Evaluating the Effectiveness of Various Store-Brand Disinfectants and One Commercial Kitchen Disinfectant in Eliminating Bacterial Contamination on Kitchen Surfaces

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Abstract: Cleaning is generally sufficient for routine household needs; however, certain situations, such as the presence of an ill family member or handling potentially contaminated food, may necessitate disinfection. In these contexts, microbiological disinfection becomes crucial as it helps to swiftly eliminate bacteria from various surfaces, floors, and inanimate objects. Effective disinfection is vital for preventing the spread of harmful bacteria that can lead to foodborne illnesses and other health complications. To thoroughly evaluate the efficacy of different disinfectants, the current study focused on a range of bacteria commonly associated with foodborne illnesses. Reference strains of *Bacillus cereus, Escherichia coli*, *Listeria monocytogenes*, *Salmonella enterica*, and *Staphylococcus aureus* were selected for testing due to their relevance in food safety and their potential to cause serious health issues if not adequately controlled. The Kirby Bauer disc diffusion method was used for this evaluation. This standard laboratory technique involves applying discs saturated with disinfectant solutions onto an agar plate inoculated with bacteria. The area around the discs where bacterial growth is inhibited is measured to determine the effectiveness of each disinfectant. Muller-Hinton agar was used as it is specifically designed to support the growth of a wide range of bacteria and provide clear results for antimicrobial testing.

The study compared one commercially known disinfectant with three different store-brand detergents. The results demonstrated that the store-brand disinfectants were more effective in eliminating the reference bacterial strains compared to the commercially known disinfectant. Larger inhibition zones around the store-brand disinfectant discs indicated a more robust antimicrobial action. This finding was consistent across all tested bacterial strains and was particularly noticeable on the Muller-Hinton agar medium, which facilitated clear visualization of the inhibition zones. The importance of these results is evident in their potential to influence consumer decisions and public health practices. Although store-brand disinfectants are frequently viewed as less effective or lower in quality, they have shown a high level of antimicrobial efficacy, which contradicts the common belief that commercial products are always superior. This information can help consumers make more informed decisions about disinfectant purchases and highlight the importance of evidence-based testing rather than brand reputation. Moreover, the study contributes valuable data to the field of food safety and hygiene, particularly in environments where bacterial contamination is a significant concern. By providing a comparative analysis of disinfectant effectiveness, the research supports better practices in maintaining cleanliness and preventing foodborne illnesses.

In conclusion, the study emphasizes the effectiveness of store-brand disinfectants and underscores the importance of rigorous testing in evaluating product performance. The findings can guide both consumers and industry professionals in selecting appropriate disinfectants for ensuring high standards of hygiene and safety in food preparation areas and other critical environments.

Keywords: Disinfection, cleaning, surface contamination, foodborne bacteria, Kirby Bauer

Introduction

Under normal circumstances, cleaning is sufficient for household needs. However, in specific situations like having a family member with an illness or handling potentially contaminated food, disinfection may be necessary. Therefore, microbiological disinfection is important. Disinfectants function by promptly eliminating bacteria upon contact with various surfaces, floors, and inanimate objects. Various disinfectants operate through different mechanisms; a diverse array of substances, including alcohols, aldehydes like ortho-phthalaldehyde, chlorine-based bleaches, hydrogen peroxide, iodine, and potassium permanganate solution, are utilized as disinfectants [1].

Cleaning disinfectants are widely available for domestic use and offer consumers a diverse range of options for maintaining cleanliness in the home environment. Disinfectants play an important role in the home environment by serving as versatile cleaning agents. Cleaning disinfectants are specialized substances, often in the form of liquids, powders, or sprays, designed to remove dirt, stains, and impurities from surfaces [2]. These substances typically contain a combination of chemicals that help break down and lift away contaminants, making cleaning more effective. Some cleaning disinfectants might possess the capability to eliminate bacteria and other microorganisms on surfaces [3]. They play a role in maintaining cleanliness and hygiene in various environments, including homes by preventing the proliferation of harmful microorganisms, reducing the risk of infections, and ensuring the overall well-being of residents.

The process of household cleaning with disinfectants involves using specialized cleaning agents on surfaces and materials within the home, with the goal of removing dirt, stains, and harmful microorganisms. This activity is crucial for public health, as it helps prevent the transmission of infectious agents, reduces the risk of diseases, and promotes a sanitary living environment [4]. This, in turn, positively influences the general health and well-being of both individuals and communities.

Legislative information

The Foodstuffs, Cosmetics, and Disinfectants Act (Act 54 of 1972) [5] defines disinfectants as formulated chemicals utilized in various industries, including food and health services, to eliminate microorganisms on surfaces. According to the Act, any product claiming to be a disinfectant must meet or exceed the performance indicated on its label, supporting publicity material, and data sheets. If a disinfectant adheres to the compulsory specifications, it can be effective against bacteria, fungi, spores, or viruses. However, it is important to note that meeting these specifications does not necessarily guarantee suitability for a specific purpose [5].

Foodborne illnesses

The rise in foodborne illnesses from cross-contamination in South African households following the Corona Virus (COVID-19) pandemic is associated with various factors [6]. The pandemic heightened awareness of hygiene, prompting an increased emphasis on regular handwashing and sanitization to curb the virus's spread. However, this heightened focus on personal hygiene may have unintentionally resulted in a lack of attention to other areas, such as proper food handling and kitchen cleanliness [7]. The elevated stress and disruptions experienced by households during the pandemic may have contributed to a lapse in adhering to rigorous food safety measures. Previous research has raised concerns about the occurrence of foodborne disease outbreaks in households [8-10]. These instances are often linked to improper food handling, cross-contamination, and inadequate storage or cooking methods. Although studies suggest that raw materials likely play a role in kitchen contamination, adjacent areas like food preparation surfaces may also harbour populations of bacteria [11-12].

According to Unilever [13], when compared to renowned brands like Dettol, these store-brand disinfectants vary in formulation, pricing, and specific cleaning capabilities. While Dettol has gained recognition for its disinfectant properties, many store-brand disinfectants focus on general cleaning tasks, such as removing stains, grease, and dirt. Hollis [14] reports that the choice between these categories often depends on individual cleaning needs and preferences.

In general, there is a potential risk of foodborne illnesses, emphasizing the need to make the public more aware and vigilant about food, hygiene, and sanitation. Investigating the efficiency of disinfectants will provide insights into how foodborne pathogens persist, spread, and react to stress in home kitchens. This study aimed to evaluate how well store-brand detergents and popular disinfectants intended for domestic cleaning perform against bacteria. Additionally, this study will outline the resistance of *Bacillus cereus, Escherichia coli, Listeria, Salmonella and Staphylococcus aureus* to surface cleaning disinfectants, as these selected pathogens are the primary culprits behind foodborne diseases.

Materials and Methods

Study design: A comparative study was carried out to evaluate the effectiveness of different store-brand and commercial kitchen disinfectants in eradicating bacterial contamination on kitchen surfaces.

Study area: Bloemfontein, the largest city and capital of the Free State province in South Africa. It sits at an elevation of approximately 1,395 meters (4,577 feet) above sea level. The city is home to 256,185 residents and is a part of the Mangaung Metropolitan Municipality, with a total population of 747,431.

Study settings: The study took place at the Central University of Technology, Free State, where all experiments were conducted. The researcher purchased the disinfectants at retail shops and subsequently tested them in the laboratory using the institution's test bacteria.

Study size: The researcher tested three store-brand disinfectants and one commercial disinfectant to determine their effectiveness in eliminating five distinct bacteria: *Bacillus cereus*, *Escherichia coli*, *Listeria*, *Salmonella*, and *Staphylococcus aureus*.

Statistical methods: The tests were duplicated to improve result reliability by reducing the influence of random variations or errors, enabling a thorough assessment of the findings consistency and reproducibility for a stronger basis in drawing conclusions from the experiment.

Laboratory Sampling Method

Firstly, the testing zone underwent sterilization with 70 % ethanol and an open burner in a biosafety cabinet. A sterile cotton swab was then used to collect the inoculum, and excess medium was removed by pressing the swab against the tube wall [15]. The plate was swabbed using a rotating technique known as lawn culture or carpet culture to ensure even distribution. Afterward, the plates were left to air-dry for 5 minutes to facilitate proper absorption of the inoculum by the medium. To maintain sterility, forceps were sterilized with alcohol before picking up antibiotic discs, which were subsequently placed 24 millimetres apart. Each disc was gently touched with forceps to ensure optimal contact and prevent misplacement. Finally, the plate was inverted and incubated for 24 hours at 37 ºC to observe bacterial growth inhibition around the antibiotic discs [15].

Disc Diffusion Method

The disc diffusion method, specifically using the disc diffusion technique, involved impregnating discs with disinfectants. In that process, a sterile agar medium was uniformly inoculated with a bacterial culture. Disinfectant-soaked discs were then placed on the agar surface to evaluate their effectiveness against bacterial growth, using the Kirby-Bauer disk diffusion method. As the disinfectants diffused into the agar, they created zones of inhibition around the discs where bacterial growth was suppressed. The plates were then incubated to allow for bacterial growth and to evaluate the effectiveness of the disinfectants. The inhibition zones around the discs were then measured, providing valuable information about the bacterial strain's susceptibility to the disinfectants and the potential antimicrobial activity of the disinfectants. This method is widely used in microbiology for assessing antibiotic effectiveness and studying microbial resistance patterns [16].

Data analysis

The main goal was to check if there was an area where the disinfectant had an effect. This important part meant looking at the space around the filter discs [Minimum Inhibitory Concentration (MIC)] treated with disinfectant on the plates with cultures. The size of this affected region provides significant insights into the effectiveness of the disinfectants against the tested bacteria, as illustrated in Figure 1. Measuring this assisted in understanding how the disinfectants influenced the growth of microorganisms and facilitated drawing conclusions regarding their efficacy in inhibiting the tested bacteria under the specific conditions of the experiment.

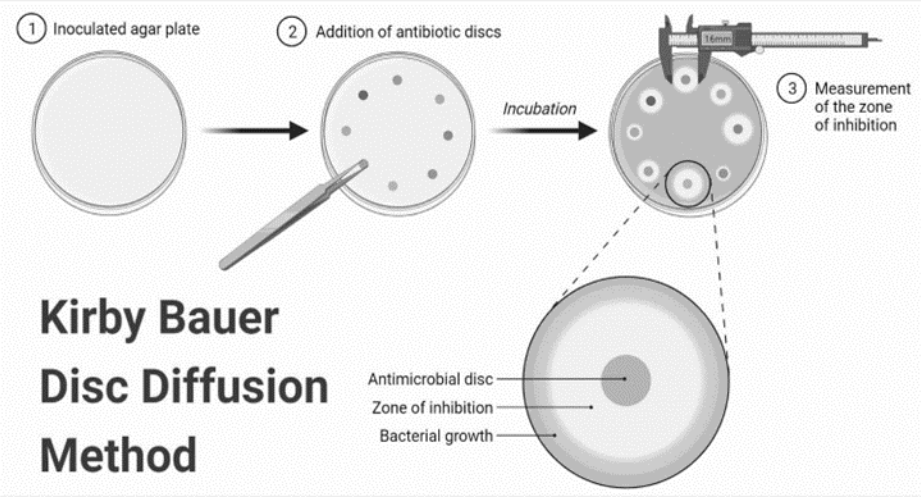

Figure 1: *Disk Diffusion Method.* The arrangement of the disks on the agar plate, the growth inhibition zones around each disk, and any variations in the size of the zones, which can indicate differences in susceptibility among bacterial strains or antimicrobial agents. (Source: Reeju Sharma [17]).

Results and Discussion

In the experiment, a total of 32 agar plates were prepared, including both original and duplicate plates, for each bacterial strain. These plates were meticulously inoculated and treated with various disinfectants. Upon analysis, small inhibition zones were observed around the impregnated discs on agar plates for store-brand disinfectants labeled X, Y, and Z, in contrast to a more widely recognized commercial disinfectant, which displayed larger inhibition zones around its impregnated disc, indicating greater effectiveness against the bacteria tested, as seen in Figure 2.

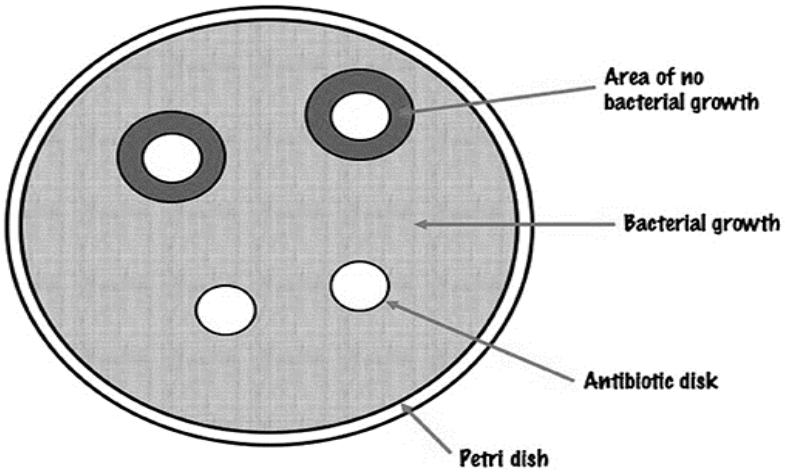

Figure 2: *An illustration of a Kirby-Bauer Test evaluating the effectiveness of disinfectants against bacterial pathogens.* Clear zones around the discs post 24-hour incubation indicate bacterial growth inhibition, with larger zones signifying increased antibiotic sensitivity linked to diminishing antibiotic concentration from the source.

Understanding the correlation between the size of the inhibition zone and Minimum Inhibitory Concentration (MIC) values is important in evaluating the effectiveness of disinfectant agents. In essence, the inverse relationship signifies

that a larger zone of growth inhibition indicates a lower concentration of the disinfectant is required to impede bacterial growth. The MIC serves as a quantitative method in susceptibility testing, providing insights into which class of disinfectants proves most effective against the tested bacteria, refer to Table 1. This information is instrumental in guiding the selection of an appropriate disinfectant, maximizing the likelihood of treatment success, and contributing to the ongoing efforts to combat resistance. Adapting disinfectant selections according to MIC values and inhibition zones allows for well-informed decisions that align with effective treatment strategies and help reduce the risk of resistance development.

Selective Test Bacteria Results

Bacillus cereus

When testing *Bacillus cereus* against various disinfectants, smaller inhibition zones were observed with Disinfectant 1 and Store-brand X. This observation implies that *Bacillus cereus* exhibited intermediate susceptibility to these disinfectants. In microbiology, inhibition zones refer to the areas surrounding an antimicrobial disc where bacterial growth is visibly restrained. A smaller inhibition zone indicates that the antimicrobial agent is less effective at inhibiting bacterial growth, suggesting that the microorganism has a degree of resistance to the disinfectant [18]. Therefore, the smaller inhibition zones seen with Disinfectant 1 and Store-brand X against *Bacillus cereus* suggest that these disinfectants may not be as potent in inhibiting the growth of this specific bacterium compared to other disinfectants. The term "intermediate susceptibility" indicates that while there is some inhibitory effect, it is not as pronounced as with disinfectants where larger inhibition zones are observed [19].

Table 1: Disinfectant Disc Inhibition Zone Sizes for Test Bacterial Strains Using the Kirby Bauer Disc Diffusion Method.

Test microorganism	**Disinfectant 1**		**Store-brand X**		**Store-brand Y**		**Store-brand Z**	
	SIR & MIC		**SIR & MIC**		**SIR & MIC**		**SIR & MIC**	
Bacillus cereus	<1.1 **(S)**	<1.1 **(S)**	<1.1 **(S)**	<1.1 **(S)**	>2.3 **(S)**	>2.0 **(S)**	<1.3 **(S)**	<1.3 **(S)**
Escherichia coli	>0.5 **(I)**	>0.8 **(I)**	>0.5 **(I)**	>0.4 **(I)**	>0.5 **(I)**	>0.5 **(I)**	>0 **(R)**	>0 **(R)**
Listeria	<1.3 **(S)**	<1.5 **(S)**	<1.4 **(S)**	<1.4 **(S)**	<1.8 **(S)**	<1.7 **(S)**	>2.1 **(S)**	>2 **(S)**
Staphylococcus aureus	<1 **(S)**	<1 **(S)**	>0.4 **(I)**	>0.4 **(I)**	<1 **(S)**	<1 **(S)**	>0 **(R)**	>0 **(R)**

SIR: S (sensitive), I (intermediate), or R (resistant). "Sensitive" implies that the organism is inhibited by the serum concentration of the drug that is achieved using the usual dosage; "Intermediate" implies that the organisms are inhibited only when higher concentrations than with the usually recommended dosages are achievable; and "Resistant" implies that the organisms are resistant to the usually achievable serum drug levels.

MIC: *Minimum Inhibitory Concentration*

"<=" (in case of below the range, in the susceptible category)

">=" (in case of above the range, in the resistant category)

Numbers indicate the minimum inhibitory concentration measured on each Muller-Hinton agar plates.

Escherichia coli

The observation of smaller inhibition zones for *Escherichia coli* tests against each disinfectant, specifically Disinfectant 1 (well-known) and Store-brand disinfectants labelled X, Y, and Z, indicates that these strains of *Escherichia coli* were not susceptible to the disinfectants. In the context of disinfectant testing, the inhibition zone represents the area where bacterial growth is visibly restricted due to the disinfectant. A smaller inhibition zone suggests that the disinfectant is less effective in inhibiting the growth of *Escherichia coli*, indicating a degree of resistance of the bacteria to the disinfectant agent.

Escherichia coli, being a commonly used indicator organism in microbiological studies, is often used to assess the effectiveness of disinfectants. The susceptibility of *Escherichia coli* to the tested disinfectants implies that these disinfectants have the potential to control or eliminate this bacterial strain

Listeria

Smaller inhibition zones were observed for all disinfectants, indicating that *Listeria* exhibited susceptibility to these disinfectants. This susceptibility is inferred from the smaller inhibition zones, as a more susceptible strain would display a greater response to the antimicrobial action of the disinfectant, resulting in larger zones of bacterial growth. To substantiate this interpretation, several scientific studies have investigated the susceptibility of *Listeria* to disinfectants [20-22]. A study by Carrascosa *et al*. [23] explores the susceptibility of *Listeria monocytogenes* to various disinfectants using bioluminescent assays. The researchers found that *Listeria monocytogenes* exhibited varying susceptibilities to different disinfectants, supporting the idea that susceptibility can be assessed through inhibition zone size. Another relevant study is the work of Rodríguez-Lopez *et al*. [24], which addresses the efficacy of disinfectants against *Listeria monocytogenes* biofilms on high-density polyethylene surfaces. The findings in such studies contribute to the understanding of how *Listeria* responds to disinfectants, providing evidence for susceptibility based on inhibition zone sizes.

Staphylococcus aureus

The observed inhibition zones in *Staphylococcus aureus* tests against different disinfectants provide valuable insights into the susceptibility of this bacterium to the tested agents. In the context of the results, it is noted that Disinfectant 1 and Store-brand Y exhibited inhibition zones, suggesting that these agents effectively inhibit the growth of *Staphylococcus aureus*. For Store-brand X, an intermediate inhibition zone was observed. This implies that the bacteria were inhibited, but at concentrations higher than the usually recommended dosages. This could indicate a degree of susceptibility, although requiring higher concentrations for effective inhibition.
Conversely, Store-brand Z showed resistance, indicating that the bacteria are not effectively inhibited even at concentrations typically achievable with recommended dosages. This resistance implies that higher concentrations may be needed to achieve an inhibitory effect. To support these findings, various studies have investigated the susceptibility of *Staphylococcus aureus* to disinfectants. Research by Rozman *et al*. [20] discusses the mechanisms of action of disinfectants and the factors influencing their efficacy against *Staphylococcus aureus*.

Variables

The independent variable is the type of kitchen disinfectant (store-brand or commercial), while the dependent variable is its effectiveness in eradicating bacterial contamination on kitchen surfaces, measured by the size of inhibition zones.

Bias

The study may exhibit a bias in favor of store-brand disinfectants, as it emphasizes their potential effectiveness without thoroughly exploring the limitations or drawbacks associated with these products.

Discussion

The presence of larger inhibition zones around the impregnated disc with a disinfectant on bacterial culture media indicates a more potent antimicrobial effect, suggesting greater efficacy in inhibiting bacterial growth. The inhibition zone is the area surrounding the disc where bacterial growth is visibly restricted, reflecting the effectiveness of the disinfectant. Scientifically, a larger inhibition zone is associated with a lower Minimum Inhibitory Concentration (MIC), which is the lowest concentration of the disinfectant that inhibits visible growth of a microorganism. When the MIC is lower, it means that the disinfectant is more effective at inhibiting bacterial growth, leading to larger zones of inhibition. Inhibition zones are a key measure in assessing the effectiveness of disinfectants and antibiotics; the size of these zones reflects the disinfectant's ability to diffuse through the agar and inhibit bacteria. A more extensive zone

indicates a higher potency and efficiency of the disinfectant. This is particularly important because a larger inhibition zone means that the disinfectant can work effectively at lower concentrations, benefiting both effectiveness and cost. Several studies and references support the correlation between inhibition zone size and antimicrobial efficacy. For example, the Clinical and Laboratory Standards Institute [25-26] provides guidelines for antimicrobial susceptibility testing, including the interpretation of inhibition zones. Additionally, foundational research articles, such as those by Bauer *et al*. [27] and Andrews [28], help in understanding the principles behind inhibition zones and their relationship to antimicrobial effectiveness. These findings emphasize the significance of considering store-brand disinfectants as viable and potent alternatives for maintaining optimal hygiene in kitchen environments, highlighting their promising role in ensuring effective bacterial control and surface disinfection. Further investigation into what makes store-brand disinfectants so effective could provide additional insights into their performance. Understanding the specific ingredients and mechanisms at work can help improve sanitation practices and ensure that even affordable options can deliver strong protection against bacteria. This research could lead to better, more accessible hygiene solutions for everyday use.

Limitations

A potential limitation to the study could be the exclusion of certain real-world factors that may affect the performance of disinfectants in a kitchen environment. For example, variations in surface materials, the presence of organic matter, or different application methods might influence the actual effectiveness of the disinfectants but may not be fully accounted for in a controlled laboratory setting. This limitation could impact the generalizability of the study's findings to real-life kitchen scenarios.

Interpretation

Considering the limitations of the study, the interpretation would acknowledge that while the research provides valuable insights into the effectiveness of various store-brand and commercial kitchen disinfectants in eliminating bacterial contamination on kitchen surfaces, the findings should be interpreted with caution due to certain constraints. Limitations, such as the specific test conditions, bacterial strains chosen, and potential variations in real-world usage, may impact the generalizability of the results. Therefore, the study's interpretation would emphasize the need for further research and consideration of these limitations when applying the findings in real-world settings.

Conclusion

This research highlights the significant potential of store-brand disinfectants as effective and feasible alternatives for maintaining optimal cleanliness in kitchen settings. The observed larger inhibition zones surrounding the treated discs suggest a promising role in controlling bacteria and disinfecting surfaces. These results advocate for a shift in perspective, acknowledging store-brand disinfectants as valuable contributors to household sanitation practices. To deepen our understanding, future studies should investigate the specific mechanisms and ingredients responsible for the enhanced performance of store-brand disinfectants. Such inquiries could offer valuable insights to improve kitchen sanitation practices and maximize the effectiveness of these readily available and cost-effective disinfectant choices. In essence, the implications of this study extend beyond the laboratory, emphasizing the practical significance of store-brand disinfectants in fostering a hygienic and bacteria-free kitchen environment.

Author contributions

Tshegofatso Nhabe: Contributed to the conceptualisation, sample analysis, data analysis, validation, and the initial drafting of the writing, as well as the subsequent revisions.

Funding: No funding was necessary since the researcher personally purchased the products, and the bacteria along with all laboratory supplies were readily accessible at the tertiary institution for registered students.

Ethical considerations

Ethical approval was not required.

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Conflicts of interest

The author declares no conflict of interest.

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