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ARTICLE

Studies on Fungi Associated with Naira Notes from Selected Markets in Ojo Local Government Area of Lagos State, Nigeria

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Abstracts
Money is a medium of exchange for commodities and services. However, money can house microorganisms such as bacteria and fungi if not managed appropriately. Fungi are ubiquitous organisms that are resistant to harsh environments, could be associated with money, and might cause adverse effects on health when handled improperly. This research aimed at isolating and identifying fungi associated with naira notes from selected markets in Lagos State. A total of 50 sampled naira notes (N20, N50, N100, N200, and N500) were randomly collected from merchants at Okoko and Iyana-Iba markets in Ojo local government, Lagos State. Pour-plate and serial dilution were the methods utilized in the isolation of fungi. In addition, the antifungal activity of ketoconazole, fulcin, and hand sanitizer was tested against the isolated fungi using the agar-well diffusion technique. *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *Lasiodiplodia theobromae*, *Mucor* sp., *Penicillium notatum*, and *Rhizopus* sp. were isolated and identified from sampled naira notes. In terms of antifungal activity, ketoconazole effectively suppressed the growth of all isolated fungi except *L. theobromae* and *Rhizopus* sp., whereas fulcin and hand sanitizer showed no inhibitory effect on fungal growth. Due to the potential adverse health effects associated with some fungal spores, it is imperative that adequate sanitary measures be put in place while handling money.

Keywords: Anti-fungal, Fungi, Health, Naira notes, Serial dilution.

1.0 Introduction

Fungi, a group of diverse microorganisms with significance in food and health sciences, are resilient pathogens with spores that endure dry conditions. They thrive in various environments, are resistant to harsh conditions, and can easily spread through the air. Human activities, such as handling money or spoiled food, can foster fungal growth. According to research, paper currency, transferred globally, may serve as a vehicle for the spread of harmful microorganisms due to its ample surface area. (Talaro, 2005). Research from different areas of the world indicated that there is a high level of microbial contamination in money whether it is coins or paper (Michaels, 2002; Rote et al., 2010; Alwakeel et al., 2011; Ukpong and Joshua, 2019; Otu-Bassey et al., 2021).

Improper management using saliva or unclean water, sneezing and coughing while handling or counting naira notes are ways Nigerian notes become contaminated. Some other means of contamination include the atmosphere, during storage (Ajobiewe et al., 2012; Orji et al., 2012), wounds, and counting machines (Badvi et al., 2017). The populace without formal education in Nigeria has experienced elevated rates of mortality and morbidity due to their common practice of storing naira notes in uncomfortable areas such as intimate parts, shoes, armpits and socks. Several of these locations harbour opportunistic pathogens capable of transmitting between individuals during interactions (Michaels, 2002). In Riyadh, Saudi Arabia, fungal strains have been identified in both new and old currency notes. *Aspergillus niger* emerged as the most frequently identified fungal species, followed by A. flavus, *Candida spp*., *Penicillium spp*., and *Rhizopus spp*. (Alwakeel et al., 2011). Numerous studies have shown that antibiotic-resistant microorganisms infiltrate naira notes and may be a significant factor in the spread of both pathogenic microorganisms and drug-resistant organisms (Rote et al., 2010; Ayandele and Adeniyi, 2011; Agresew, 2014). This resistance also raises concerns about potential public health hazards. Various disease-causing microorganisms or those resistant to antibiotics have been detected in coins and paper money obtained from medical personnel and food handlers (Agresew, 2014).'

The confirmation of multi-drug-resistant microorganisms being isolated from currency notes serves as evidence that currency plays a significant role in the transmission of drug-resistant microorganisms. One of the primary sources of banknote contamination during handling and transactions is contact with the skin, wounds, nasal secretions, aerosols, and even the anal region (Moses et al., 2018; Agholor et al., 2020).

Money is an item generally acceptable for means of transaction, i.e. for paying for goods and services. Paper money was first introduced in China in 1000 AD (Agersew, 2014). Several years later, scientists began hypothesizing about the potential connection between the transmission of diseases and the handling of money. Modern scientific methods have since provided support for these hypotheses, revealing that viable pathogenic micro-organisms such as bacteria, viruses and fungi can indeed be detected and isolated from the surfaces of both paper money and coins (Kuria, 2009; Lamichanne et al., 2009).

Initially, a monetary system was absent, leading to people exchanging goods directly, a practice known as bartering. This practice, widespread in early civilizations and still observed in societies with rudimentary economies, poses challenges due to the varying values of traded items. Over time, ancient societies recognized the drawbacks of bartering, finding it laborious and slow (Investopedia, 2010; Federal Reserve Bank of Philadelphia, 2011). Paper notes gained widespread acceptance as a form of money substitute over the succeeding centuries before being officially acknowledged as such (Agersew, 2014). Paper money notes were created in this manner, and they are now frequently used in transactions for products and services (Wray, 1993; Oyero and Emikpe, 2007).

Dust, dirt, water, and micro-flora on handlers' hands, skin and other body parts contribute to note contamination. Saliva used during counting and the absorbent nature of paper money enable microorganism development. Fungi contaminate money through air, dirt, and storage areas, posing health risks. As money circulates, contamination levels increase, potentially causing infections and respiratory diseases (Okungbowa and Dede, 2008).

Despite the push for a cashless economy, a substantial part of trade still involves physical currency. The implementation of the Central Bank of Nigeria's cashless policy is still in its early stages, and while compliance is enforced through the banking system, a large number of individuals in township, urban and rural areas continue to handle and exchange cash in their everyday transactions. The aim of the study was to isolate and identify the fungi associated with naira notes from selected markets in Lagos State.

2.0 Materials and Methods

Fifty samples of circulating Nigerian currency comprising of notes in the denominations N20, N50, N100, N200 and N500 were randomly collected from Iyana-iba and Okoko markets in Ojo local government, Lagos State. The markets are situated on Longitude 3.2043˚E and Latitude 6.4609˚N and Longitude 3.1905˚E and Latitude 6.4750˚N, respectively. Twenty-five samples were obtained from each market with five samples from each of the denominations. Five new crisp notes were obtained to serve as control, and all

samples were brought to the Laboratory of the Department of Botany, Lagos State University for further analysis.

Each sample of the different denominations was separately left in 100 mL sterile distilled water for 48h. Samples of same denomination (5 each) from the same market were soaked together. The resulting mixture containing currency diffusate was used as stock inoculum and was added to 9 mL sterile distilled water and 0.2 mL of each diluted stock was collected from 10-4, 10-5 and 10-6 and transferred to plates containing Potato Dextrose Agar mixed with 1 mL chloramphenicol (Chloramphenicol 250mg) and was spread with a sterile test-tube base. The grown cultures were observed under the microscope at X10 and X40 objective lens (Subashini et al., 2016), and the fungi were identified with reference to standard textbooks (William and Dennis, 1990; Olutiola et al., 2002).

The anti-fungal activity of the anti-fungal drug was determined, using the agar well diffusion method (Balouiri et al., 2016). Sterile distilled water was used as a negative control and 0.3 mL of Ketoconazole (Ketaglo 200mg), 0.3 mL of Fulcin (Artcin 500mg) and Hand sanitizer (Lifebuoy 70% Alcohol) were used as positive controls. Four wells of diameter were dug in each plate. Five millimeter mycelial discs were taken from 8 days old culture and placed on the middle of the plate. The plates were done in duplicates and were incubated at room temperature. The anti-fungal activity was taken based on diameter of zone of inhibition, which was measured after 4 days of incubation and the mean standard deviation of two readings was presented. Data were analyzed using Statistix 10.0 software and was expressed as mean ± standard deviation.

3.0 Results and discussion

The isolated fungi were *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *Lasiodiplodia theobromae*, *Mucor sp*., *Penicillium sp*., and *Rhizopus sp*. The occurrence of the isolates in the various naira notes randomly collected from traders showed that the naira notes studied were contaminated by the fungal organisms (Tables 1 and 2). Aspergillus spp. was the most predominant on the currency notes. Ketoconazole inhibited the growth of all the isolated fungi except *L. theobromae* and *Rhizopus sp.* while fulcin and hand-sanitizer did not inhibit the growth (Table 3). The result from this research reveals the presence of different fungal species (*Aspergillus niger*, *A. flavus*, *A. fumigatus*, *Mucor sp*., *Rhizopus sp*., *Lasiodiplodia theobromae* and *Penicillium sp*. The most prevalent fungi were *A. niger*. Similar results had been reported by other authors (Pope et al, 2002; Orababa et al., 2021). In nature, *A. niger* can be found everywhere, the organism is a typical secondary intruder. In individuals with compromised immune systems, it might also result in pulmonary disease. Compared to some other Aspergillus species, *A. niger* has a lower risk of causing disease to humans. However, exposure to a significant number of spores from those other Aspergillus species can still result in the serious lung condition known as Aspergillosis.

Higher denominations of naira notes such as the N500 notes reportedly had reduced contamination rates than lower denominations such as the N50 and N200 notes. Some writers have also reported that lower-denomination currency notes are highly contaminated (Otu-Bassey et al., 2021). This might be a result of lower denominations being commonly found and spent amongst the average Nigerians.

Improper handling and misuse of the naira notes have been suggested to be one of the many ways naira notes become tainted. Naira notes could become contaminated with microorganisms through certain behaviours such as coughing and sneezing while handling, using saliva, handling the naira notes with soiled hands from the bathroom, using polluted or contaminated water while counting and spraying money at events, which end up in the ground and stepped on by people wearing dirty footwear. In addition, contamination can occur during storage and in the atmosphere, (Ajobiewe et al., 2012; Orji et al., 2012), wounds, and counting machines (Badvi et al., 2017).

Table 1: Occurrence of the isolates on the various naira notes collected randomly from traders from Okoko market

Currencies	*Aspergillus niger*	*Aspergillus fumigatus*	*Mucor* sp.	*Rhizopus* sp.	*Lasiodiplodia theobromae*
20	-	-	-	-	+
50	+	+	-	-	-
100	-	-	-	-	-
200	-	-	+	+	-
500	-	-	-	-	-

Key: + = present; - = absent

Table 2: Occurrence of the isolates on the various naira notes collected randomly from traders from Iyana-iba market

Currencies	*Aspergillus flavus*	*Aspergillus niger*	*Penicillium* sp.
20	-	-	-
50	-	-	-
100	-	-	+
200	+	+	-
500	-	-	-

Key: + = present; Key: - = absent

Table 3: Antifungal activity of ketoconazole, fulcin and hand-sanitizer on test fungi at 0.3mg/mL

Antifungal drugs/ hand-sanitizer	Ketoconazole	Fulcin	Hand-sanitizer	Sterile distilled water
Organisms				
Aspergillus fumigatus	33.50±2.12^{ab}	0.00±0.00	0.00±0.00	0.00±0.00
Aspergillus flavus	21.00±29.69^{ab}	0.00±0.00	0.00±0.00	0.00±0.00
Penicillium sp.	18.00±25.45^{ab}	0.00±0.00	0.00±0.00	0.00±0.00
Mucor sp.	39.50±3.53^{a}	0.00±0.00	0.00±0.00	0.00±0.00
Aspergillus niger	11.50±16.26^{ab}	0.00±0.00	0.00±0.00	0.00±0.00
Aspergillus niger	25.00±7.07^{ab}	0.00±0.00	0.00±0.00	0.00±0.00
Rhizopus sp.	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00
Lasiodiplodia theobromae	0.00±0.00^{b}	0.00±0.00	0.00±0.00	0.00±0.00

Value show means of duplicate analysis ± standard deviation. Figures with different superscript are significantly different ($p \leq 0.5$).

The antifungal activity conducted in this study also offers insightful information regarding the efficacy of frequently prescribed antifungal drugs like ketoconazole against isolated fungi. The research revealed that the majority of the isolated fungi were sensitive to ketoconazole and that there was a concentration-dependent apparent resistance to fulcin and hand sanitizer, indicating that such drugs might be useful in treating fungal infections brought on by these species.

The study also stresses the importance of educating the public and increasing awareness about the possible health risks associated with contaminated naira notes. This entails advocating both the use of antifungal medications to prevent and treat fungal infections as well as good hygiene habits like hand washing.

4.0 Conclusion

The isolation and identification of fungi associated with Naira notes from two selected markets at Ojo Local Government Area of Lagos State revealed the presence of various fungal species, some of which are potential human pathogens. The study showed that most of the isolated fungi were susceptible to the ketoconazole and apparent resistance of fulcin and hand-sanitizer due to the concentration and suggesting that these drugs could be effective in treating fungal infections caused by these species. These findings underscore the importance of proper handling and storage of currency notes and the need for improved public awareness regarding the potential health risks associated with contaminated currency notes.

5.0 Recommendation

It is recommended that efforts be made to promote proper hygiene practices, including hand washing, and the use of antifungal agents to prevent and control fungal infections. Further studies are needed to investigate the prevalence and distribution of fungal species on currency notes and to determine the possible sources of contamination. Further research is needed to expand on these findings and develop new strategies for the prevention and treatment of fungal infections. Governments should also put in place the cashless policy to reduce the use of currency notes.

Conflict of Interest

The authors declare no conflict of interests.

Individual author's contribution

Conception: TSE, BOO and OAO

Design: TSE, BOO and AOA

Execution: TSE, BOO, AOA and OLO

Interpretation: AOA, OLO and OAO

Writing the paper: TSE, BOO and OLO

All the authors have read the final manuscript and approved the submission.

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