2	NG	NG	NG
D	8.0×10^1	NG	NG	3.0×10^1
E	1.0×10^2	NG	NG	NG
Non-alcoholic (From Packs)				
A	2.6×10^2	1.0×10^1	NG	3.0×10^1
B	4.2×10^1	NG	3.0×10^1	4.0×10^1
C	1.8×10^2	NG	NG	6.0×10^1
D	1.6×10^2	3.0×10^1	NG	3.0×10^1
E	2.0×10^2	NG	4.0×10^1	8.0×10^1
Alcoholic (From Refrigerator)				
A	1.4×10^2	NG	NG	4.0×10^1
B	4.0×10^1	NG	NG	3.0×10^1
C	1.4×10^2	NG	NG	NG
D	6.0×10^1	NG	NG	2.0×10^1
E	4.0×10^1	NG	NG	NG
Alcoholic (From Packs)				
A	6.0×10^2	NG	NG	2.0×10^1
B	1.0×10^2	2.0×10^1	NG	3.0×10^1
C	1.4×10^2	NG	1.0×10^1	4.0×10^1
D	2.4×10^2	NG	2.0×10^1	6.0×10^1
E	8.0×10^1	4.0×10^1	NG	2.0×10^1

Key: NG = No growth
TVBC = Total viable bacterial count
TCC =Total coliform count
TFC =Total fungal count
TSC = Total Staphylococci count
cfu= Colony forming unit
A – E = Canned drink samples from different vendor

positive bacteria include; *Bacillus, Staphylococcus, Corynebacterium* and *Micrococcus* species while Gram-negative bacteria were: *Pseudomonas, Klebsiella* and *Proteus* species.

Frequency and percentage occurrence of the bacterial isolated from the surfaces of the canned drinks

From Table 3, *Bacillus* species had the highest bacterial occurrence (27.0%) followed by *Pseudomonas* species (18.9%) while *Proteus* species had the least occurrence (8.1%). Surfaces of non-alcoholic canned drinks collected from the packs had the highest bacterial occurrence (70%). *Bacillus* species were isolated from all the surfaces of both alcoholic and non-alcoholic packs of the canned drinks. *Proteus* species were isolated from three (3) out of twenty (20) samples used.

Cultural morphological and microscopic characteristics of the fungal isolates from the surfaces of the canned drinks

A total of four (4) fungal were isolated. They include; *Mucor, Aspergillus, Penicillium* and *Rhizopus* species as shown in Table 4.

Frequency and percentage occurrence of the fungal isolates from the surfaces of the canned drinks

From the study, *Aspergillus* species had the highest fungi occurrence (40.7%) followed by *Mucor* species (25.9%) while *Penicillium* species was the least occurring fungi 3(11.1%). Surfaces of non-alcoholic canned drinks collected from the packs had the highest fungi occurrence (11) followed by that of alcoholic drinks collected from the packs (9). Surfaces of alcoholic canned drinks collected from the refrigerator had the least fungi occurrence (2). This was shown in Table 5.

Health Implications of the Bacteria Isolated from the Surfaces of the Canned Drinks

The health implications of the bacterial isolates were determined through the susceptibility of the bacterial isolates to commercial antibiotics (Table 6). The zones of inhibition recorded with the antibiotics against the Gram-

Table 2. Identification and characterization of the bacterial isolates from the surfaces of the canned drinks

Morphological Characteristics	Gram reaction	Oxidase test	Indole test	Spore test	Catalase test	Citrate test	Coagulase test	Motility test	S FT				Possible bacteria
									S	B	G	H_2S	
flat, rhizoid-like dry-surface colonies	Gram-positive rods in short chains	-	-	+	+	-	-	-	Y	Y	+	-	*Bacillus* species
Bluish-green, flat, non-mucoid colonies	Gram-negative rods in diploids	+	-	-	+	-	-	+	R	R	-	-	*Pseudomonas* species
Milkish, raised, non-mucoid colonies	Gram-positive rod	-	-	-	+	-	-	-	No Reaction	No Reaction	-	-	*Corynebacterium* species
Pale, flat, non-mucoid elongated colonies	Gram-negative rods in short chains	-	+	-	-	+	-	+	R	Y	+	+	*Proteus* species
Yellowish, raised, non- mucoid colonies	Gram-positive cocci in clusters	-	-	-	+	-	+	-	No Reaction	No Reaction	-	-	*Staphylococcus* species
raised, non-mucoid circular colonies of about 3mm in size	Gram-positive cocci in pairs	-	-	-	+	-	-	-	No Reaction	No Reaction	-	-	*Micrococcus* species
Pinkish, raised, mucoid enlarged colonies	Gram-negative rods in short chains	-	-	-	+	+	-	-	R	Y	-	-	*Klebsiella* species

KEY: - = Negative + = Positive S = color of slope B = color of butt G = Gas production H_2S = Hydrogen sulphide production (blackening) R = Reddish coloration (alkaline production) Y= Yellow coloration (Acidic production) SFT= Sugar fermentation test

Table 3. Frequency occurrence of the bacterial isolates from the surfaces of the canned drinks

Bacteria Species	AF	AP	NAF	NAP	Total	Percentage(%)
Micrococcus species	0	2	0	3	5	13.5
Corynebacterium species	1	1	0	2	4	10.8
Pseudomonas species	2	2	2	1	7	18.9
Proteus species	0	1	0	2	3	8.1
Staphylococcus species	0	2	0	2	4	10.8
Bacillus species	0	5	0	5	10	27.0
Klebsiella species	0	2	0	2	4	10.8
	3	15	2	17	37	100

Key
% = Percentage occurrence
AF = Surfaces of alcoholic canned drinks from the refrigerator
AP = Surfaces of alcoholic canned drinks from the packs
NAF = Surfaces of non-alcoholic canned drinks from the refrigerator
NAP = Surfaces of non-alcoholic canned drinks from the packs

Table 4. Identification and characterization of the fungal isolates from the surfaces of the canned drinks

Cultural morphology	Microscopy	Possible fungi
Green brown and white surface, and short aerial mycelium.	Filamentous, septate conidia	*Penicillium* species
Whitish, fluffy raised colonies that covered the plate	Non-septate hyphae with spores at one end	*Rhizopus* species
Whitish, fluffy, enlarged colonies with grey powdery surface	Non-branched hyphae	*Mucor* species
Dark-brown, enlarged, circular smooth-edged powdery colonies with light yellow reverse.	Septate globose hyphae	*Aspergillus* species

Table 5. Frequency occurrence of the fungal isolates from the surfaces of the canned drinks

Fungal Species	AF	AP	NAF	NAP	Total	Percentage
Aspergillus species	3	3	1	4	11	40.7
Penicillium species	0	1	0	2	3	11.1
Mucor species	1	3	0	3	7	25.9
Rhizopus species	1	2	1	2	6	22.2
Total	5	9	2	11	27	100

Key: % = Percentage occurrence
AF = Surfaces of alcoholic canned drinks from the refrigerator
AP = Surfaces of alcoholic canned drinks from the packs
NAF = Surfaces of non-alcoholic canned drinks from the refrigerator
NAP = Surfaces of non-alcoholic canned drinks from the packs

Table 6. Health Implications of the Bacteria Isolated from the Surfaces of the Canned Drinks

Organisms	Zones of inhibition (mm)/Antibiotics used									
	NB	CH	CPX	E	LEV	CN	RD	AMX	S	APL
Staphylococcus species	26	28	28	28	30	28	28	28	24	26
Klebsiella species	14	18	15	26	25	18	26	18	24	20
Bacillus species	14	18	15	24	25	18	26	18	24	20
Corynebacterium species	-	30	25	30	30	28	25	18	18	20
Pseudomonas species	-	30	25	30	30	28	25	18	18	20
Proteus species	-	30	25	30	30	28	25	18	18	20
Micrococcus species	-	-	15	28	22	22	20	20	-	10

Key: mm = millimetre
- = No inhibition
mcg = microgram
CLSI standard = Clinical laboratory standard institute
R= Resistant (0-12mm)
I= Intermediate (12-16mm)
S= Susceptible (16mm and above)
NB = Norfloxacin (10mcg) CH = Chloramphenicol (30mcg)
CPX = Ciproflax (10mcg) E = Erythromycin (30mcg)
LEV = Levofloxacin (20mcg) CN = Gentamycin (10mcg)
RD = Rifampicin (20mcg) AMX = Ampiclox (20mcg)
S = Streptomycin (30mcg) APL = Amoxil (20mcg)

positive bacterial isolates ranged from 14mm to 30mm. Levofloxacin antibiotic was the most effective antibiotics against the bacterial isolates. *Staphylococcus* species were the most susceptible bacterial isolate compared to the other isolates. Norfloxacin showed no zones of inhibition against *Corynebacterium, Pseudomonas, Bacillus, Klebsiella;* while *Micrococcus* species were resistant to chloramphenicol, Norfloxacin and streptomycin.

Health Implications of the Fungi Isolated from the Surfaces of the Canned Drinks

The health implications of the fungi isolates were determined by testing their susceptibility to antifungal drugs. The zones of inhibition recorded ranged from 10mm to 24mm with ketoconazole and 12mm to 28mm with fluconazole. *Penicillium* and *Aspergillus* species were

Table 7. Zones of Inhibition of Antifungal Drugs against the Fungal Isolates from the Surfaces of the Canned Drinks

Organism	Antifungal drugs/Zones of inhibition (mm)	
	Ketoconazole	Fluconazole
Mucor species	24	28
Aspergillus species	12	14
Penicillium species	10	12
Rhizopus species	18	24

Key: mm = millimetre CLSI guidelines = Clinical laboratory standard institute
R = Resistant (0-12mm) S = Susceptible (16mm and above)

resistant to both ketoconazole and fluconazole antifungal drugs. This was depicted in Table 7.

DISCUSSION

The findings of this study showed that surfaces of canned drinks can be readily contaminated irrespective of whether they are kept in the refrigerator or in packs. It showed that the cans from the refrigerator and the packs had viable bacteria on them. This was consistent with the findings of Michaels et al. (2003) which noted that there was no correlation between the visual appearance of cleanliness on the tops of aluminum cans and the level of microbial contamination. Kigighai and Jonathan (2012) carried out microbiological survey of non-alcoholic carbonated beverages. The researchers reported the presence of bacterial pathogens such as *Staphylococcus, Bacillus, Enterococcus, Micrococcus Proteus* and *Pseudomonas* species which are of public health significance. The study reported that an effective way to clean the surface on the can lids was to rinse the can top and then wipe it with either a paper towel or a napkin. FDA (2015) equally reported the isolation of certain microorganisms from refrigerators. The findings of Ogofure et al. (2018) further supported this research finding. The researchers discovered that the surfaces of canned drinks tested were contaminated irrespective of whether they were kept in the refrigerator or not.

The frequency and percentage occurrence of the bacterial isolates from the surfaces of the canned drinks were analyzed. *Bacillus* species had the highest bacterial occurrence (27.0%) followed by *Pseudomonas* species (18.9%). *Bacillus* species were isolated from all the surfaces of both alcoholic and non-alcoholic packs of the canned drinks. Since the early 1970s, several reports have implicated *Bacillus* species other than *B. cereus* as the cause of foodborne disease, mainly involving species were *B. subtilis* group (*B. subtilis, B. pumilus, and B. licheniformis*) (Christopher, 2015). *Bacillus* species produce endospores that can resist heat, cold, radiation, and chemical treatments (Samuel, 1996). The Gram-positive bacteria isolated were; *Bacillus, Staphylococcus, Corynebacterium* and *Micrococcus* species. The isolated Gram-negative bacteria were; *Pseudomonas, Klebsiella* and *Proteus* species. Similar bacterial isolates were reported by Ogofure et al. (2015) from surfaces of canned drinks sold in Ugbor, Benin City. Their results reported the isolation of *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Bacillus cereus, Bacillus* species and *Enterococcus* species. The researchers discovered that the isolated organisms were of public health importance and are multi drug-resistant pathogens. These bacteria species on the surface of canned drinks sampled could get there through food products stored in the refrigerator or as a result of the vendor's poor personal hygiene practices. The presence of *P. aeruginosa* could be attributed to improperly packed food sources (raw milk). This organism has been shown to grow inside the refrigerator due to incessant power outages and inconsistent power supply (Ogofure et al., 2015). Moreover, most of these refrigerators were not adequately sanitized. Surface contamination observed is a clear reflection of the poor hygienic practices of the vendors as well as the surrounding environmental conditions which favour the survival and proliferation of the bacterial pathogens. *Klebsiella* species is widely or generally regarded as an indicator of fecal contamination. This implied unhygienic practices among the retailers. This bacterium can be sourced from the nose and excreta. It might have been introduced into the surfaces of the canned drinks through nose drilling with the hands of the retailers and subsequent touching of the surfaces of the cans.

Frequency and occurrence of the fungal isolates from the surfaces of the canned drinks showed that *Aspergillus* species had the highest fungi occurrence (40.7%). Surfaces of non-alcoholic canned drinks from the packs had the highest fungi occurrence (11) followed by that of alcoholic drinks collected from the packs (9). Diseases associated with *Aspergillus* species included invasive pulmonary aspergillosis, aspergilloma and different forms of hypersensitivity diseases such as allergic asthma, hypersensitivity, pneumonitis, and allergic bronchopulmonary aspergillosis (ABPA) (Latge, 1999). There is considerable concern regarding the potential health outcomes of exposure to biological materials existing in the air. Molds constitute an important threat to human health; their effects range from moderate allergies and severe asthma to disseminated infections (Ammann, 2002).

Fungal counts recorded in this study could be as a result of the air quality of the environment where these canned drinks were displayed for sale in the shops. Fungi spores present in the air can be deposited on the surfaces of materials such as can drinks.

The health implications of the bacterial isolates were determined by determining the susceptibility of the bacterial isolates to commercial antibiotics. Norfloxacin showed no zones of inhibition against *Corynebacterium, Pseudomonas, Bacillus, Klebsiella;* while *Micrococcus* species were resistant to chloramphenicol, Norfloxacin and streptomycin. Resistant of bacteria to antibiotics is of public health significance. According to Chitanand et al. (2010), antibiotic resistance reflects the pathogen's importance as a public health threat. The zones of inhibition recorded ranged from 10mm to 24mm with ketoconazole and 12mm to 28mm with fluconazole. *Penicillium* and *Aspergillus* species were resistant to both ketoconazole and fluconazole antifungal drugs. The implications of antibiotic resistance on healthcare systems as a whole are enormous as resistance leads to the limitation of treatment options. Within the healthcare system, there are cases in which antibiotic resistance may limit available and often lifesaving treatment options. Drug resistance is a growing hazard as many microorganisms have become multi-resistant to several drugs. This drug resistance could be observed in bacteria, fungi and viruses. This failure of drugs to treat some microbial infections has been associated with abuse and misuse. Therefore, it is necessary to ensure that the surfaces of canned drinks are properly washed to avoid fomite-mediated transmission of infectious agents to humans during the consumption of canned drinks.

CONCLUSION

From this study, the surfaces of canned drinks sold within the Federal University of Technology, Owerri, were contaminated with microorganisms of public health importance. The results showed that the canned drinks collected from the packs of canned drinks had higher microbial plate counts as well as higher bacterial and fungal isolates. Some of the bacteria and fungi isolated from the surfaces of the canned drinks were found to be resistant to two or more antibiotics and antifungal drugs. However, some were susceptible to the drugs. Adequate washing of any canned drink irrespective of whether it is from the refrigerator or not is likely to reduce or eliminate these microbes from the canned surfaces.

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Availability of data and materials: All data generated and analysed during this study are included in this manuscript.

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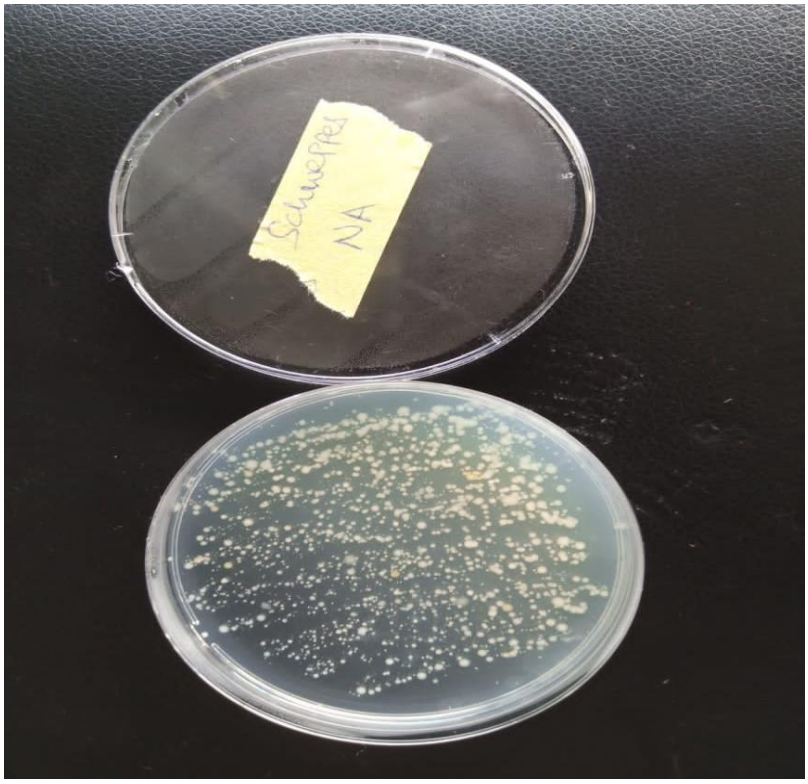
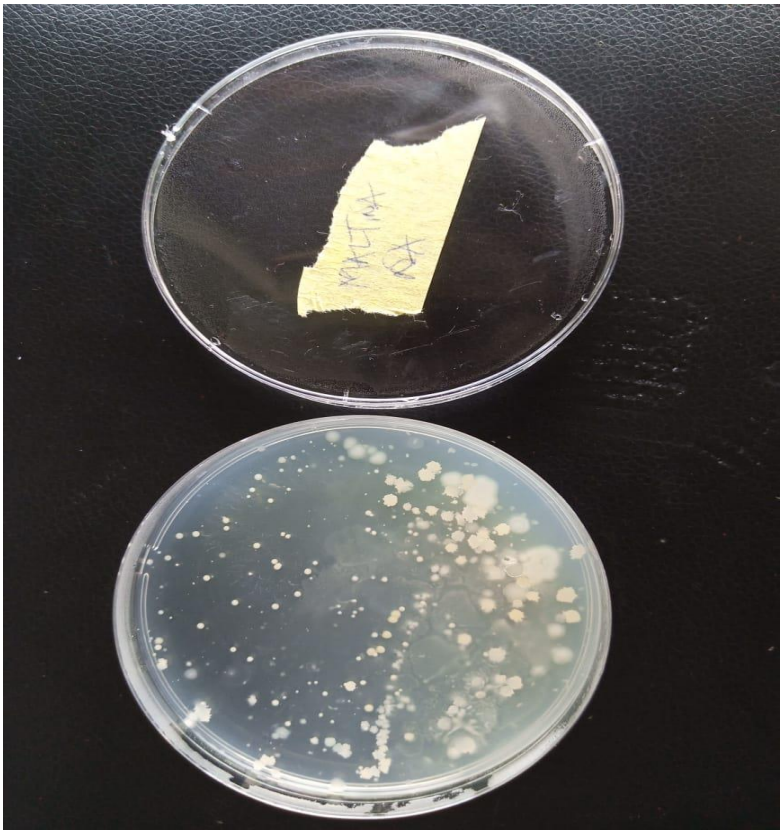
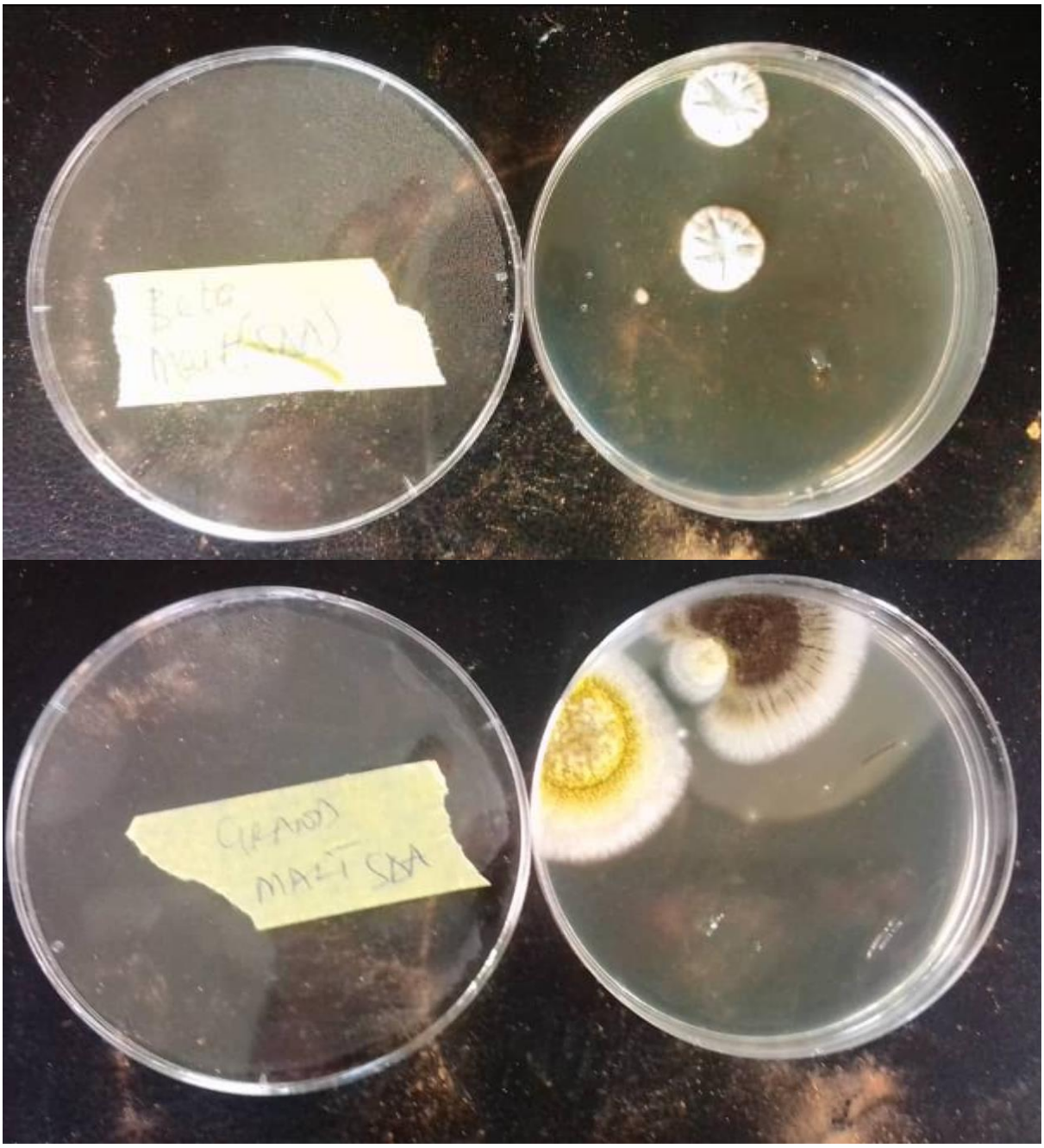


APPENDIX A: Bacteria growth on the surface of Schweppes canned drink



Appendix B: Bacterial growth on the surfaces of Maltina canned drink



APPENDIX C: Fungi isolates from the surfaces of the canned drinks