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Examination of Higher Denomination Naira Notes Exchanged in Veritas University Cafeteria for Fungal Contamination

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: This study is aimed examination of higher denomination of naira notes exchanged at Veritas University cafeteria for fungal contamination.
Study Design: The factorial experimental design was employed for this study.
Place and Duration of Study: Department of Microbiology, Veritas University, Abuja, between February 2023 to July, 2023.
Methodology: A total of 60 Nigerian currency notes, (denominations: N100, N200, N500, N1000), were randomly collected from the Veritas University Cafeteria, and subjected to analysis. Each Naira note samples were aseptically soaked and thoroughly mixed separately, in 20 ml of peptone water in a 250 ml beaker for 15 minutes. This was done to dislodge the cells into the Peptone water. Using sterile forceps, the currency notes were carefully removed for preservation from each beaker and the contents of each beaker was sealed with foil paper and incubated for 24hrs at 37C. Standard microbiological methods were followed for the isolation and characterization of the fungal species.

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Results: The result of the findings showed that, all the different naira notes had fungal contamination. The fungal count ranged from 1 x 10^7 to 6.4 x 10^9 while the ₦100 currency denomination had the highest TVC (6.4 × 10^9 cfu/ml) and the ₦200 currency denomination had the least TVC (1.0 × 10^7 cfu/ml). The result of the findings also revealed the presence of a diverse range of fungal species which include the genera; *Aspergillus*, *Penicillium*, *Candida*, *Neurospora, Trichothecium*, *Rhizopus* and *Cladosporium*. The percentage occurrence of fungal isolates revealed *Aspergillus* spp to be the most occurred except in Samples D where *Neurospora crasa* was the most present fungi.
Conclusion: The fungal species isolated from the naira notes include**,** *Neurospora crasa, Aspergillus, Candida spp, Trichothecium spp, Penicillium spp, Rhizopus spp, Mucor spp. Aspergillus* spp had the highest occurrence in all the samples except Sample D. These results emphasize the necessity of frequent monitoring in order to avoid any health hazards related to fungal contamination, as well as the implementation of good hygienic procedures in the handling and management of cash.

Keywords: Fungi; naira notes; veritas cafeteria; contamination.

1. INTRODUCTION

According to [1,2,3] money can be used as a store of value, a medium of exchange for goods and services, a unit of account, a method of deferring payment in economic operations, and a way to settle debt. The majority of daily cash transactions involve multiple people handling money in the form of notes and coins [2]. There are eight naira note denominations available at the moment: N5, N10, N20, N50, N100, N200, N500, and N1000 notes. The most widely used notes for everyday monetary transactions are the N5, N10, N20, N50, N100, and N200 naira notes. While the N500 and N1000 notes are frequently utilized by the wealthy and in business transactions, they are more prevalent among the general public [3].

A varied collection of microorganisms known as fungi are important to many different ecological processes. They can be found in a variety of locations, including interior ones like cafeterias, and are common in nature. The potential for currency notes to act as carriers of dangerous fungi and other germs makes them particularly interesting. Paper money may contain microbiological contamination from a variety of sources, such as counting machines, the ambient, storage conditions, handling, usage, or manufacture.

Moreover, the contamination of currency notes could be traced to dust, soil, water, body of currency handlers (such as hand, skin, and wounds). Furthermore, many people tongue-wet their fingers when counting money thereby, contaminating their fingers as well as currency notes [4].

Some researchers have examined the existence and variety of fungi on banknotes originating from various geographical areas, providing insights into the possible hazards and microbiological characteristics linked to these surfaces. For example, [5] study looked at the variety of fungi present on banknotes that were gathered from different Sri Lankan public spaces. Some fungal species, such as *Aspergillus, Penicillium, Cladosporium*, and Candida, were isolated and identified by the researchers.

The study underlined the necessity of good cleanliness standards and the existence of potentially harmful fungi on banknotes. In a similar vein, [6] study concentrated on the fungal populations present on Chinese banknotes. Using metagenomic analysis, the researchers examined the diversity of fungal species and found many of them, such as *Trichoderma, Fusarium,* and *Alternaria.* This study highlighted the potential function of these surfaces as reservoirs for fungal infections and showed the abundance of several fungal communities on bank notes.

Despite the significant implications of fungal contamination on currency notes, no research has been conducted on the examination of currency notes for fungal contamination in the Veritas University cafeteria. It is reasonable to say that food handlers in Nigeria, oftentimes, after handling currency notes, do fail to properly wash or sanitise their hands and other food/food-related facilities. This should be considered particularly important with respect to food handlers in Nigeria who many a times have to perform financial duties alongside foodstuffs. For the reason that foodstuffs would most likely differ with microbial contaminants/load, however, such

additional knowledge and understanding the fungal diversity associated with these currency notes is crucial for evaluating the potential health risks posed to individuals who handle them.

Furthermore, by identifying the actual sources of foodborne illnesses and educating food handlers, food traders, health professionals, and the general public about the potential risks to public health associated with handling currency notes—especially when not done so in a hygienic and safe manner—this information can help develop strategies that effectively mitigate fungal contamination and improve overall hygiene in the cafeteria setting [7]. The general trend of rising communicable disease transmission is a result of inadequate health management strategies.

People adopt many practices to prevent infectious diseases, while leaving the fact that, most infections are contracted through contact surfaces; for example, currency notes in circulation [8]. The habit of poor handling and abuse of Naira notes is widely prevalent in Nigeria. The older the Naira notes the more the accumulation of microbes occur [9]. Despite the frequent exchange of currency notes in the Veritas University cafeteria, there is a lack of comprehensive understanding regarding the presence, diversity, and identification of fungi on these notes. The potential for fungal contamination on currency notes raises concerns about the transmission of fungal pathogens to individuals who handle them, including cafeteria staff and students.

Appropriate preventive measures cannot be put into place without information about the particular fungus species present, the level of contamination, and the health hazards connected with it [9]. It is important to carry out a study that focuses on checking different banknotes exchanged at the Veritas University cafeteria for fungal infestation in order to address this issue. Consequently, the goal of the current study was to examine the larger value naira notes that were exchanged at the cafeteria of Veritas University microbiologically.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in Veritas University, located in Bwari, Area Council of the Federal Capital Territory, Nigeria. It was founded by the Catholic Bishops Conference of Nigeria through a resolution given at its March 2002 meeting in Abuja and established in 2007. Veritas University is a private higher-education institution located in the small city of Abuja (population range of 50,000-249,999 inhabitants), Federal Capital Territory. A provisional License to operate the University was granted by the National Universities Commission in May 2007. Although, the permanent site of the University is located in Bwari, Area Council of the Federal Capital Territory, Abuja, However, the University commenced admission of students in October 2008, for the 2008/2009 academic year at its take-off campus in Obehie Town, Abia State, Nigeria.

2.2 Sample Collection

A total of sixty (60) Naira currency notes were used for this study. 20 samples of the Naira notes, comprising of five (15) samples for each of the four (4) higher denominations (that is, N1000, N500, N200 and N100) were randomly collected from the cafeteria in Veritas University, Abuja, Nigeria. Each Sample were collected in sterile polythene bags using hand gloves, labeled and taken to the laboratory in the Department of Microbiology, Veritas University Abuja for microbiological analysis [10].

2.3 Preparation of Samples for Analysis

Each Naira note samples were aseptically soaked and thoroughly mixed separately, in 20 ml of peptone water in a 250 ml beaker for 15minutes. This was done to dislodge the cells into the Peptone water. Using sterile forceps, the currency notes were carefully removed for preservation from each beaker and the contents of each beaker was sealed with foil paper and incubated for 24hrs at 37C [11].

2.4 Isolation of Fungi Species

The medium used for the preparation of the stock solution was Peptone water while Potato Dextrose Agar **(**PDA**)** was the medium used for the isolation of the fungal species. These were prepared according to the manufacturer's instructions. All the media were sterilized by autoclaving at 121^0C for 15 minutes and 15 psi. A concentration of 50mg/L of chloramphenicol was added to the PDA after sterilization and after been allowed to cool to a temperature of 45^0C, this was stirred gently but thoroughly to ensure uniform distribution of chloramphenicol throughout the liquid medium. The

chloramphenicol- supplemented PDA was dispensed into sterilized petri dishes [12].

A rack of sterile test tubes were arranged for each samples, and each containing 9ml of sterile distilled water. The stock culture was serially diluted as follows; One (1ml) was taken from the stock culture to the first test-tube in a test tube rank to make 10^{-1}. From the first tube 1 ml was taken to the second test tube to make 10^{-2} and further dilution was made up to 10^{-8} and 1 ml from the last test tube was discarded. A volume of 0.1 ml aliquot from 10^{-7} dilution using sterile pipettes was spread-plated in duplicate on solidified plates of PDA (Potato Dextrose Agar). The inoculated plates were incubated at room temperature for 3 - 5days [11].

2.4.1 Characterization and identification of fungi isolates

After 5 days of incubation, fungal colonies were aseptically picked and sub-cultured on freshly prepared PDA (Potato Dextrose Agar) plates. The isolated fungi were identified on the basis of colour, macroscopic and microscopic observations [12]

3. RESULTS AND DISCUSSION

3.1 Results

Results showed that different species of fungi were present on the surfaces of the various higher denominations of Naira notes exchanged amongst students/customers and food vendors at the Cafeteria of Veritas University.

Table 1. Colony counts of the fungal isolates

Isolates	Dilution factor (10^{-7})	Plate count	Total plate count (CFU/mL)	Log cfu /ml
A1	7	30	3.0×10^{8}	8.48
A2	7	38	3.8×10^{9}	9.58
A3	7	64	6.4×10^{9}	9.81
B1	7	4	4×10^{7}	7.60
B2	7	14	1.4×10^{8}	8.15
B3	7	1	1×10^{7}	7.00
B4	7	1	1×10^{7}	7.00
B5	7	2	2×10^{7}	7.30
B6	7	5	5×10^{7}	7.70
B7	7	2	2×10^{7}	7.30
B8	7	1	1×10^{7}	7.00
C1	7	1	1×10^{7}	7.00
C2	7	1	1×10^{7}	7.00
D1	7	33	3.3×10^{9}	9.52
D2	7	5	5×10^{7}	7.70
D3	7	5	5×10^{7}	7.70
D4	7	28	2.8×10^{9}	9.44
D5	7	2	2×10^{7}	7.30
D6	7	1	1×10^{7}	7.00

Key: A= 1000 Naira Notes; B= 500 Naira Notes; C=200 Naira Notes; D=100 Naira Notes

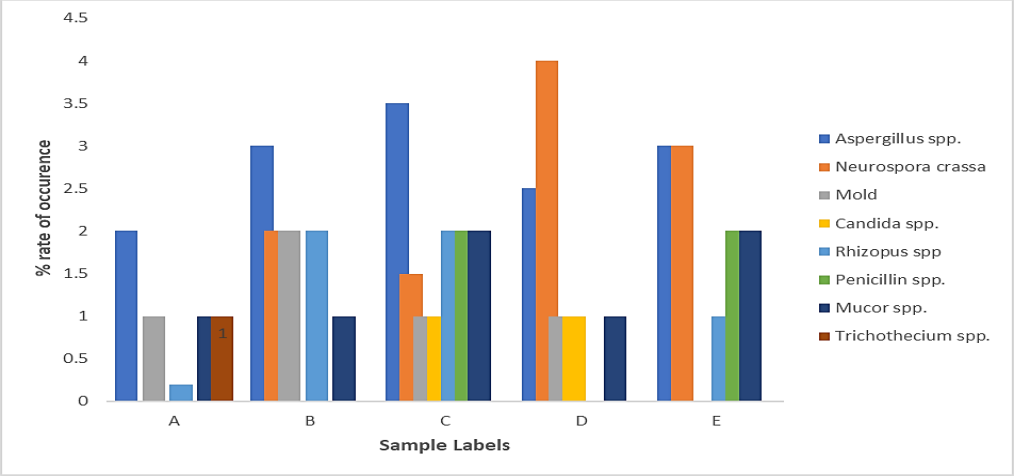

Fig. 1. Percentage occurrence of fungal isolates at various points of sample collection

Key: Sample A- Boys hostel cafeteria 1; Sample B- Boys hostel cafeteria 3; Sample C- Ase café; Sample D – Block A cafeteria; Sample E – Girls hostel cafeteria

Table 2. Macroscopic characteristics of fungi isolates

Species designation	Colour of hyphae	Reverse pigmentation	Texture	Topography	Size	Opacity	Probable isolate
A1	Black	White/greyish	Viscid	Raised	large	Rugose	*Rhizopus species.*
A2	Green	Grey	fluffy	Flat	large	Rugose	*Aspergillus flavus*
A3	Milk	milk	creamy	Raised	Small	Rugose	*Candida species*
B1	Black	Belge	velvety	Folded	large	Rugose	*Aspergillus niger*
B2	Green	Yellow	wooly	Dome	large	Rugose	*Aspergillus flavus*
B3	Pink	Orange	wooly	Raised	Large	Rugose	*Trichothecium species*
B4	Light Green	Yellow	wooly	Dome	large	Rugose	*Aspergillus flavus*
B5	White	yellow	velvety	Raised	large	Rugose	*Mold species*
B6	Milky	Milk	creamy	Raised	small	Rugose	*Candida species*
B7	Blue	brown	powdery	Flat	large	Rugose	*Aspergillus fumigatus*
B8	Grey	Grey	fluffy	Flat	large	Rugose	*Rhizopus species*
C1	Whitish	Orange	cottony	Undulate	large	Rugose	*Mold species*
C2	Orange	orange	wooly	Flat	large	Rugose	*Neurospora species*
D1	Dark green	Grey	fluffy	Flat	large	Rugose	*Aspergillus flavus*
D2	Black	Belge	Velvety	Folded	large	Rugose	*Aspergillus flavus*
D3	Pink	Orange	wooly	Raised	Large	Rugose	*Trichothecium species*
D4	Milky	Milk	creamy	Raised	small	Rugose	*Candida species*
D5	Blue	brown	powdery	Flat	large	Rugose	*Aspergillus fumigatus*
D6	Grey	Grey	fluffy	Flat	large	Rugose	*Rhizopus species*

Table 3. Microscopic characteristics of fungal isolates

Species designation	Color of hyphae	Pattern and shape of spores	Appearance of conidiophores	Appearance of sporangiophore	Characteristics of spore head	Nature of hyphae	Probable isolate
A1	Brown	Globose	Coenocytic	Clustered and brown	Fluffy conidia	Rhizoids	*Rhizopus species*
A2	pale brown	Glubose Ellipsoid	Septate	Spherical	smooth finely roughened	Biseriate	*Aspergillus flavus*
A3	Purple	Oval	-	-	-	-	*Candida species*
B1	Black	Black	Oval	Septate	Long and erect	Fluffy conidia	*Aspergillus niger*
B2	pale brown	Glubose Ellipsoid	Septate	Spherical	smooth finely roughened	Biseriate	*Aspergillus flavus*
B3	Pink	Hyaline	Septate	Long and unbranched	Ovoid	Globose	*Trichothecium species*
B4	pale brown	Glubose Ellipsoid	Septate	Spherical	smooth finely roughened	Biseriate	*Aspergillus flavus*
B5	Blue	Round	Coenocytic	elongated	flattened	Globose	*Mold species*
B6	Purple	Oval	-	-	-	-	*Candida species*
B7	grayish near apex	brown	uniseriate pyriform	Erect	Glubose small in columns	smooth or spinose	*Aspergillus fumigatus*
B8	Brown	Globose	Coenocytic	elongated	Fluffy conidia	Rhizoids	*Rhizopus species*
C1	Blue	Round	Coenocytic	elongated	Spherical	Globose	*Penicillin simplicissimum*
C2	Dark	ellipsoidal	septate	longitudinal	spherical	Round	*Neurospora species*
D1	pale brown	Glubose ellipsoid	septate	spherical	smooth finely roughened	Biseriate	*Aspergillus flavus*
D2	Black	Oval	Septate	Long and erect	Fluffy conidia	Septateand multinucleated	*Aspergillus niger*
D3	Pink	Hyaline	Septate	Long and unbranched	Ovoid	Globose	*Trichothecium species*
D4	Purple	Oval	-	-	-	-	*Candida species*
D5	grayish near apex	brown	uniseriate pyriform	Erect	Glubose small in columns	smooth or spinose	*Aspergillus fumigatus*
D6	Brown	Globose	Coenocytic	elongated	Fluffy conidia	Rhizoids	*Rhizopus species*

3.2 Discussion

The Total viable count (TVC) on Naira denominations clearly obtained varying ranges across food vendors from the various Cafeterias (Table 1). The ₦100 currency denomination had the highest TVC (6.4×10^9 cfu/ml), which is consistent with the report of [13] while the ₦200 currency denomination had the least TVC (1.0×10^7 cfu/ml).

The results of this study showed from the various samples collected, that all the currency notes were contaminated by fungal spp with 60% percentage occurrence for *Aspergillus spp*. This is similar to the report of [14] that *Aspergillus spp were* abundant fungal species on currency notes. These species were also seen in some of the cultured plates. In humans, *A*. *flavus* aflatoxin production can lead to acute hepatitis, immunosuppression, hepatocellular carcinoma, and neutropenia.

The one hundred (100) Naira samples had species of *Aspergillus* including, *A*. *niger* and *A*. *flavus*, *Rhizopus*, *Penicillium* spp*, Mucor* spp., and Mould. From physical observation of the Naira notes after samples collection, the one hundred (100) naira samples appeared to be the dirtiest amongst all the denominations collected. This is likely because, the #100-naira notes have the highest usage in Nigeria and across her society's in daily transactions [15,16].

There was also an occurrence of *Neurospora* spp*.,* suspected to be *N. crassa* especially in four (4) of the Two hundred (200) Naira samples and in one (1) of the one hundred (100) naira samples. Though, all samples were collected at random. At the point of collection of the various samples, two of the two hundred (200) naira samples were of the newly minted currency notes (Table 2).

Research has not proven *Neurospora species* to be dangerous to human health because, they are obligate aerobes, and unable to grow in the gut or bladder, in tissues, or systemically.

Various Fungal genera were seen on the Five hundred (500) and one thousand (1000) Naira samples; including *Aspergillus*, *Rhizopus*, *Neurospora, Candida* and *Penicillium*, among others. Possible isolate of *Trichothecium spp*. was seen on the mixed colonial plate of the 500-naira sample; D_3.

Candida species are one of the most diverse pathogenic fungi known to man. They are opportunistic fungi that commonly inhabit the human body. However, under certain conditions, they can cause infections, particularly in individuals with weakened immune systems. *Candida albicans* is the most prevalent species associated with candidiasis, which can affect various sites, including the mouth, genitals, and bloodstream [17].

The growth of various Fungal genera on the 500 and #1000 naira notes in this study is probably because, these are the most used and exchanged currency in the University Cafeteria. The average cost of a meal at the cafeteria is between #500 to #1000 naira and, it is reasonable to see customers with such higher denominations to cover up an entire meal.

The findings of this study correlates in line of the research work from some scientists who revealed the presence of various fungal species, including common genera such as *Aspergillus*, *Penicillium*, *Cladosporium* and *Candida* [18,19,20]. Though, research has shown that specific fungal composition may vary depending on the geographic location, climate, and environmental factors. In most parts of the developed world, there is a popular belief that the simultaneous handling of food and money contributes to the incidence of food-related public health incidents.

4. CONCLUSION

The research study offers insightful information on the microbiological contamination linked to money. The research revealed that banknotes could act as a possible haven for a variety of fungus species. *Aspergillus, Candida spp, Trichothecium spp, Penicillium spp, Rhizopus spp, Mucor spp. Aspergillus* spp. These results emphasize the necessity of frequent monitoring in order to avoid any health hazards related to fungal contamination, as well as the implementation of good hygienic procedures in the handling and management of cash.

Further investigations into the specific sources and factors contributing to fungal colonization on currency notes are warranted to develop targeted mitigation strategies. Overall, the study contributes to our understanding of the microbial ecology of currency notes.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

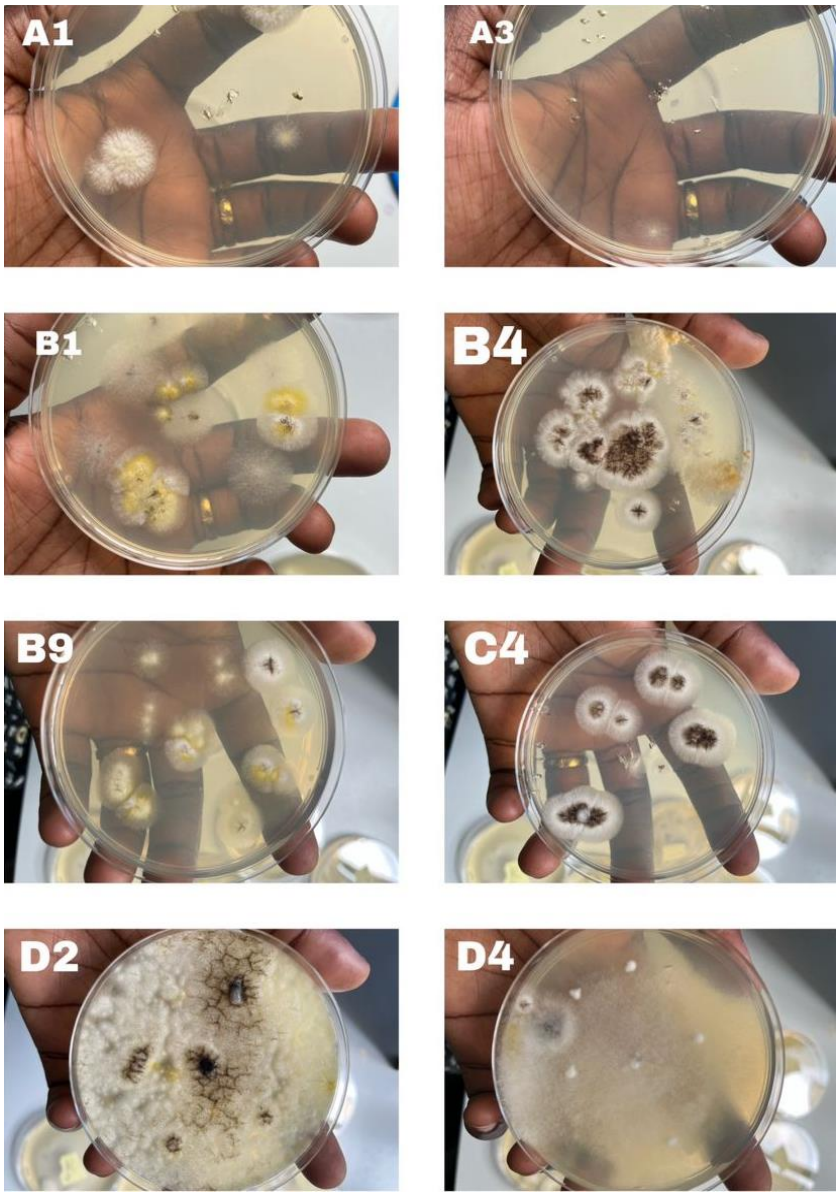
Appendix A: Ref. Table 3, Macroscopic examination results of the fungal isolates on PDA (Potato Dextrose Agar) Medium after 5days of culturing via spread plate technique.

Appendix B:

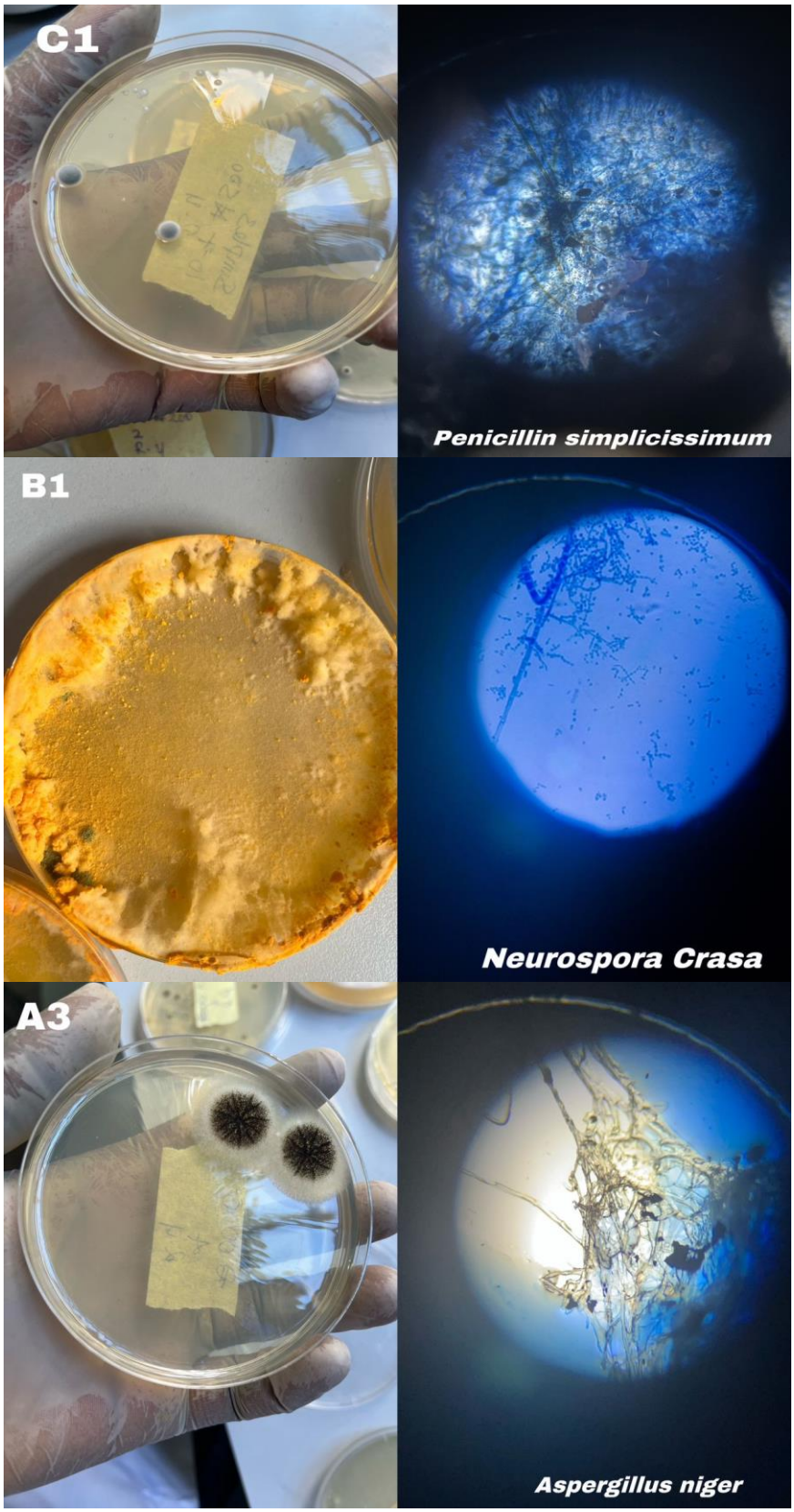
Table 1. Factorial experimental design table

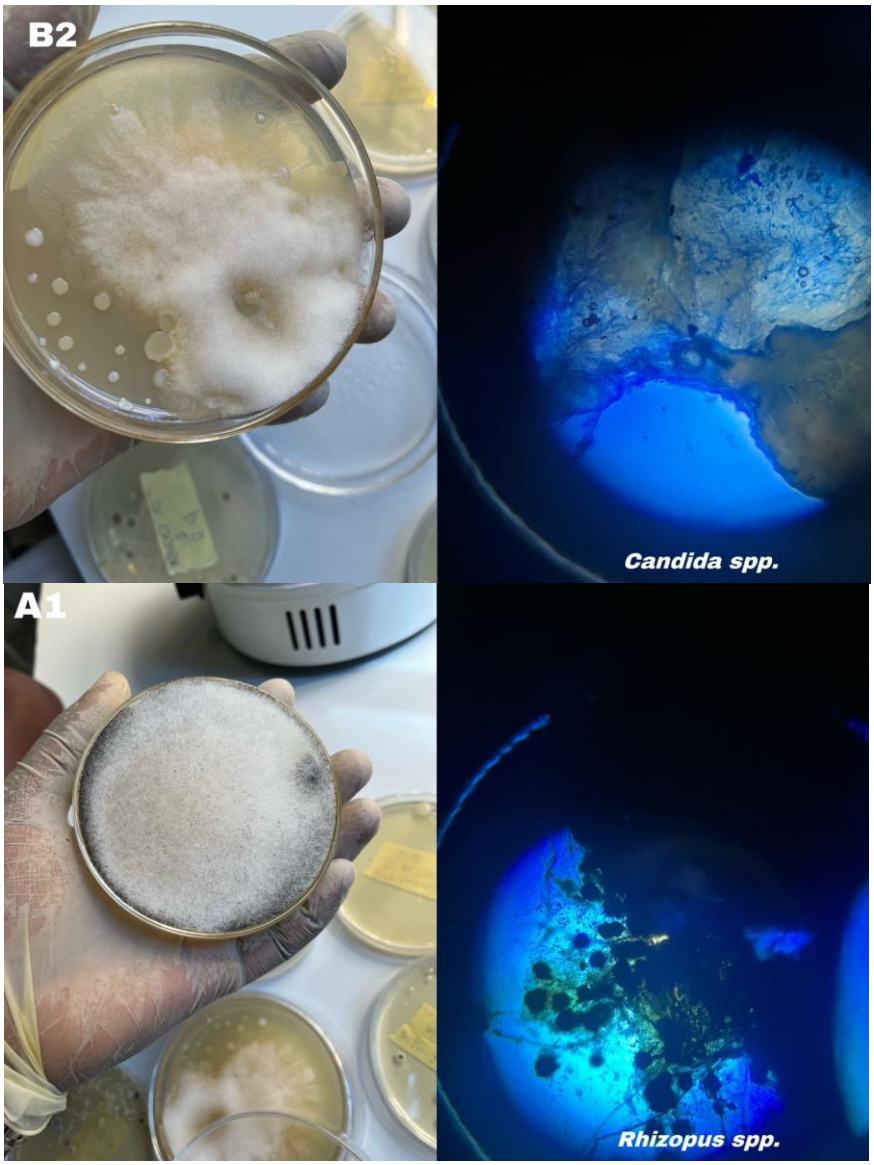
Cafeteria	Denominations (number # of samples collected from each cafeteria)			
	#100	#200	#500	#1000
A	3	-	6	3
B	6	-	6	3
C	-	6	3	3
D	-	6	-	3
E	6	3	-	3

Appendix C: Macroscopic examination results of sub-cultured fungal isolates on PDA (Potato Dextrose Agar) Medium after 3days of inoculation



Appendix D: Ref. Table 3 Fig. 1. Macro and Microscopic Examination of Fungal isolates from pure culture with possible isolates.





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