MOLD CONTAMINATION ON REFRIGERATOR DOOR HANDLES IN A MINIMARKET IN EAST WONGGADITI VILLAGE, GORONTALO CITY

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ABSTRACT

Mold contamination on frequently touched surfaces in public spaces may indicate inadequate environmental hygiene and the potential presence of fungal microorganisms. This study aimed to identify mold contamination on refrigerator door handles in a minimarket located in East Wonggaditi Village, Gorontalo City. A descriptive study was conducted using ten swab samples collected from the right and left refrigerator door handles at five sampling points. The samples were cultured on Potato Dextrose Agar (PDA) and incubated at 30°C for 14 days. Mold growth was evaluated through macroscopic and microscopic observations. The results showed mold growth in all ten samples, indicating the presence of viable fungal contaminants on the examined refrigerator handles. Macroscopic observations revealed colonies with white to yellowish-white coloration and cotton-like textures. Microscopic observations showed fungal structures, including hyphae, conidia, vesicles, and conidiophores, with morphological characteristics suggestive of *Aspergillus* spp. However, species-level identification was not confirmed. These findings demonstrate that refrigerator door handles in the investigated minimarket were contaminated with mold and highlight the importance of maintaining hygiene on frequently touched surfaces. Routine cleaning and appropriate sanitation practices are recommended to help reduce surface contamination. Further research using quantitative fungal analysis and confirmatory identification methods is needed to determine contamination levels and establish the identity of the fungal isolates.

Keywords: *mold contamination, refrigerator door handles, minimarket, Aspergillus spp., surface hygiene*

INTRODUCTION

Mold contamination is an important environmental hygiene concern because fungal spores are widely distributed in the environment and can persist on various surfaces under suitable conditions. Public environments, including retail stores, supermarkets, and minimarkets, involve frequent contact between individuals and shared facilities, creating opportunities for microbial transfer. The presence of moisture, organic residues, inadequate cleaning, and unsuitable environmental conditions may further contribute to fungal persistence and growth. Although mold contamination is often associated with damp buildings and indoor air quality, its occurrence on frequently touched surfaces also deserves attention as part of environmental health management [1][2].

Frequently touched surfaces represent potential points of contact between individuals and environmental microorganisms. Refrigerator door handles in minimarkets are particularly relevant because customers and employees

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repeatedly touch them when accessing refrigerated products. Repeated contact may facilitate the transfer of microorganisms between hands and surfaces, especially when hand hygiene and routine cleaning are insufficient. Research examining frequently touched workplace surfaces has highlighted the importance of environmental monitoring in understanding microbial contamination and improving hygiene practices [3]. However, the detection of microorganisms on a surface does not automatically establish that transmission or infection has occurred. The presence and significance of mold contamination must therefore be assessed through appropriate microbiological examination and interpretation.

Mold exposure may have several health implications, depending on the fungal species, exposure route, concentration, duration, and individual susceptibility. Exposure to indoor fungi has been associated with allergic reactions and respiratory symptoms, particularly among susceptible individuals. Certain fungi may also cause opportunistic infections in people with weakened immune systems, while some fungal species can produce mycotoxins under specific environmental and substrate conditions. Nevertheless, the health implications of mold detected on a refrigerator handle cannot be determined solely from its presence; species identification, exposure assessment, and relevant environmental information are needed to establish the potential significance of the contamination [1][4][5]. These considerations support the importance of monitoring fungal contamination as one component of broader environmental hygiene practices.

Previous studies have investigated fungal contamination in different indoor environments. Oluchi and Jalaludin [6], for example, examined the isolation and identification of molds in naturally ventilated preschools in urban and suburban areas of Selangor, Malaysia. Their research illustrates the relevance of investigating fungal occurrence in environments where people spend time and may encounter airborne or environmental fungi. Zielińska-Jankiewicz et al. [7], also examined microbiological contamination involving molds in libraries and archive storage facilities, demonstrating the importance of evaluating fungal contamination across different indoor settings. In addition, Nazri and Rahim [3], investigated bacterial contamination on frequently touched workplace surfaces, providing relevant context for understanding the microbiological significance of shared contact points. Although these studies contribute to knowledge about environmental fungi and surface contamination, their settings and research focuses differ from refrigerator door handles in community retail environments.

In Indonesia, minimarkets provide convenient access to food, beverages, and other consumer products and are regularly used by local communities. Maintaining the cleanliness of shared facilities is therefore an important aspect of retail hygiene. Refrigerator door handles may be overlooked during routine cleaning because attention is often directed toward visible dirt, product storage areas, and refrigerator interiors. In East Wonggaditi Village, Gorontalo City, investigating these surfaces may provide locally relevant information about fungal contamination in a retail environment. Nevertheless, the extent of contamination at this particular location should be established through empirical investigation rather than assumed from findings reported in other settings.

Despite existing research on indoor molds and microbial contamination of frequently touched surfaces, evidence specifically addressing mold contamination on refrigerator door handles in minimarkets remains limited within the literature considered for this study. The characteristics of contamination may vary according to surface material, frequency of contact, environmental conditions, and cleaning practices. Localized investigation is consequently needed to determine whether mold can be detected on these handles and to describe the findings in their specific environmental context. Such evidence may also support recommendations for routine cleaning, appropriate disinfection, and improved monitoring of frequently touched surfaces.

Therefore, this study aims to examine mold contamination on refrigerator door handles in a minimarket in East Wonggaditi Village, Gorontalo City. Specifically, it seeks to determine the presence of mold on the sampled surfaces and describe the findings obtained through microbiological examination. The results are expected to contribute to local environmental hygiene information and provide a scientific basis for considering appropriate sanitation measures in minimarket settings. Any conclusions concerning fungal species, health risks, or the effectiveness of existing hygiene practices will depend on the parameters and evidence obtained during the investigation.

Literature Review

Fungal Contamination on High-Touch Surfaces

Fungal contamination in indoor environments is a relevant environmental hygiene concern because fungi can occur in air, dust, building materials, and other environmental reservoirs. Frequently touched surfaces, such as door handles and refrigerator handles, may become contaminated through deposition of airborne spores, contact with contaminated hands, or exposure to surrounding materials. Nazri and Rahim [3], investigated bacterial contamination on frequently touched workplace surfaces, providing contextual evidence for the importance of monitoring shared contact points, although bacterial findings should not be interpreted as direct evidence of fungal contamination. Similarly, Zielińska-Jankiewicz et al. [7], examined mold contamination in libraries and archival storage facilities, while Oluchi and Jalaludin [6], investigated mold in naturally ventilated preschools in Malaysia. Other studies have addressed indoor fungal exposure and associated health concerns [8][9][10]. More recently, Hussain et al. (2022) reviewed airborne microorganisms associated with human diseases. Collectively, these studies establish the relevance of investigating fungi in different indoor environments, but the occurrence of mold on refrigerator door handles in minimarkets requires direct surface sampling because airborne contamination, visible mold growth, and surface contamination represent distinct environmental conditions.

Environmental Factors Contributing to Mold Contamination

Environmental conditions influence the persistence and growth of indoor molds, particularly moisture availability, relative humidity, temperature, ventilation, and the characteristics of contaminated materials. Metts [5], discussed the relationship between water damage and mold growth, emphasizing the importance of promptly drying affected materials after flooding. Miranda et al. [11], examined crawl spaces and mold transmission, contributing to the broader understanding of environmental

pathways associated with indoor fungal exposure. Kempton et al. [12], evaluated mold risks in residential buildings using site audits and longitudinal monitoring and reported that mold could recur even in properties that had previously undergone remediation. Bex et al. [13], also examined environmental audits in the context of environmental health assessment. Although these studies primarily concern buildings and indoor environments rather than retail refrigerator handles, their findings provide a basis for examining environmental conditions that may contribute to contamination. In minimarkets, condensation, moisture accumulation, surface cleanliness, contact frequency, and cleaning practices are therefore relevant variables to document. However, their contribution to contamination should be determined from observations and microbiological findings rather than assumed solely from the presence of a refrigerator or a frequently touched surface.

Health Implications of Mold Exposure

Indoor mold exposure has been investigated in relation to allergic responses, respiratory symptoms, irritation, and, in certain circumstances, opportunistic fungal infections. Palot et al. [9][8], discussed nonallergic disorders associated with domestic molds, while Perčič et al. [10], reviewed indoor molds and their possible health effects. Edmondson et al. [14], examined the relationship between allergy and concerns surrounding so-called toxic mold syndrome, highlighting the need to distinguish recognized health effects from claims that may not be adequately supported by evidence. Metts [5], described infectious and noninfectious health effects associated with exposure to mold following major flooding, and Herbarth and Müller [15], reviewed epidemiological, environmental health, and intervention studies concerning mold-related allergic disorders. Santilli and Rockwell [16], also investigated fungal contamination in elementary schools as an environmental health concern. More recently, Hussain et al. [17], reviewed airborne microorganisms associated with human diseases. Taken together, this literature indicates that the health implications of fungal exposure depend on the organism, exposure pathway, intensity, duration, and susceptibility of the exposed individual. Nevertheless, detecting mold on a refrigerator handle does not by itself demonstrate that customers or employees have experienced harmful exposure or developed disease. Such conclusions require evidence beyond surface contamination, including appropriate fungal identification and, where relevant, exposure or health assessments.

Hygiene Interventions and Prevention

Preventing and controlling mold contamination requires attention to moisture sources, cleaning practices, environmental monitoring, and appropriate remediation procedures. Metts [5], emphasized the importance of environmental controls and protective measures when addressing mold exposure after flooding, while Kempton et al. [12], demonstrated the value of site audits and longitudinal monitoring in evaluating mold risks and recurrence in residential buildings. Bex et al. [13], provide additional context for environmental auditing as an approach to identifying environmental health concerns. Menetrez [18], discussed antimicrobial treatment and efficacy, and Menetrez et al. [19], investigated the efficacy of antimicrobial cleaners on gypsum wallboard contaminated with *Stachybotrys chartarum*. These studies illustrate the relevance of evaluating cleaning and remediation approaches, although findings

from building materials cannot automatically establish the effectiveness of a particular cleaner on refrigerator handles. In retail settings, preventive measures may include scheduled cleaning of frequently touched surfaces, use of products appropriate for the surface and intended application, compliance with product instructions, and prompt management of condensation or other moisture sources. Cleaning protocols should also consider the hygiene requirements of food retail environments. The effectiveness of these interventions should be evaluated under the conditions in which they are implemented, rather than inferred from evidence involving different materials or contamination scenarios.

RESEARCH METHODS

Research Design

This study employed a descriptive qualitative research design to examine mold contamination on refrigerator door handles in a minimarket in East Wonggaditi Village, Gorontalo City. The descriptive approach was used to document the presence and characteristics of mold detected on the sampled surfaces through microbiological laboratory examination. Qualitative observations were obtained from the macroscopic and microscopic characteristics of fungal colonies, supported by interviews with minimarket employees and photographic documentation. Laboratory findings were used to describe the contamination characteristics, while interviews provided contextual information regarding cleaning practices and the maintenance of refrigerator handles.

Research Location and Period

The study was conducted at a minimarket in East Wonggaditi Village, Gorontalo City, with microbiological examinations performed at the Microbiology Laboratory of Universitas Bina Mandiri Gorontalo. The research period was originally specified as May to June 2024. The sampling location was selected because refrigerator door handles are frequently touched by customers and employees, making them relevant surfaces for investigating potential fungal contamination. The laboratory setting enabled sample processing, fungal cultivation, and macroscopic and microscopic observations under controlled working conditions.

Data Types and Sources

The study used qualitative descriptive data derived from laboratory observations, interviews, and documentation. Primary data consisted of microbiological examination results from swab samples collected from refrigerator door handles and information obtained through interviews with minimarket employees concerning routine cleaning and hygiene practices. Secondary data comprised relevant scientific publications, textbooks, and other credible documents concerning fungal contamination, environmental hygiene, and fungal identification. Information from secondary sources was used to support the interpretation of laboratory findings and contextualize the research results.

Data Collection Techniques

Data were collected through interviews, documentation, and laboratory examinations. Interviews were conducted with minimarket employees to obtain information about refrigerator handle cleaning schedules, sanitation procedures, and routine maintenance practices. Documentation included photographs of the sampling locations, laboratory procedures, and fungal colonies observed during examination. Laboratory data were

obtained by collecting surface swab samples and cultivating the collected material on Potato Dextrose Agar (PDA) medium. The combination of these methods provided complementary information about the sampled surfaces and the environmental hygiene practices implemented at the research site.

Laboratory Examination Procedures

Pre-Analytical Stage

The pre-analytical stage involved preparing the equipment, culture medium, and swab samples before microbiological examination. The equipment included an autoclave, laminar airflow cabinet (LAF), Erlenmeyer flasks, beakers, measuring cylinders, Petri dishes, oven, Bunsen burner, analytical balance, hot plate, microscope slides, incubator, inoculating loop, microscope, colony counter, droppers, magnetic stirrer, aluminum foil, micropipette, and pipette tips. The materials included distilled water, 70% alcohol, 0.9% sodium chloride solution, PDA medium, and sterile swab sampling equipment. Glassware and other heat-resistant equipment were prepared and sterilized using an appropriate validated procedure. PDA medium was prepared by dissolving the required quantity of dehydrated medium in distilled water according to the manufacturer's instructions, followed by sterilization in an autoclave. After sterilization, the medium was aseptically poured into sterile Petri dishes inside the LAF cabinet and allowed to solidify. Each sampling device was labeled with a unique code before sample collection.

Sample Collection and Preparation

Mold samples were collected by swabbing the surfaces of refrigerator door handles at the selected minimarket. Sterile swabs were applied to the designated surface areas using a consistent sampling procedure to minimize variation between samples. After swabbing, each swab was placed into an appropriately labeled sterile transport tube and handled under conditions intended to minimize contamination during transportation. The samples were subsequently transferred to the microbiology laboratory for examination. Sampling locations, collection times, and sample codes were documented to maintain traceability throughout the laboratory process.

Analytical Stage: Fungal Cultivation

Fungal cultivation was conducted using PDA medium as the culture substrate. Under aseptic conditions in the LAF cabinet, the collected samples were processed and inoculated onto the prepared medium. The original procedure described the transfer of 1,000 µL of sample onto the culture medium, followed by incubation at approximately 30°C for 14 days. During incubation, the culture plates were monitored for colony development and potential contamination. Because incubation conditions can influence fungal recovery and colony morphology, the temperature, duration, inoculation method, and sample volume should be standardized and recorded. The reported inoculation procedure should also be verified against the actual laboratory protocol to ensure that the method used is accurately described.

Macroscopic and Microscopic Identification

After incubation, fungal colonies were examined macroscopically to document their observable characteristics. The observations included colony color, surface appearance, texture, growth pattern, and coloration on the reverse side of the culture medium. Representative colonies were then examined microscopically by preparing specimens from the fungal growth on microscope slides. Microscopic observations focused on fungal structures,

including hyphae, conidiophores or sporangiophores, vesicles, metulae, phialides, and conidia or spores, where present. Microscopic examination was conducted at magnifications ranging from 10× to 40×, as specified in the original procedure. The observed characteristics were compared with recognized fungal identification references. If a culture contained morphologically mixed colonies, subculturing was required to obtain a pure isolate before further identification. Species-level identification should only be reported when the observed characteristics and identification method adequately support that determination.

Data Analysis

Data were analyzed descriptively by organizing the interview findings, documentation, and laboratory observations into categories relevant to the study objectives. Macroscopic and microscopic findings were summarized to describe the characteristics of fungal growth recovered from the sampled refrigerator handles. Interview information concerning cleaning and sanitation practices was compared with the laboratory observations to provide contextual interpretation. The findings were then discussed in relation to relevant scientific literature on fungal contamination and environmental hygiene. Any conclusions were restricted to the samples examined and the identification methods used; the detection of mold alone was not interpreted as proof of a specific health risk or disease transmission.

Research Quality and Laboratory Control

To support the reliability of the findings, sample labeling, handling, culture preparation, incubation conditions, and observation procedures should be documented consistently. Sterile equipment, aseptic handling, and appropriate laboratory controls should be used to reduce the risk of contamination introduced during sample processing. Where feasible, negative controls should be included to assess possible contamination from the sampling materials, culture medium, or laboratory environment. Observations should be recorded systematically, and fungal identification should be based on established morphological criteria. These measures help distinguish findings associated with the sampled surfaces from potential contamination introduced during laboratory procedures.

RESEARCH RESULT

Macroscopic and Microscopic Characteristics of Mold Isolates

The laboratory examination of swab samples collected from the right and left refrigerator door handles in a minimarket in East Wonggaditi Village, Gorontalo City, revealed fungal growth with morphological characteristics presumptively consistent with the genus *Aspergillus*. The observations covered ten samples representing the right and left handles designated Lp A, Lp B, Lp C, Lp D, and Lp E. Macroscopic examination documented colony color, the color of the culture medium, the appearance of the colony surface, and the coloration of the reverse side of the culture. Microscopic examination focused on the presence of hyphae, conidia, vesicles, and conidiophores. Across the samples, the colonies generally exhibited white or yellowish-white coloration and cotton-like growth. Several samples displayed microscopic structures interpreted as characteristic of *Aspergillus*; however, these findings support only a presumptive identification based on the morphological

observations provided. Definitive identification would require more detailed morphological assessment and, where necessary, additional confirmatory methods.

The Lp A isolate from the right refrigerator handle exhibited yellowish-white colonies, with a yellowish-white culture-medium appearance and a cotton-like colony texture. Microscopic observations indicated the presence of hyphae, conidia, and vesicles. The Lp A isolate from the left handle showed similar macroscopic characteristics, including yellowish-white coloration and cotton-like growth, while conidia and vesicles were reported during microscopic examination. These observations suggest morphological similarities between the isolates obtained from the two handles. Nevertheless, the available findings do not establish whether the isolates represent the same species or whether the observed structures are sufficient to confirm their taxonomic identity.

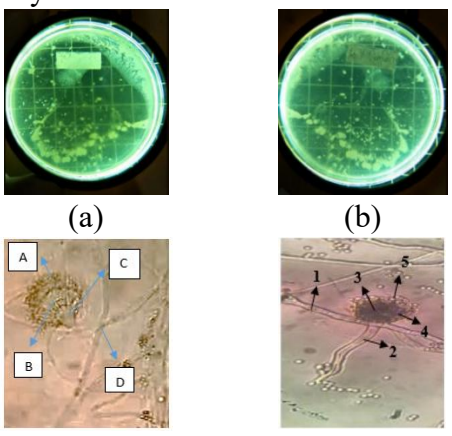


Figure 1. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Right Refrigerator Handle (Lp A).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

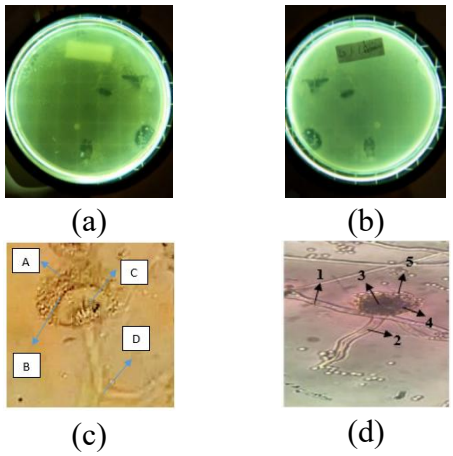


Figure 2. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Left Refrigerator Handle (Lp A).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

The Lp B isolate from the right handle presented yellowish-white colonies against a white culture-medium background, with a cotton-like appearance. Microscopic examination reportedly revealed hyphae, conidia, vesicles, and conidiophores. The corresponding isolate from the left handle also exhibited yellowish-white colony growth on a white medium, although the reported coloration of the front and reverse views differed from that of the right-handle isolate. Hyphae, conidia, vesicles, and conidiophores were observed microscopically in the left-handle sample. The presence of these structures provides morphological evidence supporting a presumptive identification of *Aspergillus* spp. However, differences in colony coloration and the completeness of the observed microscopic structures indicate that each isolate should be assessed individually rather than assumed to have an identical identity.

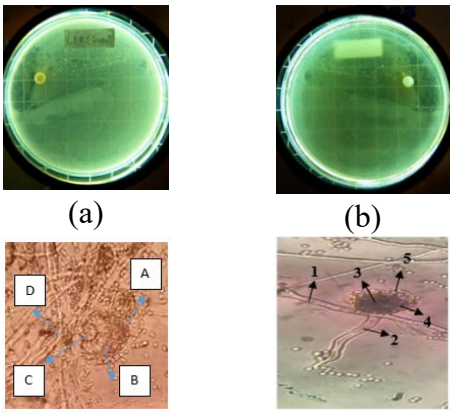


Figure 3. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Right Refrigerator Handle (Lp B).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

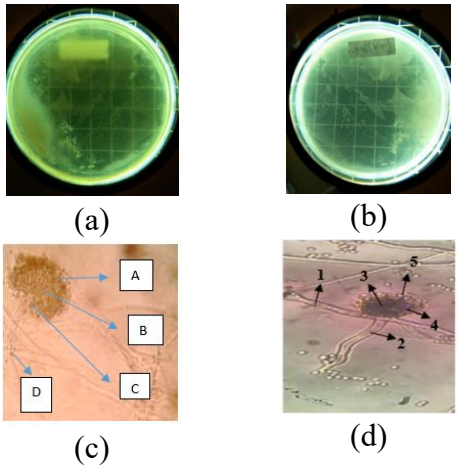


Figure 4. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Left Refrigerator Handle (Lp B).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

The Lp C isolate from the right handle displayed white colonies, a white culture-medium appearance, and cotton-like growth. Microscopic observations indicated hyphae, conidia, vesicles, and conidiophores. The Lp C isolate from the left handle also showed white colony growth on a white medium, with a cotton-like appearance. The reported microscopic findings included hyphae, conidia, vesicles, and conidiophores. The similarity in macroscopic coloration between the two samples suggests comparable colony appearances under the conditions used for cultivation. Nevertheless, white coloration and cotton-like texture are not exclusive characteristics of *Aspergillus*, and the genus-level identification should therefore remain provisional unless supported by diagnostic microscopic features or confirmatory testing.

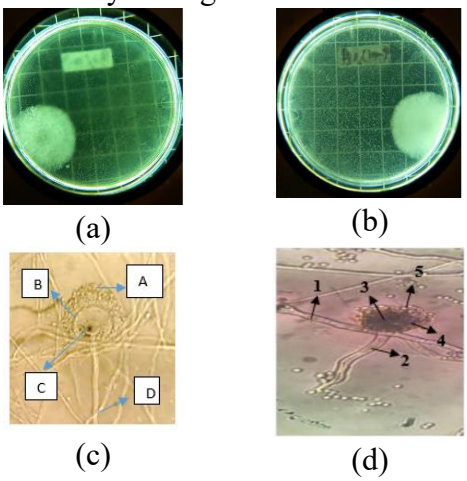
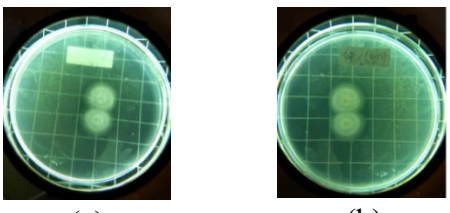
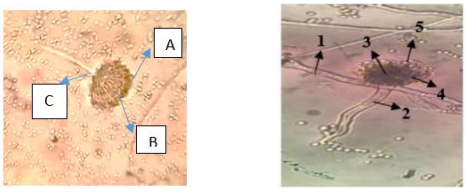


Figure 5. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Right Refrigerator Handle (Lp C).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

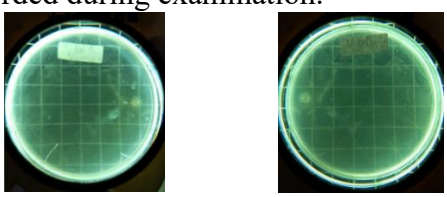




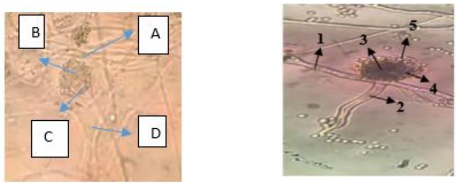
(c) (d)

Figure 6. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Left Refrigerator Handle (Lp C).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

The Lp D isolate from the right handle exhibited yellowish-white colonies, a white culture-medium background, and a cotton-like texture. Microscopic examination identified hyphae, conidia, vesicles, and conidiophores. In contrast, the Lp D isolate from the left handle showed white colonies, a white medium, and a cotton-like appearance. Its reported microscopic structures included conidia, vesicles, and conidiophores. The differences in colony coloration and the reported microscopic characteristics indicate some morphological variation between the two samples. Although the observations were considered consistent with presumptive *Aspergillus* contamination, the absence of a reported hyphal observation in the left-handle sample should not automatically be interpreted as evidence that hyphae were absent; it may reflect the structures recorded during examination.

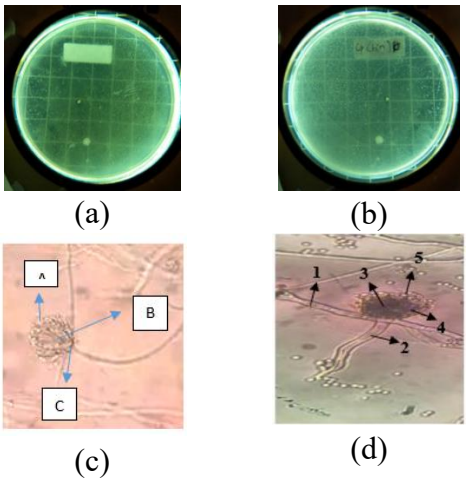


(a) (b)



(c) (d)

Figure 7. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Right Refrigerator Handle (Lp D).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.



(a) (b)

(c) (d)

Figure 8. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Left Refrigerator Handle (Lp D).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

The Lp E isolate from the right handle was reported to have white colonies, a white culture-medium background, and a cotton-like appearance. Microscopic examination reportedly revealed hyphae, conidia, vesicles, and conidiophores. The left-handle Lp E isolate displayed similar macroscopic characteristics, including white coloration on the front and reverse

views and a cotton-like colony texture. The same four types of microscopic structures were reported. These observations indicate that both Lp E samples shared similar reported morphological features. However, the original descriptions contain some ambiguity regarding the allocation of the right- and left-handle observations; the sample labels should therefore be checked against the laboratory records and figure panels before publication.

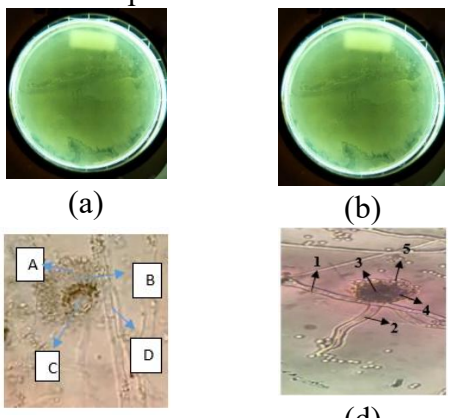


Figure 9. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Right Refrigerator Handle (Lp E).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

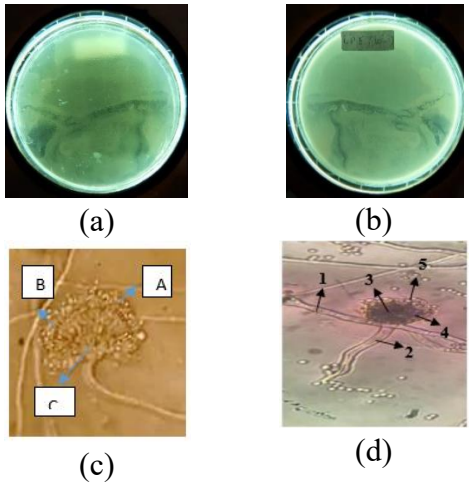


Figure 10. Macroscopic and Microscopic Characteristics of the Presumptive *Aspergillus* Isolate from the Left Refrigerator Handle (Lp E).
(a) Front view of the colony; (b) reverse view of the colony; (c) microscopic appearance of the isolate; and (d) comparative reference image of Aspergillus spp.

Overall, fungal growth was reported in the ten examined samples collected from the right and left refrigerator handles designated Lp A through Lp E. The observed colonies were predominantly white or yellowish-white and frequently described as cotton-like. Microscopic examination reportedly identified combinations of hyphae, conidia, vesicles, and conidiophores, leading to presumptive classification as *Aspergillus* spp. These results document the morphological characteristics of the recovered fungal growth under the laboratory conditions used. However, because quantitative colony counts, confirmatory species identification, and negative-control results were not provided, the findings do not establish the contamination level, the exact fungal species, the source of contamination, or the associated health risk. The results should consequently be interpreted as descriptive evidence of fungal growth on the sampled refrigerator handles rather than a quantitative assessment of contamination or proof of a specific public health outcome.

DISCUSSION

The findings of this study indicate that fungal growth was recovered from all ten examined swab samples collected from the right and left refrigerator door handles, designated Lp A to Lp E, in a minimarket in East Wonggaditi Village, Gorontalo City. The isolates were provisionally characterized as *Aspergillus* spp. based on their macroscopic and microscopic morphology. Most colonies exhibited white

or yellowish-white coloration and a cotton-like appearance, while microscopic observations identified combinations of hyphae, conidia, vesicles, and conidiophores. These findings suggest that the sampled refrigerator handles may serve as contact surfaces on which viable fungi can be recovered under the culture conditions used. However, the recovery of fungal growth should be distinguished from evidence of active mold proliferation on the handles themselves, because culture-based examination demonstrates that culturable fungi were present in the collected samples but does not establish whether they were actively growing on the original surfaces. Furthermore, the results should be interpreted as evidence from the ten examined samples rather than as a quantitative estimate of fungal contamination throughout the minimarket.

The presence of fungal growth on both right and left refrigerator handles is relevant to environmental hygiene because these surfaces are repeatedly contacted by customers and employees during routine retail activities. Frequent contact may facilitate the deposition and redistribution of environmental microorganisms, although the present study did not directly investigate transmission between hands and surfaces. Nazri and Rahim [3] examined bacterial contamination on frequently touched workplace surfaces, providing a comparative basis for considering the microbiological significance of shared contact points. Nevertheless, bacterial contamination and fungal contamination are not interchangeable phenomena, and the findings of that study cannot independently confirm the presence or behavior of fungi on refrigerator handles. Similarly, studies of mold contamination in preschools and library or archival environments demonstrate that fungal occurrence can be investigated across different indoor settings [6][7]. The present study extends this environmental hygiene perspective to a retail setting in Gorontalo City, where refrigerator handles represent frequently accessed surfaces. Its contribution lies in documenting fungal recovery from these particular surfaces rather than establishing a general prevalence pattern for minimarkets.

The presumptive identification of *Aspergillus* spp. is an important finding because this genus includes fungi commonly encountered in environmental settings. Nevertheless, the identification must be interpreted cautiously. The colonies in the present study were predominantly white or yellowish-white and frequently described as cotton-like, but colony color and texture alone are insufficient to distinguish *Aspergillus* from other fungal genera. Microscopic structures, including conidiophores, vesicles, and conidia, can support identification when their arrangement and morphology are consistent with established taxonomic characteristics. However, the recorded observations did not provide sufficient detail about conidial heads, conidial ornamentation, or other diagnostic features to establish the identity of every isolate conclusively. The presence of hyphae, conidia, and vesicles should therefore be regarded as preliminary morphological evidence rather than definitive confirmation. Further examination using validated morphological identification procedures and, where necessary, molecular methods would improve taxonomic reliability. This distinction is particularly important because different fungal species may vary in their environmental distribution, biological characteristics, and potential health implications.

Differences in colony appearance between the isolates also warrant consideration. The Lp A and Lp B samples generally exhibited yellowish-white growth, whereas the Lp C and Lp E samples were predominantly white. The Lp D isolates also differed in coloration between the right and left handles. Such variation may reflect differences among fungal isolates, culture development, or environmental conditions affecting colony appearance. However, these explanations remain possibilities rather than demonstrated mechanisms because the study did not investigate environmental parameters or conduct comparative taxonomic testing. Moreover, visually similar colonies do not necessarily represent the same fungal species, and differently colored colonies may belong to the same genus or to different genera. The observed differences therefore reinforce the need to assess isolates individually and to avoid inferring species identity solely from similarities in colony appearance. Standardized photography, systematic recording of morphological features, and confirmatory identification would strengthen future investigations.

Environmental conditions may also influence the occurrence and recovery of fungi from refrigerator handles. Moisture availability, condensation, surface residues, temperature, and cleaning practices are potential variables relevant to fungal persistence. Previous research has examined mold risks in residential buildings through site audits and longitudinal monitoring [12], while studies of water-damaged environments have highlighted the importance of moisture management in mold prevention [5]. Research on environmental audits has likewise emphasized systematic assessment of conditions associated with indoor environmental health [13]. These studies provide a conceptual basis for investigating environmental contributors to fungal contamination, but they do not demonstrate that any particular factor caused the fungal growth observed in the present study. No quantitative measurements of humidity, surface moisture, cleaning frequency, or organic residues were provided in the reported results. Consequently, the contamination cannot be attributed directly to refrigerator condensation, inadequate sanitation, or any other specific environmental condition. Future studies should combine microbiological sampling with environmental measurements and documented cleaning schedules to determine whether these factors are associated with fungal recovery from retail contact surfaces.

The findings also have potential relevance to environmental health, although their implications should not be overstated. Indoor mold exposure has been discussed in relation to allergic reactions and respiratory conditions, with the magnitude and nature of potential effects depending on the fungal species, exposure pathway, and individual susceptibility [8][9][10][14][15]. Research has also examined mold contamination in educational environments as an environmental health concern [16]. However, the present study measured neither personal exposure nor clinical outcomes among minimarket customers or employees. It therefore cannot establish that the detected fungi caused respiratory symptoms, allergic reactions, infections, or other adverse health effects. Likewise, the presence of presumptive *Aspergillus* spp. does not by itself demonstrate that pathogenic species or toxin-producing strains were present. The appropriate interpretation is that the recovery of fungi from frequently touched surfaces provides

a reason to maintain routine environmental hygiene and undertake further assessment where warranted, rather than evidence of a confirmed health hazard.

From a practical perspective, the findings support including refrigerator handles in routine cleaning and sanitation procedures at minimarkets. Cleaning schedules should address frequently touched surfaces, use products suitable for the material and intended application, and follow manufacturer instructions. Environmental hygiene measures should also consider visible moisture accumulation and the cleanliness of surrounding surfaces. Previous research on antimicrobial treatment has examined the efficacy of different approaches to controlling microbial contamination in building materials [18][19]. However, the effectiveness of a particular antimicrobial cleaner on gypsum wallboard cannot automatically be extrapolated to refrigerator handles, particularly where the surface material, contaminant, and treatment conditions differ. The present study did not compare cleaning products or evaluate contamination before and after disinfection; therefore, it cannot identify the most effective intervention. A subsequent intervention study could assess standardized cleaning procedures by comparing fungal recovery before and after treatment, while incorporating appropriate controls and consistent sampling methods. Such evidence would allow sanitation recommendations to be based on demonstrated effectiveness rather than assumptions.

Several methodological limitations should be considered when interpreting these results. First, the investigation was conducted at one minimarket, and the findings may not represent other retail establishments or locations. Second, the ten samples were described by handle position and isolate code, but quantitative colony counts and standardized surface-area measurements were not provided. The study therefore cannot determine the degree of contamination or compare contamination intensity between handles. Third, definitive species identification and negative-control results were not reported, limiting the certainty of taxonomic conclusions and the ability to exclude contamination introduced during sampling or laboratory processing. Fourth, the reported laboratory findings did not establish the relationship between cleaning practices and fungal recovery. Finally, the study did not measure human exposure or health outcomes. These limitations do not eliminate the descriptive value of the findings, but they define the scope of the conclusions that can be drawn.

Overall, this study provides preliminary evidence of culturable fungal growth on the examined refrigerator door handles in a minimarket in East Wonggaditi Village, Gorontalo City, with morphological observations provisionally consistent with *Aspergillus* spp. Its main contribution is the documentation of fungal recovery from a specific type of frequently touched surface in a local retail environment. Further investigations involving multiple minimarkets, standardized surface sampling, quantitative colony enumeration, appropriate negative controls, environmental measurements, and more definitive fungal identification are needed to clarify the distribution and characteristics of this contamination. Research evaluating the effectiveness of routine cleaning and disinfection would also help translate microbiological observations into evidence-based sanitation practices. Until such evidence is available, the findings should inform prudent environmental hygiene measures without

implying a confirmed level of public health risk.

CONCLUSION

Mold growth was detected in all ten swab samples collected from the right and left refrigerator door handles at the investigated minimarket in East Wonggaditi Village, Gorontalo City. Macroscopic and microscopic observations revealed morphological characteristics suggestive of Aspergillus spp.; however, the identification remains presumptive because no confirmatory identification method was reported. These findings indicate the presence of mold contamination on frequently touched refrigerator surfaces and emphasize the importance of routine cleaning and appropriate sanitation practices. Further studies should include quantitative measurements, confirmatory fungal identification, and evaluation of cleaning effectiveness to provide a more comprehensive assessment of surface contamination.

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