Journal of Applied Pharmaceutical Science 2025. Article in Press
Available online at http://www.japsonline.com
DOI: 10.7324/JAPS.2025.v15.i11.13
ISSN 2231-3354

Comparative efficacy of *Syzygium cumini* leaf extract and chemical disinfectants against hospital floor isolates: First report of benzalkonium chloride-resistant *Mucor* sp.

Haorongbam Joldy Devi[1], Prathiba Gnanasekaran[2*], Yumnam Asha Devi[1], Durai Saravanan[3], Thiyagarajan Gopal[3], Venkataraman Balakumar[4], Priya Sathish[5], Kavitha Nataraja[6], Blessing Kailas Jeya Sundar[7], Fidelis Daflin Femi[8]

[1]Department of Microbiology, Sathyabama Institute of Science and Technology, Chennai, India.
[2]Department of Microbiology, Sathyabama Dental College and Hospital, Chennai, India.
[3]Centre for Laboratory Animal Technology and Research, Sathyabama Institute of Science and Technology, Chennai, India.
[4]Department of Prosthodontics, Sathyabama Dental College and Hospital, Chennai, India.
[5]Department of Pharmacology, Sathyabama Dental College and Hospital, Chennai, India.
[6]Sathyabama College of Physiotherapy, Sathyabama Institute of Science and Technology, Chennai, India.
[7]Department of General Pathology, Sathyabama Dental College and Hospital, Chennai, India.
[8]Department of Oral Medicine and Radiology, Sathyabama Dental College and Hospital, Chennai, India.

ARTICLE HISTORY

Received on: 15/05/2025
Accepted on: 01/06/2025
Available Online: XX

Key words:
Agar well diffusion method, disinfectant resistant organisms, disc diffusion method, plant-derived disinfectant.

ABSTRACT

The study aimed to isolate and identify organisms present on various floor surfaces within Sathyabama Dental College and General Hospital by standard microbiological procedures and Vitek MS (Biomerieux) and to compare the antibacterial and antifungal effectiveness of *Syzygium cumini* leaf extract as a plant-derived disinfectant with three routinely used chemical disinfectants (CD1, CD2, and CD3) by agar well diffusion method. Furthermore, to determine the antibiotic and antimycotic susceptibility of floor isolates by disc diffusion method. A total of 61 organisms were isolated, including 41 bacteria and 20 fungi. The bacterial isolates were identified as *Staphylococcus* sp., *Bacillus* sp., *Providencia rettgeri*, *Micrococcus* sp., *Pseudomonas aeruginosa*, and *Enterobacter hormaechei*, while fungal isolates included *Mucor* sp., *Alternaria alternata*, *Fusarium oxysporum*, *Penicillium* sp., *Aspergillus flavus,* and *Aspergillus niger*. *Syzygium cumini* extract was effective against all bacterial and fungal isolates, whereas the three chemical disinfectants containing benzalkonium chloride were effective against *Staphylococcus* sp., *Bacillus* sp., and *Micrococcus* sp., but resistant to *P. aeruginosa*, *E. hormaechei*, and *P. rettgeri*. CD1 and CD2 were effective against all fungal isolates except *Mucor* sp., while CD3 showed resistance to all fungi. Gram-positive bacteria were 100% sensitive to Amikacin and Vancomycin and varying resistant to other tested antibiotics. Gram-negative bacteria were 100% resistant to Nitrofurantoin, with varying resistance to other tested antibiotics. Fungal isolates were 100% resistant to Fluconazole, with varying resistance to other antimycotics. *Syzygium cumini* extract showed significant antimicrobial activity against the disinfectant-resistant, antibiotic, and antimycotic-resistant isolates, supporting the potential use of *S. cumini* extract as an alternative, non-toxic, and plant-derived floor disinfectant.

INTRODUCTION

Infectious diseases remain one of the leading causes of morbidity and mortality. The majority of infections are contracted in a public place [1,2]. Antibiotic resistance has developed as an unprecedented global health threat, driven by its swift and widespread transmission [3]. Antibiotic-resistant pathogens have developed into a major concern in recent years, affecting both community and healthcare-associated infections (HAIs) [4]. The global spread of antibiotic-resistant bacteria reflects an increasing prevalence and highlights the urgent

*Corresponding Author
Prathiba Gnanasekaran, Department of Microbiology, Sathyabama Dental College and Hospital, Chennai, India. E-mail: brightstart2011@yahoo.com

need for effective sterilization products to curb the growth and transmission of pathogens [5]. The prevalence of diseases caused by pathogenic filamentous fungi has risen substantially, yet these conditions remain underestimated [6–8]. Fungal contamination in indoor environments can lead to allergic reactions [9], and inhalation of fungal spores, fragments, or metabolites can contribute to respiratory issues, such as asthma, rhinitis, and bronchitis [10]. Molds can exacerbate asthma, cause skin irritation, and headaches, and trigger allergic responses [11,12]. Immunocompromised individuals are particularly at risk, with significant evidence linking mold exposure to various respiratory diseases [6,9]. Several studies highlight the critical role of microbial contamination on surfaces and devices in facilitating pathogen transmission. The efficiency of pathogen spread is contingent upon multiple factors, including the resilience of microorganisms to persist on dry surfaces and the frequency with which contaminated surfaces or devices contact both patients and healthcare personnel [13].

Disinfecting contaminated surfaces effectively lowers the overall infection level while also preventing the dissemination of bacteria to other surfaces [4]. Disinfectants are extensively recognized for eliminating microorganisms from the surfaces of objects and transmission media [14]. They are highly effective in controlling infectious diseases by preventing or eliminating the growth of pathogenic microorganisms within transmission modes [15,16]. They are crucial for maintaining ecological health and safety, with significant applications across various sectors, including healthcare, water treatment and distribution, food processing, agriculture, and other industries [17]. However, the emergence of disinfectant resistance poses a significant threat to public health and safety, as well as to the optimal use of resources, due to the decreased effectiveness of disinfectants [18].

Bacterial resistance to disinfectants plays a critical role in the management of HAIs [19,20]. Microorganisms may display intrinsic resistance to disinfectants, frequently attributed to the low permeability of their cellular structures. Prolonged exposure to disinfectants can further exacerbate microbial resistance through genetic mutations or the acquisition of resistance-conferring genetic elements [13]. Several studies reported that benzalkonium chloride (BC) which is a quaternary ammonium compound class of chemical disinfectants, is resistant against various microorganisms, such as *Staphylococcus aureus* [21], *Escherichia coli* [22], *Pseudomonas aeruginosa* [23], *Acinetobacter baumannii* [24], *Enterobacter* sp. [25], *Listeria monocytogenes* [22], *Aspergillus ochraceus* [26], and *Aspergillus fumigatus* [27]. Regular exposure to commonly used chemical disinfectants increases the risk of chronic obstructive pulmonary disease, asthma, and eye irritation [28,29]. Additionally, there is growing evidence that such exposure may lead to infertility and negatively affect brain development in children [30]. Health workers and individuals who are regularly exposed to these disinfectants are particularly vulnerable, as continuous contact with these chemicals may contribute to long-term health complications [28]. Moreover, it can have detrimental effects on human health, including skin irritation, pruritus, headaches, and dizziness [31]. Residual chemicals left on surfaces often contain hazardous compounds that are implicated in a range of health issues such as cancer, respiratory disorders, skin irritation, central nervous system dysfunction, and oxidative stress, all of which contribute to a broad spectrum of adverse human health outcomes [28]. Additionally, rainfall facilitates the runoff of disinfectants, leading to contamination of aquatic systems, soil, and atmospheric components. Both direct and indirect discharges of sewage effluents finally enter freshwater bodies such as lakes and rivers, presenting substantial threats to aquatic ecosystems and biodiversity by disrupting ecological stability and endangering the health of wildlife [28,30].

Being an ideal disinfectant, a natural plant-derived disinfectant should possess potent antimicrobial activity and be non-toxic, non-corrosive, cost-effective, user-friendly, and safe for most surfaces. Additionally, it should be safe for skin contact and inhalation and environmentally sustainable [32,33]. *Syzygium cumini* is a large evergreen tree from the Myrtaceae family, known for its wide range of medicinal properties [34,35]. The leaf extract of *S. cumini* has been demonstrated to have significant antibacterial [36,37], antifungal [37,38], and antiviral [39] activities due to the presence of rich bioactive compounds, including tannins, saponins, terpenoids, flavonoids, and phenols, such as sitosterol, betulinic acid, crategolic acid, quercetin, myricetin, and kaempferol [40–42]. Tannins are capable of inhibiting bacterial growth or killing bacteria by binding to bacterial protein cells. This interaction causes protein denaturation, damaging the cell wall and causing lysis [43]. Terpenoids also inhibit bacterial growth [44], while saponins compromise the integrity of cell membranes [45]. Flavonoids form complex bonds with extracellular proteins in the bacterial cell wall, weakening its structure and ultimately causing cell wall breakdown and lysis [43]. Furthermore, *S. cumini* leaf extract is reported to be non-toxic in various cell lines [37,46].

In the present work, environmental bacterial and fungal organisms from different floor surfaces of Sathyabama Dental College and Hospital premises were isolated and identified, and the effectiveness of *S. cumini* leaf extract-derived disinfectant was evaluated toward the antibacterial and antifungal activity in comparison to routinely used chemical disinfectant. Furthermore, the antibiotic and antifungal susceptibility tests against environmental isolates were also determined. This study is the first to report on the antibacterial and antifungal efficacy of *S. cumini* leaf extract against isolates from the environmental floor.

MATERIALS AND METHODS

Isolation of environmental organisms from different surfaces of hospital and college premises

Samples were collected by wiping with a sterile moistened swab from various areas of Sathyabama Dental College and General Hospital (SDCGH) floor surfaces, including the patient waiting area, hospital reception, lecture hall, hospital laboratory, staircase, department of microbiology, auditorium, office, college mess, library, and corridor. The study was approved by the Institutional Biosafety and Ethical Committee (Ref: 331/IRB-IBSEC/SIST Dated 18th October 2023). The collected swabs were inoculated onto the sterile Nutrient agar (NA) plates and Sabouraud dextrose agar (SDA),

respectively. The plates were subsequently incubated at 37°C for 24 hours to facilitate bacterial isolation and at ambient temperature for 72 hours to enable fungal isolation. In order to obtain a pure isolate, individual colonies were picked from each plate and sub-cultured on respective media and then incubated at respective temperatures and days as mentioned earlier [47,48].

Identification of the environmental isolates

Identification of the environmental bacterial isolates was carried out by standard microbiological procedures, such as colony morphological analysis, Gram staining, plated on differential as well as on selective media, and biochemical tests [47]. The isolates were identified based on Bergey's Manual of Systematic Bacteriology and further confirmed by Vitek MS (Biomerieux) [4]. Environmental fungal isolates were identified by colony morphological analysis, Lactophenol cotton blue (LPCB) staining, and confirmed by Vitek MS (Biomerieux) [4,49].

Preparation of extract

Fresh *S. cumini* leaves were collected and thoroughly washed with distilled water, dried, and then ground into fine powder. About 15 g of powder was added to 150 ml of sterile distilled water. Extraction was carried out using the hot percolation method at 60°C for 2 hours. Then, the extract was filtered through Whatman filter paper and then dried overnight in an oven at 40°C–45°C. It was ground into fine powder and stored for further use [37]. Extraction yield % was calculated as the weight of the solvent-free extract/dry weight of the sample ×100 [50].

Chemical disinfectants

The ingredients present in CD-1 are BC solution, water, lauryl alcohol ethoxylate, sodium bicarbonate, cocamidopropyl betaine, perfume, tetrasodium Ethylenediaminetetraacetic acid (EDTA), denatonium benzoate, and CI 47005. CD-2 contains BC solution, water, lauryl alcohol ethoxylate, lauramine oxide, sodium bicarbonate, disodium EDTA, isopropyl alcohol, cocamidopropyl betaine, perfume, and CI 47005. CD-3 contains BC, water, non-ionic surfactant, perfume, preservative, and colorant.

Preparation of the inoculum

The bacterial isolates were inoculated on NA medium and incubated at 37°C for 24 hours. After incubation, 2–3 colonies were taken from the plate and diluted with NB. The turbidity was standardized to the 0.5 McFarland standard to reach a cell density of 10^8 cells/ml. Fungal cultures were inoculated on to SDA medium and incubated at 28°C for 72 hours. Fungal isolates were adjusted to the spore density of 10^6 spores/ml using a spectrophotometer [51].

Antimicrobial activity of *S. cumini* leaf extract and routinely used chemical disinfectant against the bacterial and fungal environmental isolates

The antimicrobial activity of the *S. cumini* extract was compared with three routinely used chemical disinfectants, which was determined by the agar well diffusion method. The lawn culture was made with the isolated organisms onto the Muller–Hinton agar [47]. Chemical disinfectants were diluted in sterile distilled water based on the instructions provided by the manufacturers. Hundred microliters of *S. cumini* extract (10%), three chemical disinfectants, and distilled water were loaded into the respective wells using a sterile micropipette. The plates were then incubated at 37°C for 24 hours for bacterial cultures and 3 days at room temperature for fungal cultures. Following incubation, the diameter of the inhibition zone was determined. The experiment was conducted in triplicate.

Antibiotic susceptibility test against the bacterial environmental isolates

Antibiotic susceptibility test against the bacterial isolates was done on Muller–Hinton agar by disc diffusion method according to Clinical and Laboratory Standards Institute guidelines [52]. Antibiotics used for Gram-positive isolates were Cephalothin (CEP30), Vancomycin (VA30), Novobiocin (NV30, Erythromycin (E15), Oxytetracycline (O30), Amikacin (AK10), Amoxicillin (AMX10), and Bacitracin (B10). Antibiotics used for Gram-negative isolates were Ciprofloxacin (CIP10), Co-Trimazine (CM25), Kanamycin (K30), Nitrofurantoin (NIT300), Streptomycin (S10), Tetracycline (TE30), Amikacin (AK10), and Carbenicillin (CB100). Lawn cultures of bacterial isolates were inoculated onto Muller Hinton agar (MHA). Respective antibiotics were then placed on the media and incubated at 37°C for 24 hours. The zone of inhibition was measured after incubation. The experiment was conducted in triplicate.

Antifungal susceptibility test against the fungal environmental isolates

Antifungal susceptibility tests against the fungal isolates were also done using the disk diffusion method according to CLSI M51-A [53]. Antimycotic drugs used were Nystatin (NS), Amphotericin B (AP), Clotrimazole (CC), Fluconazole (FLC), Itraconazole, and Ketoconazole (KT). Lawn cultures of fungal isolates were prepared on MHA. Antimycotic drugs were then placed on it and incubated at room temperature for 2–3 days, respectively. Subsequent to incubation, the diameter of the zone of inhibition was determined. The experiment was conducted in triplicate.

Statistical analysis

One-way ANOVA and Tukey's HSD post hoc test were used to analyze the significance level of data (IBM SPSS version 25.0). A p-value < 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Isolation and identification of the environmental isolates

Totally, 61 environmental organisms were isolated from SDCGH floor surfaces, of which 41 were bacterial isolates and 20 were fungal isolates, as shown in (Fig. 1). The isolated bacteria were characterized by colony morphology, gram staining, and biochemical tests and identified using Bergey's Manual of Systematic Bacteriology and further confirmed

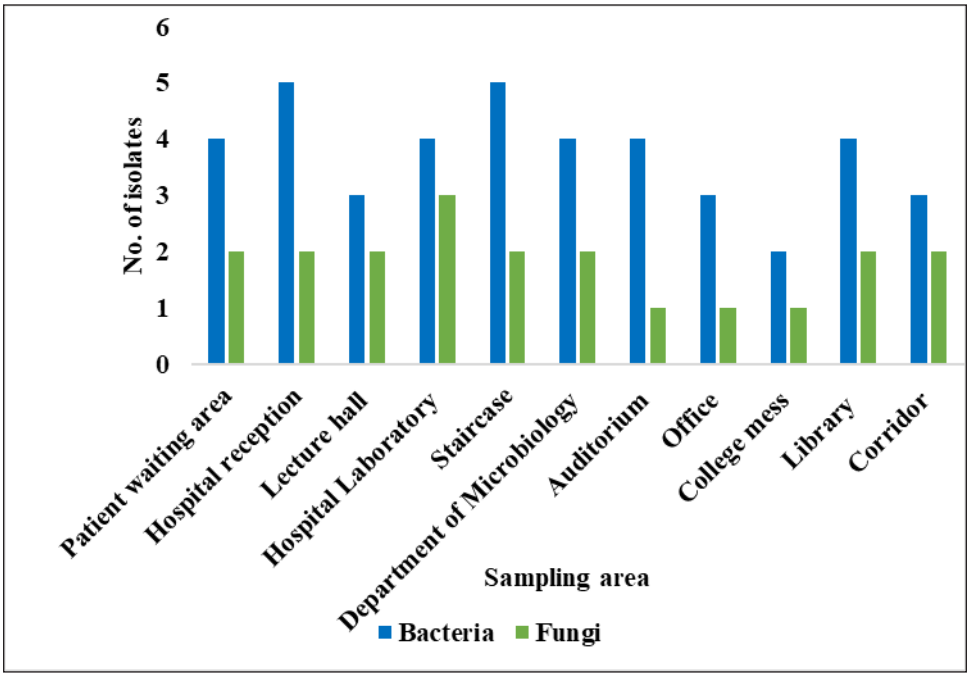

Figure 1. Number of bacteria and fungi isolated from various floors.

by Vitek MS. The identified bacteria were *Staphylococcus* sp., *Bacillus* sp., *Providencia rettgeri*, *Micrococcus* sp., *P. aeruginosa*, and *Enterobacter hormaechei* (Table 1). Among the *Staphylococcus* sp., six of them were *S. aureus*. This is the first study reported on *P. rettgeri* isolated from environmental floors. Fungal isolates were identified by colony morphology, LPCB staining and further confirmed by Vitek MS. The identified fungi were *Mucor* sp., *Alternaria* sp., *Fusarium* sp., *Penicillium* sp., *Aspergillus flavus*, and *Aspergillus niger* (Fig. 2 and Table 2). Palmer and Onifade [48] revealed that *S. aureus*, *Str. pyogenes*, *E. coli*, *P. aeruginosa*, *Klebsiella pneumoniae*, *Bacillus cereus*, *A. niger*, *A. fumigatus,* and *Candida albicans* were isolated from hospital environmental surfaces. Similarly, *A. flavus, A. niger*, *A. ustus, A. fumigatus*, *Rhizopus stolonifera, Scopulariopsis* sp., *Trichoderma* sp., *Mucor racemosus*, *Mucor hiemalis,* and *Wallemia* sp. were isolated from carpet and floor dust samples of various indoor environments [54]. *Staphylococcus* sp., *Streptococcus* sp., *Bacillus* sp., *Aspergillus* sp., *Mucor* sp., *Fusarium* sp., *Penicillium* sp., *Candida* sp., *Rhizopus* sp., and *Verticillium* sp. were isolated from the hospital indoor environment [55]. The dominant percentage of bacterial and fungal isolates is shown in (Fig. 3). In the case of bacterial isolates, *Bacillus* sp. was found predominantly, followed by *Staphylococcus* sp., *P. aeruginosa*, *E. hormaechei*, *P. rettgeri*, and *Micrococcus* sp., respectively. In the case of fungal isolates, *A. niger* was the most common fungi, followed by *Penicillium* sp., *Fusarium* sp., *A. flavus*, *Mucor* sp., and *Alternaria* sp. According to Viegas *et al*. [56], the most prevalent bacteria isolated from the indoor environment were *Micrococcus* sp., followed by *Staphylococcus* sp. and *Neisseria* sp., and in the case of fungal isolates, *Chrysosporium* sp. were prevalently found, followed by *Penicillium* sp. and *Chrysonilia* sp.

Extraction yield

Syzygium cumini leaves were extracted using distilled water as a solvent. The obtained extract was brown in color and crystalline in nature after drying. The extraction yield % of *S. cumini* leaves was calculated using the formula mentioned above, and 9.5% of yield was obtained.

Effect of *S. cumini* leaf extract and routinely used chemical disinfectant against the bacterial and fungal environmental isolates

The antibacterial activity of *S. cumini* extract and three routinely used chemical disinfectants, such as CD1, CD2, and CD3 were determined against the organisms isolated from SDCGH floor surfaces by the agar well diffusion method (Table 3). *Syzygium cumini* extract showed good activity against all the bacterial environmental floor isolates, such as *Staphylococcus* sp., *Bacillus* sp., *Micrococcus* sp., *P. aeruginosa*, *E. hormaechei,* and *P. rettgeri* (Fig. 4). *Syzygium cumini* extract produced a significant zone of inhibition against *Staphylococcus* sp. in the range of (18.07–25.3 mm), *Bacillus* sp. (12.8–20.5 mm), *Micrococcus* sp. (28.87 mm), *P. aeruginosa (*14.13–18.3 mm), *E. hormaechei* (20.33 mm), and *P. rettgeri* (21.83 mm). The significant antibacterial activity of Syzygium cumini extract (SCE) may be due to the presence of various secondary metabolites such as tannins, terpenoids, saponins, and flavonoids [40].

BC, the active ingredient of the routinely used chemical disinfectant, was used in the current investigation. In the case of chemical disinfectant, CD1 showed good activity against bacterial isolates, followed by CD2 and CD3. In this study, there was a significant difference ($p < 0.05$ according to Tukey's HSD post hoc test) between the SCE and chemical disinfectants on antibacterial activity against the isolates. CD1

Table 1. Morphological and biochemical tests of bacterial environmental floor isolates.

Sl. No.	Isolate No.	Gram stain	Spore	Motility	Colony morphology	C*	O	I	MR	VP	Ci	NR	Coa	Identified bacteria
1.	PW1	+ rod	+	+	White, smooth, circular, raised, opaque	+	−	−	+	+	+	−	NT	*Bacillus* sp.
2.	PW2	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	−	−	+	+	+	NT	*Bacillus* sp.
3.	PW3	+ cocci**	−	−	Golden yellow, round, smooth, raised, opaque	+	−	−	+	+	+	+	+	*Staphylococcus aureus*
4.	PW4	− rod	−	+	Green, large, opaque, flat with irregular edge	+	+	−	−	−	+	−	NT	*Pseudomonas aeruginosa*
5.	L1	+ cocci	−	+	White, round, smooth, convex, opaque	+	−	−	+	+	−	−	−	*Staphylococcus* sp.
6.	L2	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	-	−	+	+	+	NT	*Bacillus* sp.
7.	L3	+ cocci	−	−	White, round, smooth, convex, opaque	+	−	−	+	+	−	−	−	*Staphylococcus* sp.
8.	L4	− rod	−	+	White, round, smooth, raised, regular	+	−	−	−	+	+	+	NT	*Enterobacter hormaechei*
9.	RL1	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	−	−	+	+	+	NT	*Bacillus* sp.
10.	RL2	+ rod	+	+	White, large, opaque, slightly convex irregular edge	+	+	−	+	−	+	+	NT	*Bacillus* sp.
11.	RL3	− rod	−	+	Blue-green, large, opaque, flat with irregular edge	+	+	−	−	+	+	+	NT	*P. aeruginosa*
12.	RL4	+ rod	+	+	Orange, small, translucent, irregular edge	+	−	−	−	+	+	−	NT	*Bacillus* sp.
13.	RL5	+ cocci **	−	−	Golden yellow, round, smooth, raised, opaque	+	−	−	+	+	+	+	+	*S. aureus*
14.	LH1	+ cocci *	−	−	Golden yellow, round, smooth, raised, opaque	+	−	−	+	+	+	+	+	*S. aureus*
15.	LH2	+ rod	+	+	Orange, small, translucent, irregular in shape,	+	−	−	−	+	+	−	NT	*Bacillus* sp.
16.	LH3	+ rod	+	+	White, smooth, circular, raised, opaque	+	−	−	+	+	+	−	NT	*Bacillus* sp.
17.	S1	+ cocci	−	−	White, round, smooth, convex, opaque	+	−	−	+	+	−	−	−	*Staphylococcus sp.*
18.	S2	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	-	−	+	+	+	NT	*Bacillus* sp.
19.	S3	+ rod	+	+	White, smooth, circular, raised, opaque	+	−	−	−	+	+	−	NT	*Bacillus* sp.
20.	S4	+ rod	−	+	Orange, small, translucent, irregular in shape,	+	−	−	−	+	+	−	NT	*Bacillus* sp.
21.	S5	+ rod	+	+	White, large, opaque, slightly convex irregular edge	+	−	−	+	−	+	+	NT	*Bacillus* sp.

Continued

Sl. No.	Isolate No.	Gram stain	Spore	Motility	Colony morphology	C*	O	I	MR	VP	Ci	NR	Coa	Identified bacteria
22.	D1	+ cocci **	−	−	Golden yellow, round, smooth, raised, opaque	+	−	−	+	+	+	+	+	*S. aureus*
23.	D2	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	−	−	+	+	+	NT	*Bacillus* sp.
24.	D3	+ rod	+	+	Orange, small, translucent, irregular in shape,	+	−	−	−	+	+	−	NT	*Bacillus* sp.
25.	D4	+ rod	+	+	White, smooth, circular, raised, opaque	+	−	−	+	+	+	−	NT	*Bacillus* sp.
26.	LB1	− rod	−	+	Milky white, small, round, opaque, slightly convex	+	−	+	−	+	+	−	NT	*Providencia rettgeri*
27.	LB2	+ cocci	−	−	White, round, smooth, convex, opaque	+	−	−	+	+	+	−	−	*Staphylococcus sp.*
28.	LB3	+ rod	+	+	White, large, opaque, slightly convex irregular edge	+	−	−	+	−	+	+	NT	*Bacillus* sp.
29.	LB4	+ rod	+	+	White, large, opaque, slightly convex irregular edge	+	−	−	+	−	+	+	NT	*Bacillus* sp.
30.	OF1	+ rod	+	+	White, smooth, circular, raised, opaque	+	−	−	+	+	+	−	NT	*Bacillus* sp.
31.	OF2	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	−	−	+	+	+	NT	*Bacillus* sp.
32.	OF3	+ cocci	−	−	White, round, smooth, convex, opaque	+	−	−	+	+	+	−	-	*Staphylococcus* sp.
33.	M1	+ cocci	−	−	Pale yellow, round, smooth, convex, opaque	+	−	−	+	+	+	−	−	*Staphylococcus* sp.
34.	M2	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	−	−	+	+	+	NT	*Bacillus* sp.
35.	C1	+ cocci **	−	−	Golden yellow, round, smooth, raised, opaque	+	−	−	+	+	+	+	+	*S. aureus*
36.	C2	+ rod	+	+	White, large, opaque, slightly convex irregular edge	+	−	−	+	−	+	+	NT	*Bacillus* sp.
37.	C3	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	−	−	+	+	+	NT	*Bacillus* sp.
38.	A1	+ rod	+	+	White, smooth, circular, raised, opaque	+	−	−	+	+	+	−	NT	*Bacillus* sp.
39.	A2	+ rod	+	+	White, large, opaque, flat, rough, circular with irregular margin	+	+	−	−	+	+	+	NT	*Bacillus* sp.
40.	A3	+ cocci **	−	−	Golden yellow, round, smooth, raised, opaque	+	−	−	+	+	+	+	+	*S. aureus*
41.	A4	+ cocci #	−	−	Bright yellow, circular, smooth convex, opaque	+	+	−	−	−	−	+	NT	*Micrococcus* sp.

A = auditorium; C* = catalase; C = corridor; Ci = citrate; Coa = coagulase; D = Department of Microbiology; I = indole; L = hospital laboratory; LB = library; LH = lecture hall; M = mess; MR = methyl red; NR = nitrate reduction; NT = not tested; O = oxidase; OF = office; PW = patient waiting area; RL = hospital reception; S = staircase; VP = Voges–Proskauer; + = positive, − = negative.

**Cluster arrangement.

#Tetrad arrangement.

Table 2. Colony morphology and microscopic characteristics of fungal environmental floor isolates.

Sl.No.	Isolate No.	Colony morphology on SDA	Microscopic morphology in LPCB stain	Identified fungi
1.	PW1	Fluffy, cottony, white to grey colony	Filamentous hyphae with sporangia	*Mucor* sp.
2.	PW2	Cottony, flat, white colony with a central orange coloration that spreads throughout the colony	Septate hyphae and sickle-shaped macroconidia	*Fusarium* sp.
3.	L1	Flat, radially sulcate, grey-green with white periphery colony	Filamentous hyphae with brush-like conidiophore	*Penicillium* sp.
4.	L2	Dark brown to black conidial head with white periphery	Large conidial head with a globose structure, radiate and biseriate with metulae covering the entire surface	*Aspergillus niger*
5.	L3	Powdery, yellowish green conidial spores with white periphery	Radiated biseriate conidial head	*Aspergillus flavus*
6.	RL1	Powdery, yellowish green conidial spores with white periphery	Radiated biseriate conidial head	*A. flavus*
7.	RL2	Flat, velvety, greyish black with concentric ring around the edge	Obpyriform-shaped conidia with conical beaks	*Alternaria alternata*
8.	LH1	Powdery, yellowish green conidial spores with white periphery	Radiated biseriate conidial head	*A. flavus*
9.	LH2	Flat, velvety, radially sulcate, grey-green with white periphery colony	Filamentous hyphae with brush-like conidiophore	*Penicillium* sp.
10.	S1	Cottony, flat, white colony with a central orange coloration that spreads throughout the colony	Septate hyphae and sickle-shaped macroconidia	*Fusarium* sp.
11.	S2	Dark brown to black conidial head with white periphery	Large conidial head with a globose structure, radiate and biseriate with metulae covering the entire surface	*A. niger*
12.	D1	Flat, velvety, radially sulcate, grey-green with white periphery colony	Filamentous hyphae with brush-like conidiophore	*Penicillium* sp.
13.	D2	Dark brown to black conidial head with white periphery	Large conidial head with a globose structure, radiate and biseriate with metulae covering the entire surface	*A. niger*
14.	LB1	Flat, velvety, radially sulcate, grey-green with white periphery colony	Filamentous hyphae with brush-like conidiophore	*Penicillium* sp.
15.	LB2	Fluffy, cottony, white to grey colony	Filamentous hyphae with sporangia	*Mucor* sp.
16.	OF1	Flat, powdery to velvety, radially sulcate, grey-green with white periphery colony and produced red pigment	Filamentous hyphae with brush-like conidiophore	*Penicillium* sp.
17.	M1	Dark brown to black conidial head with white periphery	Large conidial head with a globose structure, radiate and biseriate with metulae covering the entire surface	*A. niger*
18.	C1	Dark brown to black conidial head with white periphery	Large conidial head with a globose structure, radiate and biseriate with metulae covering the entire surface	*A. niger*
19.	C2	Flat, cottony with abundant white mycelia, pale orange color colony	Septate hyphae and sickle-shaped macroconidia	*Fusarium oxysporum complex*
20.	A1	Dark brown to black conidial head with white periphery	Large conidial head with a globose structure, radiate and biseriate with metulae covering the entire surface	*A. niger*

A = auditorium; C = corridor; D = Department of Microbiology; L = hospital laboratory; LB = library; LH = lecture hall; M = mess; OF = office; PW = patient waiting area; RL = hospital reception; S = staircase.

showed antimicrobial activity against bacterial isolates, such as *Staphylococcus* sp., *Bacillus* sp., and *Micrococcus* sp., but no activity was shown against *P. aeruginosa, P. rettgeri,* and *E. hormaechei*. Similarly, CD2 showed antimicrobial activity against most of the bacterial isolates, such as *Staphylococcus* sp., *Bacillus* sp., and *Micrococcus* sp.; however, it showed no activity against *P. aeruginosa, P. rettgeri,* and *E. hormaechei*. CD3 was found to have the least activity toward the bacterial isolates. It showed antimicrobial activity to some of the *Staphylococcus* sp. and *Bacillus* sp. only; however, no activity was shown against *P. aeruginosa, P. rettgeri,* and *E. hormaechei*. Interestingly, this study showed that *S. cumini* extract was potent against *P. aeruginosa, E. hormaechei,* and *P. rettgeri.* However, all the routinely used chemical disinfectants whose active ingredient was BC showed no activity against *P. aeruginosa, E. hormaechei* and *P. rettgeri*. Our results were consistent with the previous studies reported that BC does not show activity against *P. aeruginosa* [23,57,58] and *P. rettgeri*

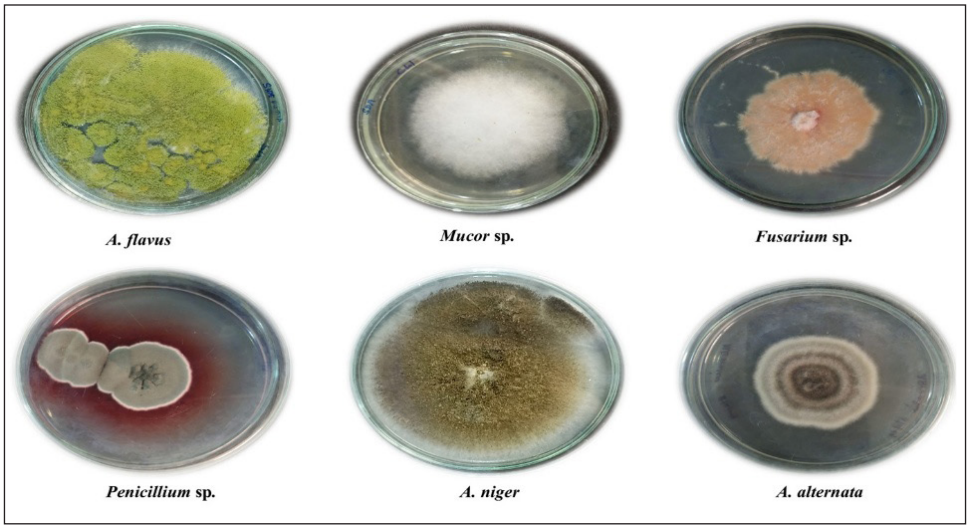

Figure 2. Fungal floor isolates on SDA.

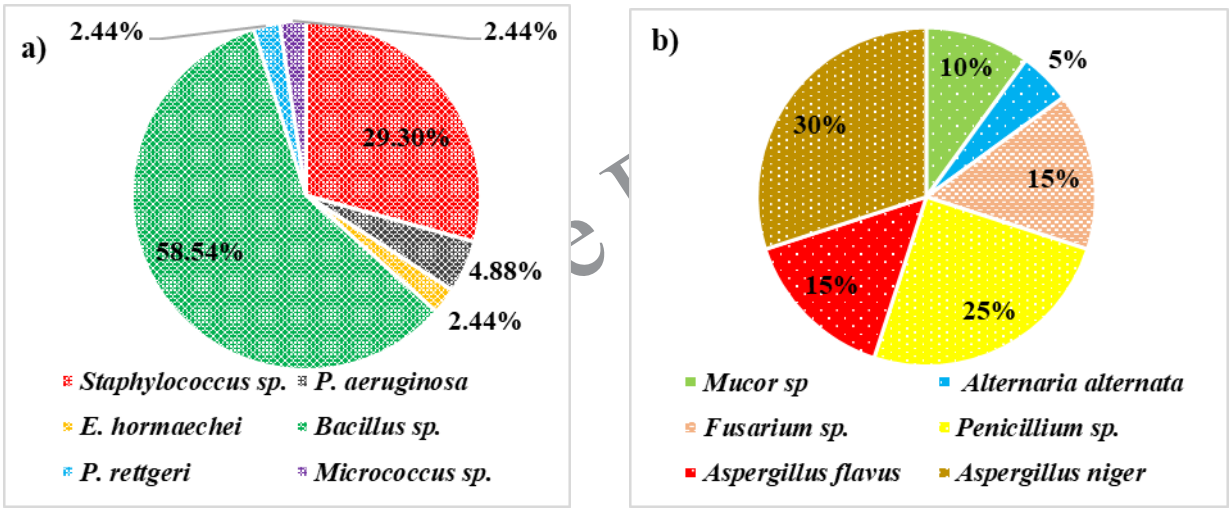

Figure 3. Dominant percentage of a) bacterial isolates and b) fungal isolates.

[59,60]. It also does not show activity against *Enterobacter* sp. isolated from the hospital environment [25].

Microbial innate resistance to disinfectants might be typically associated with the impermeability of their cell membranes, which prevents disinfectant agents from penetrating and affecting the cells [19]. This inherent defense mechanism renders certain microorganisms less susceptible to the action of disinfectants. However, continuous or prolonged exposure to disinfectants can lead to an increase in resistance [61]. This enhancement of resistance occurs through two main mechanisms: genetic mutations within the microorganism's genome, which may lead to adaptations/alterations that enable survival in the presence of disinfectants, and the acquisition of resistance genes from other microorganisms, often via horizontal gene transfer. These processes contribute to the development and spread of disinfectant resistance, which makes it more challenging to control the microorganisms [13].

The antifungal activity of *S. cumini* extract and three routinely used chemical disinfectants, such as CD1, CD2, and CD3, were also determined against the environmental fungal isolates (Table 4). *Syzygium cumini* extract showed significant activity against all the environmental fungal isolates, such as *Mucor* sp., *Penicillium* sp., *Fusarium oxysporum*, *Alternaria alternata*, *A. niger,* and *A. flavus* (Fig. 5). *Syzygium cumini* extract exhibited a significant zone of inhibition against *Mucor* sp. in the range of (23–26.33 mm), *Penicillium* sp. (15–19.8 mm), *F. oxysporum* (11.5–19.77 mm), *A. alternata* (20.83 mm), *A. niger* (13–14.47 mm), and *A. flavus* (12.17–12.83 mm). Similar to that of the antibacterial activity, the marked antifungal activity of SCE could be likely due to the presence of secondary metabolites, such as tannins, terpenoids, saponins, and flavonoids. These phytochemicals are also known to possess antifungal properties, with tannins directly affecting fungi [62]. Their antifungal action is attributed to their lipophilicity, hydroxyl groups, and ability to bind proteins and adhesins,

Table 3. Antibacterial activity comparison of SCE and chemical disinfectants against the bacterial environmental floor isolates.

Sampling sites	Bacterial isolates	SCE	CD-1	CD-2	CD-3
Patient waiting area	*Bacillus* sp. 1	15.33 ± 0.57^{b}	20.9 ± 0.66^{a}	21.33 ± 0.58^{a}	0.0 ± 00^{c}
	Bacillus sp. 2	17.37 ± 0.55^{a}	18.6 ± 0.66^{a}	13.53 ± 0.61^{b}	0.0 ± 00^{c}
	Staphylococcus aureus	22.73 ± 1.10^{a}	12.57 ± 0.6^{b}	10.7 ± 0.96^{b}	0.0 ± 00^{c}
	Pseudomonas aeruginosa	14.13 ± 1.03^{a}	0.0 ± 0.0^{b}	0.0 ± 0.0^{b}	0.0 ± 00^{b}
Hospital laboratory	*Staphylococcus* sp.1	21.57 ± 0.51^{b}	24.67 ± 0.58^{a}	23.57 ± 0.55^{a}	11.4 ± 0.53^{c}
	Bacillus sp. 1	20.5 ± 0.5^{b}	23.77 ± 0.68^{a}	19.33 ± 0.58^{b}	0.0 ± 00^{c}
	Staphylococcus sp.2	18.07 ± 0.40^{c}	24.37 ± 0.55^{a}	20.90 ± 0.36^{b}	0.0 ± 00^{d}
	Enterobacter hormaechei	20.33 ± 1.5^{a}	0.0 ± 00^{b}	0.0 ± 00^{b}	0.0 ± 00^{b}
Hospital reception	*Bacillus* sp. 1	16.1 ± 0.66^{b}	18 ± 1^{a}	18.83 ± 0.29^{a}	0.0 ± 00^{c}
	Bacillus sp. 2	19.1 ± 0.26^{b}	25.17 ± 0.29^{a}	24.9 ± 0.57^{a}	14.1 ± 0.85^{c}
	P. aeruginosa	18.3 ± 0.75^{a}	0 ± 0^{b}	0 ± 0^{b}	0.0 ± 00^{b}
	Bacillus sp. 3	12.8 ± 0.34^{b}	17.63 ± 0.6^{a}	16.6 ± 0.53^{a}	0.0 ± 00^{c}
	S. aureus	18.83 ± 1.01^{b}	19.13 ± 0.32^{a,b}	20.67 ± 0.76^{a}	0.0 ± 00^{c}
Lecture hall	*S. aureus*	25.3 ± 0.61^{a}	23.6 ± 1.04^{a}	21.13 ± 1.03^{b}	11.5 ± 0.5^{c}
	Bacillus sp.1	17.53 ± 0.5^{a}	18.23 ± 0.87^{a}	18.1 ± 0.85^{a}	0 ± 0^{b}
	Bacillus sp.2	19.27 ± 0.6^{a}	16 ± 1^{b}	12.4 ± 0.79^{c}	0 ± 0^{d}
Staircase	*Staphylococcus* sp.1	20.03 ± 0.45^{b}	24.17 ± 1.02^{a}	21.7 ± 0.62^{b}	0 ± 0^{c}
	Bacillus sp.1	15.8 ± 0.62^{c}	18.33 ± 0.56^{b}	21.43 ± 0.51^{a}	0 ± 0^{d}
	Bacillus sp.2	15.37 ± 0.47^{b}	19 ± 1^{a}	17.7 ± 0.61^{a}	0 ± 0^{c}
	Bacillus sp.3	18.5 ± 0.5^{b}	21.53 ± 0.5^{a}	19.67 ± 0.76^{b}	0 ± 0^{c}
	Bacillus sp.4	18.6 ± 0.66^{b}	18.67 ± 0.76^{b}	21.5 ± 0.5^{a}	0 ± 0^{c}
Department of Microbiology	*S. aureus*	22.73 ± 1.10^{b}	24.33 ± 0.58^{a,b}	26.17 ± 1.04^{a}	0 ± 0^{c}
	Bacillus sp.1	16.9 ± 0.57^{c}	25.5 ± 0.56^{a}	19.63 ± 0.71^{b}	0 ± 0^{d}
	Bacillus sp.2	19.9 ± 0.66^{a}	20 ± 1^{a}	13.1 ± 0.85^{b}	0 ± 0^{c}
	Bacillus sp.3	15.97 ± 1.06^{c}	19.6 ± 0.06^{b}	25.4 ± 0.6^{a}	0 ± 0^{d}
Library	*Providencia rettgeri*	21.83 ± 1.04^{a}	0 ± 0^{b}	0 ± 0^{b}	0 ± 0^{b}
	Staphylococcus sp.1	18.17 ± 0.29^{a}	12.83 ± 0.76^{b}	17.1 ± 0.79^{a}	0 ± 0^{c}
	Bacillus sp.2	15.33 ± 1.53^{b}	21.43 ± 0.51^{a}	21.7 ± 0.62^{a}	0 ± 0^{c}
	Bacillus sp.3	15 ± 1^{a}	16.4 ± 0.53^{a}	16.33 ± 0.58^{a}	0 ± 0^{b}
Office	*Bacillus* sp.1	17.5 ± 0.5^{a}	17.63 ± 0.56^{a}	15.6 ± 0.53^{b}	0 ± 0^{c}
	Bacillus sp.2	20 ± 1^{b}	20.5 ± 0.56^{a,b}	21.93 ± 0.6^{a}	0 ± 0^{b}
	Staphylococcus sp.1	18.83 ± 1.04^{a}	20.57 ± 0.98^{a}	19 ± 1^{a}	0 ± 0^{b}
Mess	*Staphylococcus* sp.1	16 ± 1^{b}	24 ± 1^{a}	15.77 ± 0.68^{b}	10.83 ± 0.76^{c}
	Bacillus sp.1	15.33 ± 1.26^{c}	22.4 ± 0.53^{a}	19.93 ± 0.6^{b}	0 ± 0^{d}
Corridor	*S. aureus* 1	23 ± 0.7^{a}	21.33 ± 0.58^{b}	20.17 ± 0.76^{b}	0 ± 0^{c}
	Bacillus sp.1	18.5 ± 0.5^{b}	20.77 ± 0.68^{a}	20.47 ± 0.81^{a}	0 ± 0^{c}
	Bacillus sp.2	15.33 ± 1.53^{b}	18.63 ± 0.7^{a}	16.1 ± 1.01^{a,b}	0 ± 0^{c}
Auditorium	*Bacillus* sp.1	15.8 ± 0.98^{b}	19.6 ± 0.72^{a}	21 ± 1^{a}	0 ± 0^{c}
	Bacillus sp.2	15 ± 1^{b}	19.5 ± 0.87^{a}	19.43 ± 0.84^{a}	0 ± 0^{c}
	S. aureus	19.53 ± 0.68^{a}	18.67 ± 0.76^{a}	14.57 ± 0.6^{b}	0 ± 0^{c}
	Micrococcus sp.	28.87 ± 0.81^{b}	37.23 ± 0.49^{a}	38.83 ± 0.76^{a}	17.17 ± 0.76^{c}

Different letters at each row denote significantly different ($p < 0.05$) according to Tukey's HSD post hoc test.

disrupting membranes, inactivating enzymes, and binding metal ions, leading to toxic effects on fungal cells [63].

Among the routinely used chemical disinfectants whose active ingredient was BC, CD1 showed good activity against most of the fungal isolates, followed by CD2. This study showed a significant difference ($p < 0.05$ according to Tukey's HSD post hoc test) between the SCE and chemical disinfectants on antifungal activity against the isolates. CD1 showed antifungal

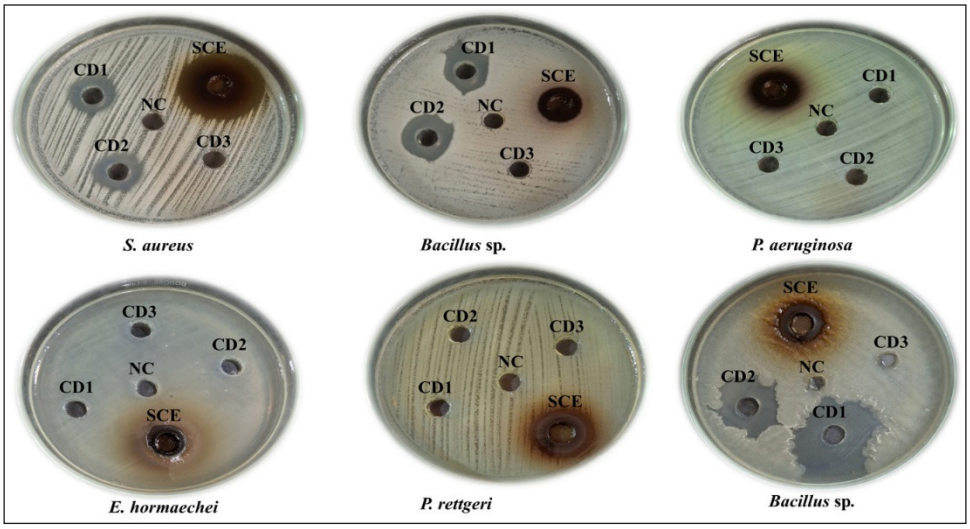

Figure 4. Zone of inhibition of SCE and chemical disinfectants against the bacterial environmental floor isolates.

Table 4. Antifungal activity comparison of SCE and chemical disinfectants against the fungal environmental floor isolates.

Sampling sites	Fungal isolates	SCE	CD-1	CD-2	CD-3
Patient waiting area	*Mucor* sp.	23 ± 1.41^{a}	0 ± 0^{b}	0 ± 0^{b}	0 ± 0^{b}
	Fusarium sp.	11.5 ± 0.41^{b}	14.97 ± 1^{a}	11.6 ± 0.66^{b}	0 ± 0^{c}
Hospital laboratory	*Penicillium* sp.	15.5 ± 0.5^{b}	14.83 ± 0.74^{b}	21.7 ± 0.7^{a}	0 ± 0^{c}
	Aspergillus niger	13 ± 1^{b}	23.5 ± 1.32^{a}	21 ± 1.32^{a}	0 ± 0^{c}
	Aspergillus flavus	12.17 ± 0.76^{b}	15 ± 1^{a}	12.87 ± 0.81^{a}	0 ± 0^{c}
Reception	*A. flavus*	12.3 ± 1.13^{b}	14.33 ± 0.58^{a}	$12.7 \pm 0.26^{a,b}$	0 ± 0^{c}
	Alternaria alternata	20.83 ± 1.04^{a}	11.73 ± 0.25^{b}	21.4 ± 1.04^{a}	0 ± 0^{c}
Lecture hall	*A. flavus*	12.83 ± 0.21^{b}	14.93 ± 0.9^{a}	12.77 ± 0.68^{b}	0 ± 0^{c}
	Penicillium sp.	15.8 ± 0.72^{b}	13.5 ± 0.62^{c}	21.43 ± 0.55^{a}	0 ± 0^{d}
Staircase	*Fusarium* sp.	19.77 ± 0.68^{a}	21.17 ± 1.26^{a}	12.87 ± 0.81^{b}	0 ± 0^{c}
	A. niger	13.33 ± 1.15^{b}	23.67 ± 1.53^{a}	20.6 ± 1.51^{a}	0 ± 0^{c}
Department of Microbiology	*Penicillium* sp.	19.8 ± 0.72^{a}	18.07 ± 0.9^{b}	13.6 ± 0.6^{c}	0 ± 0^{d}
	A. niger	14.47 ± 0.57^{c}	24 ± 1^{a}	21.97 ± 1.05^{b}	0 ± 0^{d}
Library	*Penicillium* sp.	15 ± 1^{b}	12.93 ± 0.9^{c}	21.4 ± 0.53^{a}	0 ± 0^{d}
	Mucor sp.	26.33 ± 2.1^{a}	13.67 ± 1.15^{b}	10.7 ± 1.54^{b}	0 ± 0^{c}
Office	*Penicillium* sp.	18.7 ± 1.47^{b}	26.67 ± 1.53^{a}	25.97 ± 0.45^{a}	0 ± 0^{c}
Mess	*A. niger*	13.67 ± 0.58^{c}	24.93 ± 0.9^{a}	21.8 ± 0.35^{b}	0 ± 0^{d}
Corridor	*A. niger*	11.7 ± 0.62^{b}	16.13 ± 0.81^{a}	10.87 ± 0.81^{b}	0 ± 0^{c}
	Fusarium oxysporum complex	13.43 ± 0.6^{c}	24.07 ± 0.9^{a}	21.9 ± 0.95^{b}	0 ± 0^{c}
Auditorium	*A. niger*	13.1 ± 1.01^{c}	24.37 ± 0.55^{a}	20.03 ± 0.85^{b}	0 ± 0^{d}

Different letters at each row denotes significantly different ($p < 0.05$) according to Tukey's HSD post hoc test.

activity against all the fungal isolates except one *Mucor* sp., which was isolated from the patient waiting area. Similarly, CD2 showed antifungal activity against all fungal isolates except that one *Mucor* sp., which was isolated from the patient waiting area. However, CD3 does not show activity in all the fungal isolates. Stupar *et al.* [64] revealed that BC showed antifungal activity against *A. niger*, *Bipolaris spicifera*, *Penicillium* sp., *A. ochraceus*, *Epicoccum nigrum*, and *Trichoderma viride*, which were isolated from cultural heritage objects. BC showed antifungal activity against *Aspergillus* sp. and *Fusarium* sp. [65]. It is noteworthy that this is the first study to report on the resistance of *Mucor* sp. isolated from environmental floors to BC.

Antibiotic drug susceptibility

Antibiotic drug susceptibility test was done by the disc diffusion method against the environmental Gram-positive and Gram-negative bacterial isolates. Results were interpreted according to the CLSI guidelines [52]. In the case of Gram-positive

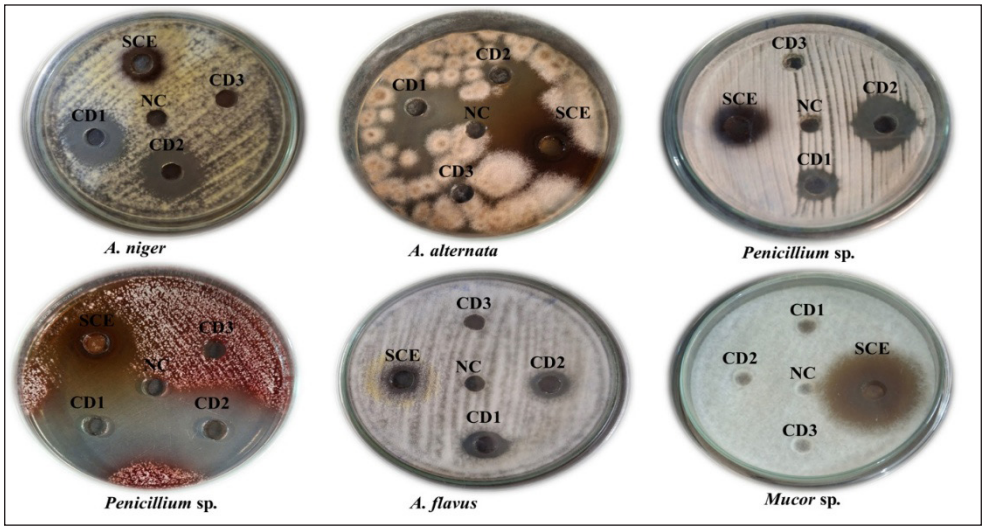

Figure 5. Zone of inhibition of SCE and chemical disinfectants against the fungal environmental floor isolates.

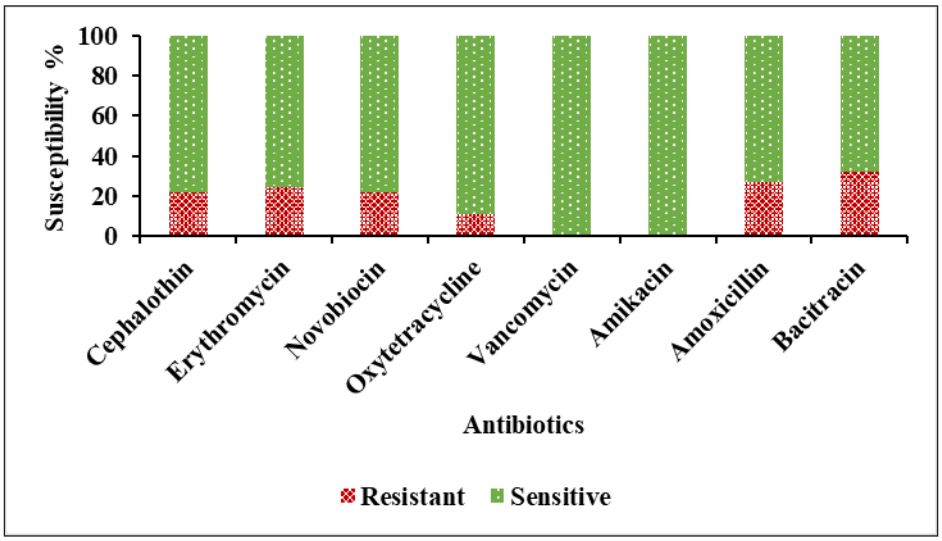

Figure 6. Percentage of antibiotic susceptibility against the Gram-positive environmental isolates.

isolates, it showed resistant of 32.4% (12/37) to B, 27% (10/37) to AMX, 24.3% (9/37) to E, 21.6% (8/37) to CEP and NV, 10.8% (4/37) to O, and it showed 100% (35/35) sensitive to AK and V (Fig. 6). Among the Gram-positive isolates, *Staphylococcus* sp. showed resistant of 58.33% (7/12) to AMX, 50% (6/12) to E, 41.67% (5/12) to NV, and 100% (12/12) sensitive to B, CEP, O, V, and AK. *Bacillus* sp. showed 52% (12/24) resistant to B, 33.33% (8/24) to CEP, 16.67% (4/24) to O, 12.5% (3/24) to AMX, E, and NV, and exhibited 100% 9 (24/24) sensitive to V and AK. *Micrococcus* sp. showed 100% (1/1) sensitivity to all the tested antibiotics. These findings were consistent with the previous study by Mohammed *et al*. [66] who reported that *Staphylococcus* sp. isolated from hospital environment showed 67% resistant to E, and 21% to V, and *Bacillus* sp. showed 8% resistant to E and sensitive to V. *B. cereus* strains isolated from fresh vegetables were 99% resistant to amoxicillin/clavulanic acid combination and 4.5% to E [67]. *Micrococcus* sp. showed 100% (1/1) sensitivity to all the tested antibiotics. This is the first study to report the antibiotic susceptibility pattern of *Micrococcus* sp. isolated from environmental floors.

In the case of Gram-negative isolates, it showed resistant of 100% (4/4) to NIT, 50% (2/4) to K, 50% (2/4) to TE, 25% (1/4) to S and CM, and it showed 100% sensitive to CIP, AK and CB. (Fig. 7). Among the Gram-negative isolates, *P. aeruginosa* showed resistant of 100% (2/2) to NIT and K, 50% (1/2) to CM and TE, and 100% (2/2) sensitive to CIP, S, AK and CB. Eyo *et al*. [68] reported that environmental isolates of *P. aeruginosa* showed resistant to CB, CIP, and AK. Low resistant to AK and CIP against *P. aeruginosa* isolated from the hospital environmental isolates [69]. *Pseudomonas aeruginosa* isolated from residential sewage was resistant to NIT and CIP [70]. Morita *et al*. [71] reported that *P. aeruginosa* was resistant to TE. *Enterobacter hormaechei* showed resistant of 100% (1/1) to NIT and showed 100% (1/1) sensitive to CIP, K, CM, TE, S, AK, and

CB. The result was in accordance with the previous finding [72]. *Providencia rettgeri* showed resistant of 100% (1/1) to NIT and TE and showed 100% (1/1) sensitive to CIP, K, S, CM, AK, and CB which was supported by the previous study [73].

Antifungal drug susceptibility

Antifungal drug susceptibility test was investigated by the disc diffusion method against the environmental fungal isolates. The results were interpreted based on CLSI guidelines [74]. They showed resistant of 100% (20/20) to FLC, 30% (6/20) to Itraconazole (ITR), 15% (3/20) to AMP, and 10% (1/20) to CC (Fig. 8). However, all the fungal isolates were 100% (20/20) sensitive to NS and KT. The results are in accordance with the previous study [75]. Among the fungal isolates, *Mucor* sp. showed 100% (2/2) resistant to FLC and 50% (1/2) to AMP and ITR and showed 100% (2/2) sensitive to NS, CC, and KT. *Alternaria alternata* showed resistant of 100% (1/1) to FLC, ITR, and CC and showed 100% (1/1) sensitive to NS, AP, and KT. *Penicillium* sp. showed resistant of 100% (5/5) to FLC and 20% (1/5) to ITR and produced 100% (5/5) sensitive to NS, AP, CC, and KT. *Fusarium oxysporum* showed 100% resistant to FLC, 33.33% (1/3) to ITR and CC, and 100% (3/3) sensitive to NS, AP, and KT. Moreover, it showed 66.66% (2/3) sensitive to ITR and CC. *Aspergillus niger* showed 100% (8/8) resistant to FLC, 16.67% (1/6) to AMP and ITR, and 100% sensitive to NS, CC, and KT. *Aspergillus flavus* showed 100% resistant to FLC, 33.33% (1/3) to AMP and ITR, and 100% sensitive to NS, CC, and KT. Consistent with our findings, the environmental fungal isolates such as *Aspergillus* sp. and *Mucor* sp. were highly

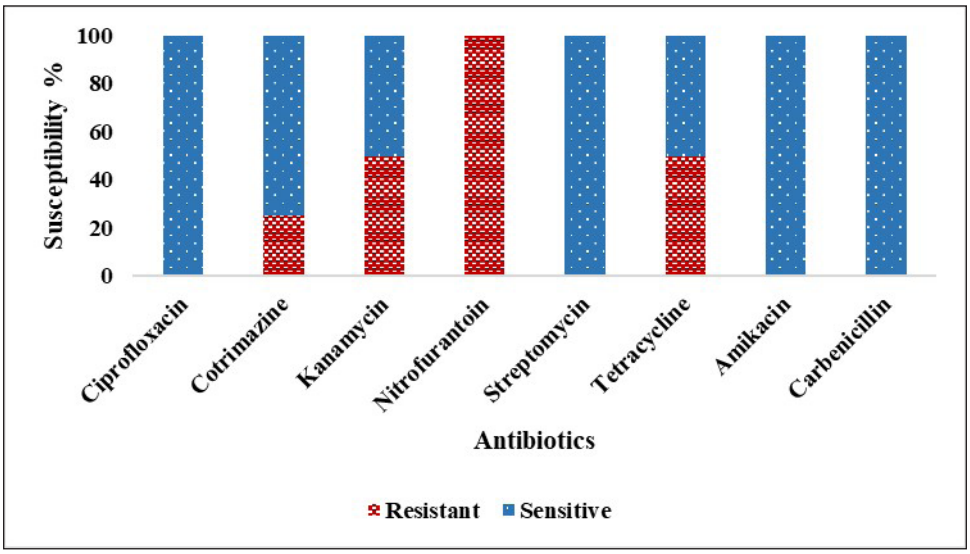

Figure 7. Percentage of antibiotic susceptibility against the Gram-negative environmental isolates.

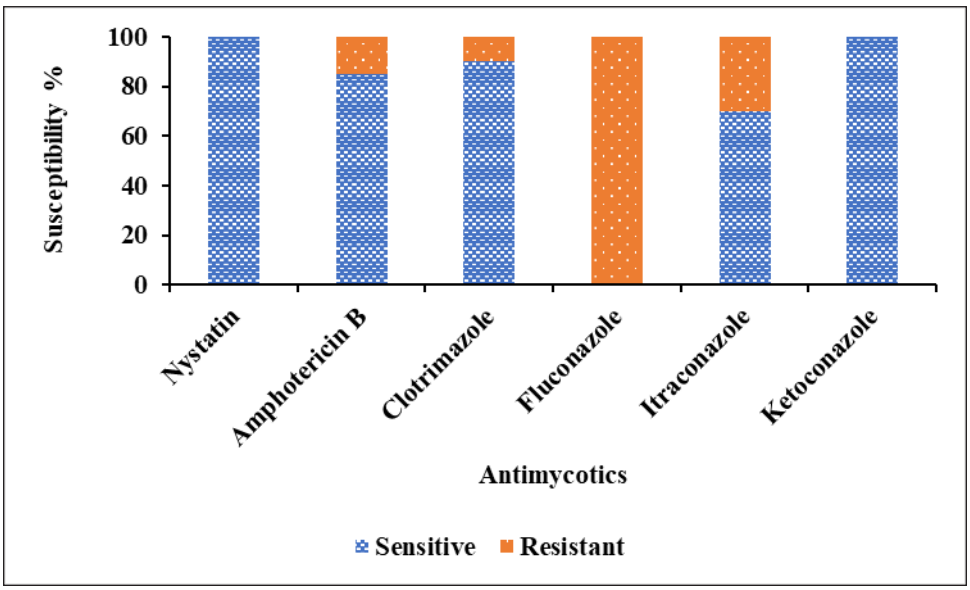

Figure 8. Percentage of antifungal susceptibility against the fungal environmental isolates.

sensitive to AMP but had low susceptibility against *Fusarium* sp. [76] However, *Aspergillus* sp. *Mucor* sp. and *Fusarium* sp. had low susceptibility toward ITR. *Penicillium* sp. and *Alternaria* sp. were highly sensitive.to AMP and ITR. Kaur *et al*. [77] revealed that *A. flavus* and *A. niger* isolated from hospital environments as well as from community environments have low MIC for ITR and high MIC for AMP. *Aspergillus niger*, *A. flavus, Penicillium* sp. And *Mucor* sp. isolated from poultry environments were sensitive to NS but resistant to FLC [78].

CONCLUSION

Syzygium cumini leaf extract showed significant antimicrobial activity against all the bacterial and fungal environmental floor isolates. *Syzygium cumini* extract showed a significant antimicrobial activity against the chemical disinfectant-resistant and antibiotic-resistant environmental isolates, supporting the potential use of *S. cumini* extract as an alternative plant-derived floor disinfectant that is eco-friendly and cost-effective. Identification of disinfectant-resistant genes should be done from the disinfectant-resistant isolates for future studies.

AUTHORS' CONTRIBUTION

All the authors made significant contributions to the conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the International Committee of Medical Journal Editors (ICMJE) requirements/guidelines.

FINANCIAL SUPPORT

There is no funding to report.

CONFLICTS OF INTEREST

The authors report no financial or any other conflicts of interest in this work.

ETHICS STATEMENT

The study was approved by Institutional Biosafety and Ethical Committee (Ref: 331/IRB-IBSEC/SIST Dated 18th October 2023).

DATA AVAILABILITY

All data generated and analyzed are included in this research article.

PUBLISHER'S NOTE

This journal remains neutral with regard to jurisdictional claims in published institutional affiliation.

REFERENCES

1. Antabe R, Ziegler BR. Diseases, emerging and infectious. In: Kobayashi A, editor. International encyclopedia of human geography. 2nd ed. Amsterdam, Netherlands: Elsevier; 2020. pp. 389–91. doi: https://doi.org/10.1016/B978-0-08-102295-5.10439-1
2. Matini E, Shayeghi F, Vaghar M E, Nematian J, Hosseini SS, Mojri N, *et al*. A survey of public restrooms microbial contamination in Tehran city, capital of Iran, during 2019. J Family Med Prim Care. 2020;9(6):3131–5. doi: https://doi.org/10.4103/jfmpc.jfmpc_300_20
3. Qiao M, Ying GG, Singer AC, Zhu YG. Review of antibiotic resistance in China and its environment. Environ Int. 2018;110:160–72. doi: https://doi.org/10.1016/j.envint.2017.10.016
4. Rutala WA, Weber DJ, Barbee SL, Gergen MF, Sobsey MD, Samsa GP, *et al*. Evaluation of antibiotic-resistant bacteria in home kitchens and bathrooms: is there a link between home disinfectant use and antibiotic resistance? Am J Infect Control. 2023;51(11):A158–63. doi: https://doi.org/10.1016/j.ajic.2023.04.005
5. Bragg RR, Meyburgh CM, Lee JY, Coetzee M. Potential treatment options in a post-antibiotic era. Adv Exp Med Biol. 2018;1052:51–61. doi: https://doi.org/10.1007/978-981-10-7572-8_5
6. Paterson RRM, Lima N. Filamentous fungal human pathogens from food emphasising *Aspergillus, Fusarium* and *Mucor*. Microorganisms 2017;5(3):44. doi: https://doi.org/10.3390/microorganisms5030044
7. Al-Shaarani AAQA, Pecoraro L. A review of pathogenic airborne fungi and bacteria: unveiling occurrence, sources, and profound human health implication. Front Microbiol. 2024;15:1428415. doi: https://doi.org/10.3389/fmicb.2024.1428415
8. Hattab Z, Ben Lasfar N, Abid M, Bellazreg F, Fathallah A, Hachfi W, et al. *Alternaria alternata* infection causing rhinosinusitis and orbital involvement in an immunocompetent patient. New Microbes New Infect. 2019;32:100561. doi: https://doi.org/10.1016/j.nmni.2019.100561
9. Caillaud D, Leynaert B, Keirsbulck M, Nadif R. Indoor mould exposure, asthma and rhinitis: findings from systematic reviews and recent longitudinal studies. Eur Respir Rev. 2018;27(148):170137. doi: https://doi.org/10.1183/16000617.0137-2017
10. Crook B, Burton NC. Indoor moulds, sick building syndrome and building related illness. Fungal Biol Rev. 2010;24(3–4):106–13. doi: https://doi.org/10.1016/j.fbr.2010.05.001
11. Jabber AS, Abbas FN, Abid IN, Qasim MT, Radhi LY, Hamim SS. Indoor air study of fungi contamination at internal departments for students in Thi-Qar Government. EJPMR. 2016;3(6):7–12. Available from: https://api.semanticscholar.org/CorpusID:251389186
12. Ozoaduche CL, Idemudia IB. Identification of Fungi isolated from bathrooms in female students' Hostel, University of Benin, Benin City. AJHSE. 2021;2:25–35. doi: https://doi.org/10.52417/ajhse.v2i2.153
13. Gomes IB, Malheiro J, Mergulhao F, Maillard J-Y, Simoes M. Comparison of the efficacy of natural-based and synthetic biocides to disinfect silicone and stainless steel surfaces. Pathog Dis. 2016;74(4):1–7. doi: https://doi.org/10.1093/femspd/ftw014
14. Maillard JY, Pascoe M. Disinfectants and antiseptics: mechanisms of action and resistance. Nat Rev Microbiol. 2024;22:4–17. doi: https://doi.org/10.1038/s41579-023-00958-3
15. Rozman U, Pušnik M, Kmetec S, Duh D, Šostar Turk S. Reduced susceptibility and increased resistance of bacteria against disinfectants: a systematic review. Microorganisms 2021;9(12):2550. doi: https://doi.org/10.3390/microorganisms9122550
16. Chaturvedi P, Shukla P, Giri BS, Chowdhary P, Chandra R, Gupta P, *et al*. Prevalence and hazardous impact of pharmaceutical and personal care products and antibiotics in environment: a review on emerging contaminants. Environ Res. 2021;194:110664. doi: https://doi.org/10.1016/j.envres.2020.110664
17. Tong C, Hu H, Chen G, Li Z, Li A, Zhang J. Disinfectant resistance in bacteria: mechanisms, spread, and resolution strategies. Environ Res. 2021;195:110897. doi: https://doi.org/10.1016/j.envres.2021.110897
18. Mc Carlie S, Boucher CE, Bragg RR. Molecular basis of bacterial disinfectant resistance [published correction appears in Drug Resist Updat. 65:100867. doi: https://doi.org/10.1016/j.drup.2022.100867]. Drug Resist Updat. 2020;48:100672. doi: https://doi.org/10.1016/j.drup.2019.100672
19. Abreu AC, Tavares RR, Borges A, Mergulhão F, Simões M. Current and emergent strategies for disinfection of hospital environments. J Antimicrob Chemother. 2013;68(12):2718–32. doi: https://doi.org/10.1093/jac/dkt281

20. Russell AD. Bacterial resistance to disinfectants: present knowledge and future problems. J Hosp Infect. 1999;43:S57–68. doi: https://doi.org/10.1016/S0195-6701(99)90066-X
21. He GX, Landry M, Chen H, Thorpe C, Walsh D, Varela MF, *et al*. Detection of benzalkonium chloride resistance in community environmental isolates of staphylococci. J Med Microbiol. 2014;63(5):735–41. doi: https://doi.org/10.1099/jmm.0.073072-0
22. Pereira BMP, Tagkopoulos I. Benzalkonium chloride: uses, regulatory status, and microbial resistance. Appl Environ Microbiol. 2019;85(13):e00377-19. doi: https://doi.org/10.1128/AEM.00377-19
23. El-Banna T, Abd El-Aziz A, Sonbol F, El-Ekhnawy E. Adaptation of *Pseudomonas aeruginosa* clinical isolates to benzalkonium chloride retards its growth and enhances biofilm production. Mol Biol Rep. 2019;46:3437–43. doi: https://doi.org/10.1007/s11033-019-04806-7
24. Maillard JY. Impact of benzalkonium chloride, benzethonium chloride and chloroxylenol on bacterial antimicrobial resistance. J Appl Microbiol. 2022;133(6):3322–46. doi: https://doi.org/10.1111/jam.15739
25. Boutarfi Z, Rebiahi S-A, Morghad T, Pulido RP, Burgos MJG, Mahdi F, *et al*. Biocide tolerance and antibiotic resistance of *Enterobacter* spp. isolated from an Algerian hospital environment. J Glob Antimicrob Resist. 2019;18:291–7. doi: https://doi.org/10.1016/j.jgar.2019.04.005
26. Gupta AK, Ahmad I, Summerbell RC. Fungicidal activities of commonly used disinfectants and antifungal pharmaceutical spray preparations against clinical strains of *Aspergillus* and *Candida* species. Med Mycol. 2002;40(2):201–8. doi: https://doi.org/10.1080/mmy.40.2.201.208
27. Terleckyj B, Axler DA. Efficacy of disinfectants against fungi isolated from skin and nail infections. J Am Podiatr Med Assoc. 1993;83(7):386–93. doi: https://doi.org/10.7547/87507315-83-7-386
28. Bhat SA, Sher F, Kumar R, Karahmet E, Haq SAU, Zafar A, *et al*. Environmental and health impacts of spraying COVID-19 disinfectants with associated challenges. Environ Sci Pollut Res Int. 2022;29:85648–57. doi: https://doi.org/10.1007/s11356-021-16575-7
29. Dewey HM, Jones JM, Keating MR, Budnathoki-Uprety J. Increased use of disinfectants during the COVID-19 pandemic and its potential impacts on health and safety. ACS Chem Health Saf. 2022;29(1):27–38. doi: https://doi.org/10.1021/acs.chas.1c00026
30. Dhama K, Patel SK, Kumar R, Masand R, Rana J, Yatoo MI, *et al.* The role of disinfectants and sanitizers during COVID-19 pandemic: advantages and deleterious effects on humans and the environment. Environ Sci Pollut Res. 2021;28:34211–28. doi: https://doi.org/10.1007/s11356-021-14429-w
31. Hashemi F, Hoepner L, Hamidinejad FS, Haluza D, Afrashteh S, Abbasi A, *et al.* A comprehensive health effects assessment of the use of sanitizers and disinfectants during COVID-19 pandemic: a global survey. Environ Sci Pollut Res. 2023;30:72368–88. doi: https://doi.org/10.1007/s11356-023-27197-6
32. William A. Rutala WA, Weber DJ and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008. Centre for Disease Control and Prevention; 2024[cited 2024 Dec 17]. Available from: https://www.cdc.gov/infection-control/media/pdfs/Guideline-Disinfection-H.pdf
33. Mandavgane SA, Rambhal AK, Mude NK. Development of cow urine based disinfectant. Natural Product Radiance. 2005;4(5):410–5. Available from: http://nopr.niscpr.res.in/handle/123456789/8129
34. Imran M, Imran M, Khan S. Antibacterial activity of *Syzygium cumini* leaf extracts against multidrug resistant pathogenic bacteria. J App Pharm Sci. 2017;7(3):168–74. doi: https://doi.org/10.7324/JAPS.2017.70327
35. Chhikara N, Kaur R, Jaglan S, Sharma P, Gat Y, Panghal A. Bioactive compounds and pharmacological and food applications of *Syzygium cumini* - a review. Food Funct. 2018;9(12):6096–115. doi: https://doi.org/10.1039/C8FO00654G
36. Elfadil AG, Karamallah AA, Abualhassan AM, Hamid AA, Sabahelkhier MK. Antimicrobial activities of *Syzygium cumini* leave extracts against selected microorganisms. NJMBS. 2015;4:1–8. Available from: https://api.semanticscholar.org/CorpusID:87668526
37. Devi HJ, Gnanasekaran P, Devi YA, Siva D, Jayashankar J. Investigation of the antimicrobial efficacy and cytotoxicity of a natural disinfectant *Syzygium cumini* (L.) skeels leaf extract on vero cell lines. J Appl Pharm Sci. 2025;15(1):125–32. doi: https://doi.org/10.7324/JAPS.2024.203410
38. dos Santos KK, Matias EF, Tintino SR, Souza CE, Braga MF, Guedes GM, *et al*. Cytotoxic, trypanocidal, and antifungal activities of *Eugenia jambolana* L. J Med Food. 2012;15(1):66–70. doi: https://doi.org/10.1089/jmf.2010.0298
39. Diningrat DS, Sari AN, Harashap NS, Kusdianti. *In silico* study of the toxicity and antiviral activity prediction of Jablang (*Syzygium cumini*) leaves essential oil as ACE_2 Inhibitor. PharmacologyOnLine. 2021;3:1334–51. Available from: https://pharmacologyonline.silae.it/files/archives/2021/vol3/PhOL_2021_3_A146_Diningrat.pdf
40. Devi HJ, Gnanasekaran P, Devi YA. Selection of effective plant extract as a disinfecting agent using hot and cold-water extraction. Eco. Env Cons. 2022;28(4):1874–81. doi: http://doi.org/10.53550/EEC.2022.v28i04.034
41. Qamar M, Akhtar S, Ismail T, Wahid M, Abbas MW, Mubarak MS, *et al*. Phytochemical profile, biological properties, and food applications of the medicinal plant *Syzygium cumini*. Foods 2022;11(3):378. doi: https://doi.org/10.3390/foods11030378
42. Rizvi MK, Rabail R, Munir S, Inam-Ur-Raheem M, Qayyum MMN, Kieliszek M, *et al*. Astounding health benefits of jamun (*Syzygium cumini*) toward metabolic syndrome. Molecules 2022;27(21):7184. doi: https://doi.org/10.3390/molecules27217184
43. Wirahmi N, Masrijal CDP, Amri F, Ikhsan, Triyansyah MI. Formulation and antibacterial activity of natural disinfectant combination of *Psidium guajava* and *Piper betle* leaf infusion against *Staphylococcus aureus*. Proceedings of the 2nd International Conference on Contemporary Science and Clinical Pharmacy 2021 (ICCSCP 2021). Dordrecht, Netherlands: Atlantis Press; 2021. pp 91–7. doi: https://doi.org/10.2991/ahsr.k.211105.013
44. Barbieri R, Coppo E, Marchese A, Daglia M, Sobarzo-Sánchez E, Nabavi SF, *et al*. Phytochemicals for human disease: an update on plant-derived compounds antibacterial activity. Microbiol Res. 2017;196:44–68. doi: https://doi.org/10.1016/j.micres.2016.12.003
45. Li J, Monje-Galvan V. *In vitro* and *in silico* studies of antimicrobial saponins: a review. Processes 2023;11(10):2856. doi: https://doi.org/10.3390/pr11102856
46. Pereira JV, Freires IA, Castilho AR, da Cunha MG, Alves HDS, Rosalen PL. Antifungal potential of *Sideroxylon obtusifolium* and *Syzygium* and their mode of action against *Candida albicans*. Pharm Biol. 2016;54(10):2312–19. doi: https://doi.org/10.3109/13880209.2016.1155629
47. Gahongayire S, Aliero AA, Kato CD, Namatovu A. Prevalence and detection of qac genes from disinfectant-resistant Staphylococcus aureus isolated from salon tools in Ishaka Town, Bushenyi District of Uganda. Can J Infect Dis Med Microbiol. 2020;2020:1–11. doi: https://doi.org/10.1155/2020/1470915
48. Palmer OG, Onifade AK. Microorganisms isolated from hospital environmental surfaces in Akure Metropolis, Ondo State, Nigeria. J Adv Microbiol. 2019;15(3):1–8. doi: https://doi.org/10.9734/JAMB/2019/v15i330104
49. Chand S, Saha K, Singh PK, Sri S, Malik N. Determination of minimum inhibitory concentration (MIC) of routinely used disinfectants against microflora isolated from clean rooms. Int J Curr Microbiol App Sci. 2016;5(1):334–41. doi: https://doi.org/10.20546/ijcmas.2016.501.03
50. Suryani AE, Nisa K, Handayani S, Darsih C, Wuryastuty H, Yanuartono Y. The UHPLC-HRMS profiling, *in vitro* antioxidant and pancreatic lipase inhibitory activities of *Peronema canescens*

leaves extract and fractions from Indonesia J Appl Pharm Sci. 2025;15(05):75–89. doi: http://doi.org/10.7324/JAPS.2025.214965
51. Nayaka S, Chakraborty B, Bhat MP, Nagaraja SK, Airodagi D, Swamy PS, *et al*. Biosynthesis, characterization, and *in vitro* assessment on cytotoxicity of actinomycete-synthesized silver nanoparticles on *Allium cepa* root tip cells. Beni-Suef Univ J Basic Appl Sci. 2020;9:51. doi: https://doi.org/10.1186/s43088-020-00074-8
52. Clinical and Laboratory Standards Institute. Performance standards for antimicrobial susceptibility testing. 33rd ed. CLSI supplement M100; 2023.
53. Clinical and Laboratory Standards Institute. Method for antifungal disk diffusion susceptibility testing of nondermatophyte filamentous fungi; approved guideline. Wayne, PA: CLSI document M51-A; 2010.
54. Buhari A-SM, Kamaldeen A-S, Hassan Ummu KM. Isolation of fungal flora in carpet and floor dust samples as an indicator of indoor air quality (IAQ): a case study of a nigerian institution. Int J Sci Res. 2012;2(8):1–7. Available from: https://www.ijsrp.org/research-paper-0812/ijsrp-p0804.pdf
55. Bhatia L, Vishwakarma R. Hospital indoor airborne microflora in private and government owned hospital in Sagar City, India. WJMS. 2010;5(3):65–70.
56. Viegas C, Dias M, Monteiro A, Faria T, Lage J, Carolino E, *et al*. Bioburden in sleeping environments from Portuguese dwellings. Environ Pollut. 2021;273:116417. doi: https://doi.org/10.1016/j.envpol.2020.116417
57. Loughlin MF, Jones MV, Lambert PA. *Pseudomonas aeruginosa* cells adapted to benzalkonium chloride show resistance to other membrane-active agents but not to clinically relevant antibiotics. J Antimicrob Chemother. 2002;49(4):631–9. doi: https://doi.org/10.1093/jac/49.4.631
58. Sakagami Y, Yokoyama H, Nishimura H, Ose Y, Tashima T. Mechanism of resistance to benzalkonium chloride by *Pseudomonas aeruginosa*. Appl Environ Microbiol. 1989;55(8):2036–40. doi: https://doi.org/10.1128/aem.55.8.2036-2040.1989
59. El Moug T, Rogers DT, Furr JR, El-Falaha BMA, Russell AD. Antiseptic-induced changes in the cell surface of a chlorhexidine-sensitive and a chlorhexidine-resistant strain of *Providencia stuartii*. J Antimicrob Chemother. 1986;16:685–9. doi: https://doi.org/10..1093/jac/16.6.685
60. Stickler DJ, Thomas B, Chawla JC. Antiseptic and antibiotic resistance in Gram-negative bacteria causing Urinary tract infection in spinal cord injured patients. Spinal Cord. 1981;19:50–8. doi: https://doi.org/10.1038/sc.1981.13
61. Russell AD, Suller MTE, Maillard JY. Do antiseptics and disinfectants select for antibiotic resistance? J Med Microbiol. 1999;48(7):613–5. doi: https://doi.org/10.1099/00222615-48-7-613
62. Arif T, Bhosale JD, Kumar N, Mandal TK, Bendre RS, Lavekar GS, *et al*. Natural products- antifungal agents derived from plants. J Asian Nat Prod Res. 2009;11(7):621–38. doi: https://doi.org/10.1080/10286020902942350
63. Kursa W, Jamiołkowska A, Wyrostek J, Kowalski R. Antifungal effect of plant extracts on the growth of the cereal pathogen *Fusarium* spp.—an *in vitro* study. Agronomy 2022;12(12):3204. doi: https://doi.org/10.3390/agronomy12123204
64. Stupar, Grbić ML, Džamić A, Unković N, Ristić M, Jelikić A, *et al*. Antifungal activity of selected essential oils and biocide benzalkonium chloride against the fungi isolated from cultural heritage objects. S Afr J Bot. 2014;93:118–24. doi: https://doi.org/10.1016/j.sajb.2014.03.016
65. Day S, Lalitha P, Haug S, Fothergill AW, Cevallos V, Vijayakumar R, *et al*. Activity of antibiotics against *Fusarium* and *Aspergillus*. Br J Ophthalmol. 2009;93(1):116–9. doi: https://doi.org/10.1136/bjo.2008.142364
66. Mohammed WE, Hassan HE, Yousif MA. Antibiotic sensitivity pattern of bacteria isolated from the environment of intensive care unit of Wad Medani emergency hospital, Gezira state, Sudan. Int J Curr Pharm Res. 2020;12(5):82–5. doi: https://doi.org/10.22159/ijcpr.2020v12i5.39772
67. Fiedler G, Schneider C, Igbinosa EO, Kabisch J, Brinks E, Becker B, *et al*. Antibiotics resistance and toxin profiles of *Bacillus cereus*-group isolates from fresh vegetables from German retail markets. BMC Microbiol. 2019;19:250. doi: https://doi.org/10.1186/s12866-019-1632-2
68. Eyo AA, Ibeneme EO, Thumamo BD, Asuquo AE. Antibiotic resistance profiles of clinical and environmental isolates of *Pseudomonas aeruginosa* in Calabar, Nigeria. J Pharm Biol Sci. 2015;10(4):09–15. Available from: https://www.iosrjournals.org/iosr-jpbs/papers/Vol10-issue4/Version-1/B010410915.pdf
69. Karami P, Mohajeri P, Mashouf RY, Karami M, Yaghoobi MH, Dastan D, *et al*. Molecular characterization of clinical and environmental *Pseudomonas aeruginosa* isolated in a burn center. Saudi J Biol Sci. 2019;26(7):1731–6. doi: https://doi.org/10.1016/j.sjbs.2018.07.009
70. Adesoji AT, Onuh JP, Palang IP, Liadi AM, Musa S. Prevalence of multi-drug-resistant *Pseudomonas aeruginosa* isolated from selected residential sewages in Dutsin-Ma, Katsina State, Nigeria. J Public Health Afr. 2023;14(2):5. doi: https://doi.org/10.4081/jphia.2023.2152
71. Morita Y, Tomida J, Kawamura Y. Responses of *Pseudomonas aeruginosa* to antimicrobials. Front Microbiol. 2014;4:422. doi: https://doi.org/10.3389/fmicb.2013.00422
72. O'Hara CM, Steigerwalt AG, Hill BC, Farmer JJ, Fanning GR, Brenner DJ. *Enterobacter hormaechei*, a new species of the family Enterobacteriaceae formerly known as enteric group 75. J Clin Microbiol. 1989;27(9):2046–9. doi: https://doi.org/10.1128/jcm.27.9.2046-2049.1989
73. Malviya M, Kale-Prathan P, Coyle M, Giuliano C, Johnson LB. Clinical and drug resistance characteristics of providencia infections. Microorganisms 2024;12(10):2085. doi: https://doi.org/10.3390/microorganisms12102085
74. Clinical and Laboratory Standards Institute. Performance standards for antifungal disk diffusion susceptibility testing of nondermatophyte filamentous fungi; informational supplement; CLSI M51-S1. 2010.
75. Farian E, Wojcik-Fatla A. Diversity and drug resistance of filamentous fungi isolated from the fresh Raspberries. Indian J Microbiol. 2022;62:146–51. doi: https://doi.org/10.1007/s12088-021-00966-y
76. Badiee P, Ghadimi-Moghadam A, Bayatmanesh H, Soltani J, Salimi-Khorashad AR, Ghasemi F, *et al*. Environmental surveillance of fungi and susceptibility to antifungal agents in tertiary care hospitals. Microbiol Spectr. 2024;12(1):e02270-23. doi: https://doi.org/10.1128/spectrum.02270-23
77. Kaur M, Singla N, Aggarwal D, Kundu R, Gulati N, Kumar MB, *et al*. J. Antifungal susceptibility profile of clinical and environmental isolates of *Aspergillus* species from a tertiary care center in North India. Cureus 2024;16(2):e54586. doi: https://doi.org/10.7759/cureus.54586
78. Mgbeahuruike AC, Aliyoo K, Karlsson M, Chah KF. Identification, antifungal susceptibility and phylogenetic comparison of fungi in poultry environment in Nigeria. Int J Poult Sci. 2020;19(12):548–56. Available from: https://scialert.net/abstract/?doi=ijps.2020.548.556

How to cite this article:
Devi HJ, Gnanasekaran P, Devi YA, Saravanan D, Gopal T, Balakumar V, Sathish P, Nataraja K, Sundar BKJ, Femi FD. Comparative efficacy of *Syzygium cumini* leaf extract and chemical disinfectants against hospital floor isolates: First report of benzalkonium chloride-resistant *Mucor* sp. J Appl Pharm Sci. 2025. Article in Press.
http://doi.org/10.7324/JAPS.2025.v15.i11.13