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Inhibitory efficiency of various natural and synthetic antibacterial agents against bacteria isolated from a hospital environment

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Abstract: Nosocomial infections pose significant challenges to healthcare systems worldwide. Despite frequent environmental cleaning and disinfection measures, the emergence of antibiotic and disinfectant-resistant bacterial pathogens continues to rise due to the misuse of antimicrobials. In this study, we aimed to identify bacteria isolated from the hospital environment, analyze their antibiotic resistance profiles, and assess their susceptibility to various antimicrobials (thymol (T), thyme oil (TO), zinc pyrithione (ZnPt), magnesium monoperoxyphthalate (MMPP)). Bacteria were isolated from the hospital environment and identified using the VITEK system. Antibiotic resistance profiles were determined using the disc diffusion technique, while the efficacy of different antimicrobials was assessed using the agar well diffusion technique. The isolates comprised 13.0% *Staphylococcus hominis*, 13.0% *Micrococcus* sp., 13.0% *Staphylococcus sciuri*, 27.0% *Staphylococcus haemolyticus*, 7.0% *Staphylococcus warneri*, 13.0% *Escherichia vulneris*, 7.0% *Sphingomonas paucimobilis*, and 7.0% *Kocuria kristinae*. It was observed that 10% of the isolates exhibited resistance to the tested antibiotics, while 74% were susceptible. Furthermore, the bacterial isolates demonstrated higher sensitivity to ZnPt compared to other substances, with the sensitivity ranking of alternative disinfectants as ZnPt>T>TO>MMPP. Our findings indicate that bacterial isolates showed a high sensitivity to ZnPt. Therefore, disinfectants containing ZnPt (0.1% concentration) could be effective in combating nosocomial infections.

Keywords: Antibiotic resistance; Bacteria; Disinfectant; Hospital, Nosocomial infection.

1 Introduction

Nosocomial infections have remained a significant challenge for healthcare systems throughout history. They not only prolong hospital stays but also contribute to the development of new infections (Kireçci et al. 2018). Numerous studies have highlighted that weakened immune systems and vulnerable patient populations, such as children, are particularly susceptible to nosocomial infections caused by opportunistic pathogenic microorganisms (Çavdar et al. 2022). Patient contact with contaminated environmental surfaces is a key factor in the transmission of hospital-acquired infections, with environmental surfaces estimated to play a role in 15-20% of such cases (Ekrami et al. 2011; Sserwadda et al. 2018). This is primarily because the hospital environment can serve as a reservoir for pathogenic organisms (Muhammad et al. 2013; Misgana et al. 2015). Consequently, regular microbiological monitoring of hospital equipment and the environment is crucial for detecting the presence of multidrug-resistant or virulent pathogens that could lead to nosocomial infections (Mulu et al. 2012; Messele et al. 2009).

Despite frequent environmental cleaning and disinfection efforts, mismanagement policies, such as the inappropriate use of antiseptics and disinfectants in hospitals, have been linked to increased rates of nosocomial infections (Kihla et al. 2014). Misuse of antiseptics and disinfectants can contribute to the development of bacterial resistance, including cross-resistance to antibiotics (Mendonça et al. 2000). The detection of pathogens like *Acinetobacter. baumannii* and methicillin-resistant *Staphylococcus aureus* (MRSA) on environmental surfaces following cleaning and disinfection underscores the importance of implementing effective cleaning practices to mitigate the risk of nosocomial infections. The proliferation of resistant pathogens in hospital environments not only leads to prolonged hospital stays but also contributes to higher

morbidity and mortality rates, as well as imposing a significant economic burden (Kamat et al. 2008).

Effective disinfectant selection is a critical step in preventing nosocomial infections (Fagon et al. 1989). However, contemporary challenges include the emergence of bacterial resistance to commonly used disinfectants. Therefore, there is a growing need for disinfectants with high efficacy and diverse mechanisms of action. In this study, we aimed to investigate the identification of bacteria isolated from the hospital environment, their antibiotic resistance profiles, and their susceptibility to different antimicrobials (thymol, thymol mixture, thyme oil, zinc pyrithione, magnesium monoperoxyphthalate).

2 Materials and Method

2.1 Bacterial Isolation

A total of 35 samples were collected from various sites within a private hospital in Duzce using sterile swab sticks. Sampling sites included the x-ray cassette (RK), urine specimen collection cabinet (HR), laboratory bench (LT), microscope (M), effort (EF), blood collection stretcher (KS), operating room endoscopy device (E), audiometer headset (OK), electrocardiography device (EKG), centrifuge (S), and operating room autoclave (O). These samples were inoculated onto petri dishes containing nutrient agar (NA, Merck) and then incubated at 37°C for 24 hours. Following incubation, bacteria were isolated and purified based on their colony morphology.

2.2 Identification of Isolates

Gram properties of the bacterial isolates were initially determined using the Potassium Hydroxide Test (3% KOH) (Suslow et al. 1982). Subsequently, the isolates were identified using the VITEK 2 system (BioMérieux). The bacterial isolates were incubated in Tryptic Soy Agar (TSA) medium for 16-18 hours at 37°C, and cultures from these incubations were used for card inoculation.

2.3 Antibiotic Susceptibility of Isolates

The antibiotic susceptibility of the isolates was assessed using the agar disc diffusion method with seven different antibiotic discs: IMC (imipenem-cilastatin, 20 µg, Bioanalyse), E (erythromycin, 15µg, Oxoid), CIP (ciprofloxacin, 5µg, Oxoid), S (streptomycin, 10µg, Oxoid), CD (cefdinir, 30µg, Bioanalyse), AZM (azithromycin, 15µg, Oxoid), and TOB (tobramycin, 10µg, Oxoid) (Maragkoudakis et al. 2006; Turhan-Eryılmaz, 2011). Bacterial isolates were first incubated in nutrient broth (NB, Merck) for 18-24 hours. Following incubation, bacterial dilutions were prepared to achieve a concentration of 10^8 cells/ml, and 100 µl of these dilutions were spread onto NA-containing petri dishes. Antibiotic discs were then placed on these petri dishes, and the dishes were incubated at 37°C for 16-18 hours. Antibiotic susceptibility was determined based on the inhibition zones around the antibiotic discs, with results interpreted according to guidelines provided by the Clinical and Laboratory Standards Institute (CLSI).

2.4 Susceptibility Profile of Isolates to Some Antimicrobial Agents

Alternative disinfectants used in this study included T (1-10% (v/v) Thymol), TO (1-10% (v/v) Thyme Oil), ZnPt (0.1-10% (v/v) zinc pyrithione,), and MMPP (1-10% (v/v) Magnesium monoperoxyphthalate,). The solutions were prepared using distilled water. The antibacterial activities of these molecules against bacterial isolates were assessed using the agar well diffusion method (Aytar et al. 2019). Bacterial isolates were incubated in NB for 18-24 hours, and bacterial dilutions were prepared at a concentration of 10^8 cells/ml. Subsequently, 100 µl of the bacterial dilutions were spread onto petri dishes containing NA. Wells (6 mm) were then drilled under aseptic conditions on the petri dish, and 100 µl of the antimicrobial substances (alternative disinfectants) were added to the wells. The dishes were incubated at 37°C for 16-18 hours, after which the sensitivity of the isolates to the antimicrobial substances was determined based on the zones around the wells.

3 Results

3.1 Identification of Bacteria

The samples were collected from 35 different hospital environments, resulting in the culturing of 15 different bacterial isolates. Subsequently, the gram properties of these isolates were assessed, revealing 14 Gram-positive and 1 Gram-negative bacteria (Table 1). Using the VITEK identification system, the isolates were further characterized, yielding the following distribution: 13.0% *Staphylococcus hominis*, 13.0% *Micrococcus* sp., 13.0% *Staphylococcus sciuri*, 27.0% *Staphylococcus haemolyticus*, 7.0% *Staphylococcus warneri*, 13.0% *Esherichia vulneris*, 7.0% *Sphingomonas paucimobilis*, and 7.0% *Kocuria kristinae* (Figure 1 and Table 1).

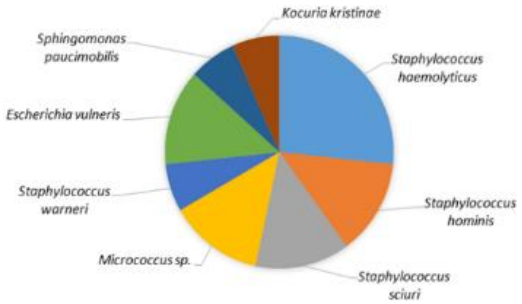

Fig. 1 Identification of isolates with VITEK.

Antibiotic susceptibility analysis of the bacterial isolates revealed high sensitivity to Imipenem and Ciprofloxacin antibiotics. However, *S. paucimobilis* (IK3) and *S. sciuri* (E1) exhibited resistance to approximately 43% of antibiotics. Specifically, E1 demonstrated resistance to Tobramycin, Azithromycin, and Cefdinir antibiotics, while IK3 displayed resistance to Tobramycin, Streptomycin, and Cefdinir antibiotics.

Table 1 VITEK identification results of bacterial isolates

Isolate Code	Source	Gram Properties	Colony Morphology	Bacterial Isolate
RK1	X-Ray Cassette	G (+)	Yellow	*Micrococcus* sp.
IK2	Urine Sample Collection Cabinet	G (+)	White	*Staphylococcus hominis*
LT1	Laboratory Bench	G (+)	White, Mucous	*Staphylococcus sciuri*
M2	Microscope	G (+)	White	*Staphylococcus haemolyticus*
EF2	Effort	G (+)	Yellow, Matte	*Staphylococcus haemolyticus*
KS5	Blood Collection Stretcher	G (+)	Orangey yellow	*Staphylococcus warneri*
IK1	Urine Sample Collection Cabinet	G (-)	Light yellow	*Escherichia vulneris*
IK3	Urine Sample Collection Cabinet	G (+)	White	*Sphingomonas paucimobilis*
E1	Operating Room Endoscopy Device	G (+)	White	*Staphylococcus sciuri*
E5	Operating Room Endoscopy Device	G (+)	White, Matte	*Staphylococcus haemolyticus*
OK1	Audiometer Headset	G (+)	White, Matte	*Staphylococcus hominis*
RK5	X-Ray Cassette	G (+)	Transparent	*Escherichia vulneris*
EKG2	Electrocardiography Device	G (+)	White	*Staphylococcus haemolyticus*
OK4	Audiometer Headset	G (+)	Light yellow	*Kocuria kristinae*
O2	Operating Room Autoclave	G (+)	Yellow	*Micrococcus* sp.

Table 2 Antibiotic susceptibility profiles of bacterial isolates

Isolate Code	Antibiotics / Zone of Inhibition (mm)						
	IMC20	**TOB10**	**AZM30**	**S25**	**E30**	**CD30**	**CIP30**
RK1	>30[a]	17.25±1.23[b]	19.75±1.26[a]	20.50±1.29[a]	24.50±0.58[a]	10.75±1.26[c]	27.25±0.50[a]
IK2	>30[a]	18.50±0.50[b]	27.25±1.26[a]	23.50±2.08[a]	>30[a]	23.50±1.29[a]	>30[a]
LT1	>30[a]	14.75±1.26[b]	18.75±0.96[a]	20.25±0.50[a]	21.00±0.82[a]	12.00±0.82[c]	>30[a]
M2	>30[a]	18.75±1.26[b]	16.75±0.96[b]	20.50±1.00[a]	21.75±1.26[a]	22.00±0.82[a]	>30[a]
EF2	>30[a]	16.25±1.26[b]	20.50±1.29[a]	19.75±0.50[a]	24.50±1.29[a]	20.50±1.29[a]	22.75±2.63[a]
KS5	>30[a]	17.25±0.50[b]	22.75±1.71[a]	20.00±3.56[a]	29.00±0.82[a]	25.50±1.29[a]	>30[a]
IK1	21.75±1.26[a]	19.00±0.82[b]	21.75±1.26[a]	24.00±0.82[a]	15.25±0.96[b]	19.75±0.26[a]	>30[a]
IK3	>30[a]	11.50±1.29[c]	18.50±0.58[a]	10.00±1.63[c]	20.50±0.29[a]	13.00±2.16[c]	21.50±0.58[a]
E1	>30[a]	11.00±0.82[c]	00.00±0.00[c]	20.25±0.50[a]	22.75±0.50[a]	00.00±0.00[c]	29.25±1.26[a]
E5	>30[a]	18.75±0.25[b]	>30[a]	22.50±3.11[a]	>30[a]	>30[a]	>30[a]
OK1	>30[a]	19.75±1.26[a]	25.75±0.96[a]	22.00±1.41[a]	>30[a]	28.75±0.96[a]	>30[a]
RK5	>30[a]	17.25±1.26[b]	20.75±1.26[a]	20.75±1.26[a]	23.50±1.00[a]	10.50±3.32[c]	21.75±0.96[a]
EKG2	>30[a]	12.50±1.29[c]	21.00±2.16[a]	17.75±1.71[b]	20.25±0.50[a]	14.50±0.25[b]	>30[a]
OK4	>30[a]	23.75±0.50[a]	>30[a]	>30[a]	25.50±1.29[a]	27.75±1.71[a]	>30[a]
O2	>30[a]	10.50±1.29[c]	16.50±1.29[b]	20.00±0.82[a]	19.75±0.50[b]	20.75±0.36[a]	21.75±0.50[a]

IMC20; imipenem-cilastatin (10-10 µg/disc), TOB10; tobramycin (10 µg/disc), AZM30; azithromycin (30 µg/disc), S25; streptomycin (25 µg/disc), E30; erythromycin (30 µg/disc), CD30; cefdinir (30 µg/disc), CIP30; ciprofloxacin, (30 µg/disc). Antibiotic susceptibility: a: Sensitive, b: Intermediate, c: Resistant.

Additionally, *Micrococcus* sp. (RK1), *S. sciuri* (LT1), and *E. vulneris* (RK5) were found to be resistant to Cefdinir. *S. haemolyticus* (EKG2) and *Micrococcus* sp. (O2) exhibited resistance to Tobramycin antibiotic, whereas *K. kristinae* (OK4) displayed overall sensitivity. Overall, 10.48% of the isolates were resistant to the tested antibiotics, 14.29% showed intermediate sensitivity, and 75.24% were susceptible (Table 2, Figures 2). Furthermore, the inhibition activities of T, TO, ZnPt, and MMPP were assessed using the well diffusion method against the bacterial isolates. The sensitivity of bacterial isolates was determined based on the inhibition diameters around the wells, with ZnPt demonstrating the highest sensitivity compared to other substances. The sensitivity ratios were ranked as follows: ZnPt > T > TO > MMPP (Table 3)

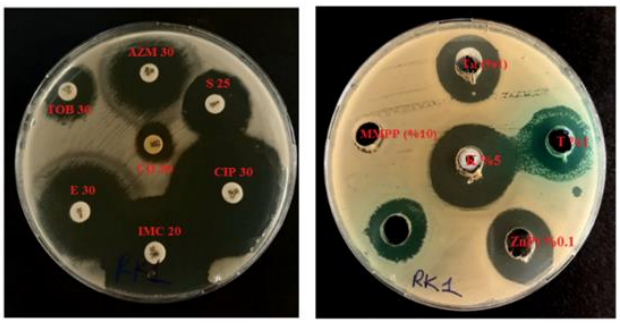

Fig. 2 Antibiotic and disinfectant susceptibility of the isolate *Micrococcus* sp.

Table 3 Susceptibility profiles of bacterial isolates against antimicrobials

Code	Antimicrobial Agents / Zone of Inhibition (mm)								
	(T)		(TO)			(ZnPt)		(MMPP)	
	1%	10%	1%	5%	10%	0.1%	1-10%	1%	10%
RK1	13.75±0.50	>30	-	25.50±1.29	>30	20.00±1.29	>30	-	-
IK2	09.00±1.29	>30	11.75±1.26	>30	>30	17.25±1.26	>30	-	08.50±1.00
LT1	-	10.50±0.50	-	-	10.25±1.25	15.25±1.26	>30	-	-
M2	16.25±0.50	>30	11.25±0.82	11.50±0.50	>30	20.25±0.50	>30	-	09.50±0.50
EF2	10.75±1.26	>30	-	19.50±1.00	>30	23.50±1.00	>30	-	13.25±1.29
KS5	12.50±1.25	>30	10.25±2.63	21.75±2.00	>30	20.00±0.80	>30	-	18.25±1.00
IK1	09.50±1.00	>30	10.50±1.25	11.00±1.26	>30	>30	>30	-	-
IK3	-	10.50±2.50	-	-	09.75±1.26	17.00±0.50	>30	-	-
E1	-	10.50±1.26	-	-	10.25±2.65	16.25±1.26	>30	-	-
E5	17.00±1.29	>30	08.25±1.63	>30	>30	18.00±0.50	>30	-	09.00±0.50
KS4	10.75±0.82	>30	>30	>30	>30	>30	>30	-	17.25±0.82
OK1	>30	20.75±1.26	18.75±1.00	25.00±1.29	>30	24.75±1.29	>30	-	10.00±1.00
RK5	12.50±1.26	>30	-	12.00±0.82	>30	16.50±0.82	>30	-	10.75±0.50
EKG2	>30	>30	07.25±1.00	30.25±1.26	>30	17.00±1.29	>30	-	-
S3	22.00±2.00	>30	12.75±0.50	27.75±1.29	>30	21.50±1.29	>30	-	-
OK4	>30	>30	-	18.00±0.50	>30	16.00±1.26	>30	-	-
O2	>30	>30	20.25±2.50	29.00±1.00	>30	21.25±0.50	>30	-	-

(T); Thymol, (TO); Thyme Oil, (ZnPt); Zinc Pyrithione, (MMPP); Magnesium monoperoxyphthalate. (-); no inhibition activity.

4 Discussion

Nosocomial infections pose a significant threat in developing countries, contributing substantially to morbidity and mortality rates (Orji et al. 2005). Environmental surfaces are estimated to be involved in 15-20% of these infections (Ekrami et al. 2011; Sserwadda et al. 2018). A study revealed that 65% of nurses' gowns carrying methicillin-resistant *Staphylococcus aureus* (MRSA) transmitted the bacteria during patient care activities (Orji et al. 2005; Boyce et al. 1997). Treating infections caused by antibiotic-resistant bacteria is incredibly challenging, with an estimated 33,000 deaths reported in Europe in 2015 due to resistant pathogens. The greatest impact on mortality is attributed to third-generation cephalosporin-resistant *Escherichia coli*, methicillin-resistant *S. aureus* (MRSA), third-generation cephalosporin-resistant *Klebsiella pneumoniae*, and carbapenem-resistant *Pseudomonas aeruginosa* (Cassini et al. 2019).

This study aimed to investigate the levels of antibiotic resistance among bacteria isolated from hospital environments. The findings revealed that 9% of the isolates developed resistance to the tested antibiotics, with 10% showing intermediate sensitivity and 81% being susceptible. While 9% resistance is concerning, it may exacerbate as resistance spreads to other bacteria over time. Hospital environments are regularly disinfected to mitigate the transmission risk of such pathogens. However, the development of bacterial resistance is exacerbated by mismanagement policies, such as the use of high-concentration and low-efficacy antiseptics and disinfectants in hospitals (Mendonça et al. 2000; Kihla et al. 2014; Kireçci et al. 2018; Sserwadda et al. 2018).

Despite routine cleaning efforts throughout the day, this study identified several bacterial species in the hospital environment, including *Micrococcus* sp., *Staphylococcus hominis*, *Staphylococcus sciuri*, *Staphylococcus haemolyticus*, *Staphylococcus warneri*, *Escherichia vulneris*, *Sphingomonas paucimobilis*, and *Kocuria kristinae*. These findings indicate that standard disinfection procedures may not be sufficient to eliminate all potentially harmful bacteria. Moreover, other studies have reported the isolation of various bacterial species from hospital environments. For example, in a study evaluating 288 Deep Tracheal Aspirate (DTA) samples, bacterial growth was detected in 140 samples, with *Acinetobacter* spp. accounting for 45%, *Pseudomonas aeruginosa* for 21.4%, *Klebsiella pneumoniae* for 16.4%, *Enterobacter* spp. for 6.4%, *Staphylococcus aureus* for 5%, *Escherichia coli* for 2.8%, and other species for 3%. Additionally, high rates of carbapenem resistance were observed, with rates of 87.3% for *Acinetobacter* spp., 65.2% for *K. pneumoniae* strains, and 40% for *P. aeruginosa* strains (Mizrakci 2022).

Considering these findings, the selection of appropriate disinfectants is crucial for preventing hospital infections (Fagon et al. 1989). Disinfectants with high efficacy and diverse mechanisms of action are required. Although many new disinfectants have been introduced in recent years, the lack of appropriate disinfection policies in hospitals may lead to their misuse, compromising the provision of quality and safe healthcare services. Therefore, it is essential to understand the properties of disinfectants, including their usage areas and potential toxic effects (Coates and Hutchinson, 1994). Ideally, selected disinfectants should be broad-spectrum, fragrant or odorless, non-irritating to the skin, unaffected by organic substances, possess cleaning

properties, and maintain their activity when applied with detergent (Fraise, 2004; Suljagic, 2008). Commonly used disinfectants in hospitals include alcohol, aldehydes, halogen-based disinfectants, peroxides and peracids, phenol compounds, and quaternary ammonium compounds (Sehulster and Chin, 2003).

Eryılmaz et al. conducted a study isolating nosocomial infection factors, including thirty different strains of *S. aureus* (sixteen of which were methicillin-resistant (MRSA) and fourteen methicillin-susceptible (MSSA)), and twentyone different *Enterococcus* spp. (thirteen isolates of *E. faecalis*, seven isolates of *Enterococcus faecium*, and one untypeable isolate of *Enterococcus* spp.). All these isolates demonstrated sensitivity to 2% glutaraldehyde, 4% chlorhexidine gluconate, 7.5% povidone-iodine, 10% povidoneiodine, and 70% 2-propanol at varying contact times. However, it was noted that most of these isolates exhibited resistance to 3% hydrogen peroxide. Consequently, the study concluded that 2% glutaraldehyde, 4% chlorhexidine gluconate, 7.5% povidone iodine, 10% povidone-iodine, and 70% 2-propanol could be safely used for disinfection in İbn-i Sina Hospital against *S. aureus* and *Enterococcus* spp. strains. Nevertheless, it was suggested that hydrogen peroxide should not be preferred due to the presence of 3% resistance among isolates (Satar and Springthorpe 2008).

In this study, the inhibitory effects of four different antimicrobial agents thymol (T), thyme oil (TO), zinc pyrithione (ZnPt), and magnesium monoperoxyphthalate (MMPP) which are regarded as alternative disinfectants, were evaluated against bacteria isolated from a hospital setting. The results revealed that bacterial isolates exhibited varying degrees of sensitivity to these substances, with susceptibility ratios listed as ZnPt>T>TO>MMPP. ZnPt demonstrated particularly strong inhibitory activity against the tested isolates.

Thymol (T), utilized in this study, is a white crystalline solid natural monoterpene phenol renowned for its antimicrobial, anti-inflammatory, antitumor, and fungicidal effects (Eryılmaz 2011; Zhu 2016). It serves as the primary component of thyme (*Thymus vulgaris*) essential oil, a staple ingredient in the food industry and cosmetics due to its antioxidant and preservative properties (Milovanovic 2013). Thymol is present in various species such as *T. vulgaris*, *Ocimum gratissimum*, *Thymus ciliates*, and others, each containing thymol and offering diverse biological benefits, including antioxidant, antibacterial, antifungal, and antiparasitic activities (Salehi et al. 2018). Thymol functions as an antiseptic and disinfectant by enhancing the permeability of bacterial and fungal cytoplasmic membranes, thereby exerting bactericidal and fungicidal effects (Nagoor et al. 2017). In this study, thymol demonstrated potent bactericidal properties.

Thyme oil (TO), another substance employed in this research, possesses numerous pharmacological properties, including antioxidant, antimicrobial, antitumor, antidiabetic, and antihypertensive effects (Benkaci-Ali et al, 2007; Najafloo et al, 2020). Most of these attributes are attributed to compounds like thymoquinone, carvone, p-cimene, and notably thymol and carvacrol (Ali and Blunden, 2003; Ündeğer et al. 2009). Thyme oil's incorporation into products helps retard oxidation processes and extend product shelf life due to its antimicrobial activity. In the study, thyme oil exhibited robust antibacterial activity against bacterial isolates, albeit slightly less potent than thymol for some bacteria. This variance may be attributed to the diverse molecules present in thyme oil. Additionally, thyme oil displayed higher antimicrobial efficacy than thymol against certain bacteria, such as IK2 and KS4 strains, possibly due to the synergistic effects of other compounds present in thyme oil.

Zinc pyrithione (ZnPT), identified as another candidate for use as an alternative disinfectant in this study, is an organic metal compound renowned for its broad-spectrum antimicrobial properties, effectively inhibiting the growth of bacteria, fungi, algae, and molds. Its antimicrobial efficacy has been harnessed across various industries, with decades of use as a fungicide, particularly in anti-dandruff shampoos (Windler et al. 2013). This study determined ZnPT to possess the strongest antibacterial activity among the tested molecules, suggesting its potential as a potent disinfectant additive.

Magnesium monoperoxyphthalate (MMPP) is a water-soluble peroxy acid employed as an oxidant in organic synthesis. Its primary applications include the conversion of ketones to esters, epoxidation of alkenes, and oxidation of sulfides to sulfoxides and sulfones, among others (Carvalho et al. 2009). MMPP also serves as an active ingredient in certain surface disinfectants, showcasing a broad-spectrum biocidal action, including the inactivation of endospores (Baldry 1984). Its compatibility with a wide range of surfaces enables its use on sensitive materials such as plastic and rubber equipment in hospitals. Furthermore, MMPP has been explored as a potential antibacterial agent for mouthwashes and toothpastes (Scully et al. 1999). However, in this study, MMPP exhibited the lowest inhibitory activity compared to other antimicrobials tested.

5 Conclusion

Despite regular disinfection efforts in hospitals, this study underscores the persistent presence of bacteria in the hospital environment. Moreover, these bacteria have demonstrated the capacity to develop resistance against both antibiotics and traditional disinfectants. Given this challenge, there is a pressing need for novel antimicrobial agents to effectively combat these resilient pathogens.

The findings of this study highlight the remarkable sensitivity of bacterial isolates to low concentrations of Zinc pyrithione (ZnPt). This suggests the potential efficacy of ZnPt (at 0.1% concentration) as an additive in disinfectants aimed at combating nosocomial infections. Implementing ZnPt-based disinfectants could represent a promising strategy in enhancing the effectiveness of hospital sanitation protocols and reducing the risk of healthcare-associated infections.

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The author declares no conflict of interest.

References

Ali BH, Blunden G (2003) Pharmacological and toxicological properties of Nigella sativa. Phytother Res 17(4):299-305.

Aytar M, Oryaşın E, Başbülbül G, Bozdoğan B (2019). Standardization study for agar well diffusion. JONAS 2(2): 138-145.

Baldry MGC (1984) The antimicrobial properties of magnesium monoperoxyphthalate hexahydrate. J Appl Bacteriol 57(3):499-503.

Benkaci-Ali F, Baaliouamer A, Meklati BY, Chemat F (2007) Chemical composition of seed essential oils from algerian nigella sativa extracted by microwave and hydrodistillation. Flavour Fragr J 22(2):148-153.

Boyce JM, Pott-Bynoe G, Cheneevert C, King T (1997) Environmental contamination due to methicillin resistant Staphylococcus aureus: possible infection control implications. Infect Control Hosp Epidemiol 18:622.

Carvalho J, Silva M, Sá E Melo M (2009). Highly efficient epoxidation of unsaturated steroids using magnesium bis(monoperoxyphthalate) hexahydrate. Tetrahedron 65(14):2773-81.

Cassini A, Högberg LD, Plachouras D, Quattrocchi A, Hoxha A, Simonsen GS, et al. (2019). Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the eu and the european economic area in 2015: a population-level modelling analysis. Lancet Infect Dis 19(1):56-66.

Coates D, Hutchinson DN (1994). How to produce a hospital disinfection policy. J Hosp Infect 26(1):57-68.

Çavdar G, Köroğlu M, Ölmez M, Şahin E, Altındiş M (2022) Microbiological analysis of hospital drinking and usage water; Sakarya. Online Turkish Journal of Health Sciences 7(3):346-355.

Ekrami A, Kayedani A, Jahangir M, Kalantar E, Jalali M (2011) Isolation of common aerobic bacterial pathogens from the environment of seven hospitals, ahvaz, iran. Jundishapur J Microbiol 4(2):75-82.

Eryılmaz M, Akın A, Arıkan Akan O (2011) Investigation of the efficacy of some disinfectants against nosocomial Staphylococcus aureus and Enterococcus spp. isolates. Find Microbiome 45(3):454-60.

Fagon JY, Chastre J, Domart Y, Trouillet L, Pierre J, Darne C, et al. (1989) Nosocomial pneumonia in patients receiving continuous mechanical ventilation. Prospective analysis of 52 episodes with use of a protected specimen brush and quantitative culture Techniques Am Rev Respir Dis 139(4):877-84.

Fraise AP (2004) Decontamination of the environment and medical equipment in hospitals, "Fraise AP, Lambert PA, Maillard JY (eds): "Russell, Hugo, Ayliffe's Principles and Practice of Disinfection, Preservation and Sterilization. Blackwell Publishing, Hoboken NJ . pp.563-85.

Kamat US, Ferreira AMA, Savio R, Motghare DD (2008) Antimicrobial resistance among nosocomial isolates in a teaching hospital in goa. Indian J Community Med 33(2):89-92.

Kihla AJ, Ngunde PJ, Mbianda SE, Gerard N, Ndip RN (2014) Risk factors for wound infection in health care facilities in buea, cameroon: aerobic bacterial pathogens and antibiogram of isolates. Pan African Medical Journal 18(1):6.

Kireçci M, Arslan E, Kirişci Ö, Karaman Ş (2018) Investigation of the potential resistance of the bacteria ısolated from the hospital environment to some disinfectants and antiseptcs. Flora 23(4):179-185.

Maragkoudakis PA, Zoumpopoulou G, Miaris C, Kalantzopoulos G, Pot B, Tsakalidou E (2006) Probiotic potential of lactobacillus strains isolated from dairy products. Int Dairy J 16(3):189-199.

Mendonça S, Ecclissato C, Sartori MS, Godoy AP, Guerzoni RA, Degger M, et al. (2000) Prevalence of helicobacter pylori resistance to metronidazole, clarithromycin, amoxicillin, tetracycline, and furazolidone in brazil. Helicobacter 5(2):79-83.

Messele G, Woldemedhin Y, Demissie M, Mamo K, Geyid A (2009) Common causes of nosocomial infections and their susceptibility patterns in two hospitals in addis ababa. Ethiop J Health Biomed Sci 2(1):3–8.

Milovanovic S, Stamenic M, Markovic D, Radetic M, Zizovic I (2013) Solubility of thymol in supercritical carbon dioxide and its impregnation on cotton gauze. J Supercrit Fluids 84:173-181.

Misgana GM, Abdissa K, Abebe G (2015) Bacterial contamination of mobile phones of health care workers at jimma university specialized hospital, jimma, southwest ethiopia. International Journal of Infection Control 11(1):1-8.

Mizrakci S (2022). Global overview of publications on rotavirus. BSJ Health Sci. 5(2):239-244.

Muhammad UK, Isa MA, Aliyu ZM (2013) Distribution of potential nosocomial pathogens isolated from environments of four selected hospital in Sokoto, Northwestern Nigeria. J Microbiol Biotechnol Res 3(1):139–43.

Mulu W, Kibru G, Beyene G, Damtie M (2012) Postoperative nosocomial infections and antimicrobial resistance pattern of bacteria isolates among patients admitted at felege hiwot referral hospital, bahirdar, Ethiopia. Ethiop J Health Sci 22(1):7–18.

Nagoor MMF, Javed H, Al Taee H, Azimullah S, Ojha SK (2017) Pharmacological properties and molecular mechanisms of thymol: prospects for its therapeutic potential and pharmaceutical development. Front Pharmacol 8:380.

Najafloo R, Behyari M, Imani R, Nour S (2020) A mini-review of thymol incorporated materials: applications in antibacterial wound dressing. J Drug Deliv Sci Technol 60:101904.

Orji MU, Mbata TI, Kalu OU (2005) Isolation of pathogenic bacteria from hospital staff appareli in Nigeria. Malawi Med J 17(4):128-130.

Salehi B, Mishra AP, Shukla I, Sharifi-Rad M, Contreras MDM, Segura-Carretero A, et al. (2018) Thymol, thyme, and other plant sources: health and potential uses. Phytother Res 32(9):1688-1706.

Sserwadda I, Lukenge M, Mwambi B, Mboowa G, Walusimbi A, Seguija F (2018) Microbial Contaminants Isolated From İtems And Work Surfaces in The Post-Operative Ward at Kawolo General Hospital, Uganda. BMC Infect Dis 68.

Satar SA, Springthorpe S (2008) The need for safer and better microbicides for infection control. In book: Disinfection and Decontamination. Principles, Applications and Related Issues Edition: First Publisher: CRC Press Editors: Gurusamy Manivannan. pp.41-58.

Scully C, El-Kabir M, Greenman J, Porter SR, Mutlu S, Barton I, et al. (1999) The effects of mouth rinses and dentifrice-containing magnesium monoperoxyphthalate (MMPP) on oral microflora, plaque reduction, and mucosa. J Clin Periodontol 26(4):234–238.

Sehulster L, Chinn R (2003) Centers for diseases control and prevention: guidelines for environmental infection control in health care fascilities. Recommendations of Cdc and The Healthcare Infection Control Practices Advisory Committee (Hicpac). 52(10):1-42.

Suljagic V (2008) A pragmatic approach to judicious selection and proper use of disinfectant and antiseptic agents in healthcare

settings. In book: Disinfection and Decontamination. Principles, Applications and Related Issues Edition: FirstPublisher: CRC PressEditors: Gurusamy Manivannan. pp.124-154.

Suslow TV, Schroth MN, Isaka M (1982). Application of a rapid method for gram differentiation of plant pathogenic and saprophytic bacteria without staining. Phytopathol 72:917-918.

Turhan-Eryılmaz F (2011) Identification of potential probiotic properties of some lactic acid bacterial genera which is isolated from vaginal secretion. Ankara.

Ündeğer Ü, Başaran A, Degen GH, Başaran N (2009) Antioxidant activities of major thyme ingredients and lack of (oxidative) dna damage in v79 chinese hamster lung fibroblast cells at low levels of carvacrol and thymol. Food Chem Toxicol 47(8):2037-2043.

Windler L, Height M, Nowack B (2013) Comparative evaluation of antimicrobials for textile applications. Environ Int 53:62-73.

Zhu X, Pan H, Yang Z, Cui B, Zhang D, Ba-Thein W (2016) Self-medication practices with antibiotics among chinese university students. Public Health 130:78-83.