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COMPARATIVE ANALYSIS OF FUNGAL CONTAMINANTS IN SLICED WATERMELON (*Citrullus lanatus*) AND PINEAPPLE (*Ananas comosus*) SOLD IN JOS SOUTH LOCAL GOVERNMENT AREA.

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ABSTRACT

Food safety is a paramount concern, and the presence of fungal contaminants in fresh fruits is a topic of increasing importance. This study conducted a comparative analysis of fungal contaminants in sliced watermelon (Citrullus lanatus) and pineapple (Ananas comosus) sold in Jos South local government Area. The objectives were to isolate and identify the fungal species present in the sliced fruits and to determine the market with the highest level of contamination. A total of twenty-four (24) samples, comprising twelve (12) sliced watermelon and twelve (12) sliced pineapple samples, were collected from four selected markets; Vom, Bukuru, Building Materials and Abattoir markets. Standard microbiological techniques were used for isolation and identification of fungal isolates. The results revealed variations in the types of fungal contaminants between sliced watermelon and pineapple. The fungal isolates identified were; Aspergillus spp, Rhizopus spp, Penicillium spp, Alternaria spp, Rhodotorula spp and Mucor spp. Fungal growth was observed in 10 of 12 (83.3%) watermelon samples and 9 of 12 (75.0%) pineapple samples. Among the markets, Building Materials recorded the highest proportion of fungal-positive samples (100%), followed by Vom (83.3%), while Bukuru and Abattoir each recorded 66.7%. Vom market recorded the highest diversity of fungal isolates, while Mucor spp. had the highest frequency of occurrence (44.44%) among the fungal isolates recorded in Building Materials market. Data were

analyzed using descriptive statistics, Chi-square and Fisher's exact tests, with statistical significance set at $p < 0.05$. The findings indicate that watermelon had a slightly higher proportion of fungal-positive samples than pineapple, although the difference was not statistically significant. The presence of these fungal isolates may have been associated with poor handling, unhygienic display, and exposure of sliced fruits in open markets. The study emphasizes the need for improved hygiene practices and consumer awareness to reduce fungal-related health risks associated with consuming sliced fruits sold in open markets. Fruit handlers and vendors should also be educated on proper sanitary practices for processing the fruits in order to reduce fungal contamination and potential health risks.

Keywords: *fungal contamination; sliced fruits; watermelon; pineapple; Jos South*

INTRODUCTION

Fruits are rich sources of vitamins, minerals, antioxidants, and diverse phytonutrients essential for human health and well-being. Regular consumption of fruits and vegetables reduces the risk of various diseases and contributes significantly to a balanced diet. “Sliced fruits” refer to fresh fruits that have been cut open and portioned into smaller pieces for convenience and sold for immediate consumption (Kalia and Gupta, 2006).

Watermelon (*Citrullus lanatus*), a member of the Cucurbitaceae family, is a popular tropical fruit valued for its refreshing taste, high water content, and health-promoting nutrients. It contains lycopene, citrulline, and other bioactive compounds that provide both nutritional and therapeutic benefits (Dane and Liu, 2017). Similarly, pineapple (*Ananas comosus*), belonging to the Bromeliaceae family, is another economically important fruit rich in antioxidants such as carotenoids, flavonoids, and ascorbic acid, which contribute to disease prevention and immune function (Hossain *et al.,* 2015). In many urban areas, including Jos South Local Government Area of Plateau State, these fruits are commonly sold in sliced form by roadside vendors, often wrapped in polyethylene bags and exposed to open-air environments. The increasing consumption of these ready-to-eat fruits raises public health concerns due to the potential exposure of consumers to microbial contamination.

The convenience, affordability, and accessibility of sliced fruits have contributed to their growing popularity, particularly among low-income populations. However, these fruits are often processed and sold by unlicensed vendors who may lack adequate food safety training or hygiene practices. The informal nature of this trade has expanded in many developing countries due to unemployment, providing households with a source of income but also increasing the risk of unsafe food handling (Bean & Griffin, 1996).

Outbreaks of foodborne diseases have been increasingly linked to the consumption of contaminated fruits. Although fresh fruits naturally possess non-pathogenic microbiota and an outer epidermal barrier that limits microbial invasion, cutting and slicing compromise these natural defenses, allowing microorganisms to penetrate internal tissues. Poor handling, contaminated water, and exposure to unsanitary environments during preparation and sale may further contribute to contamination risks. Additionally, the open display of sliced fruits attracts flies, dust, and rodents, which can serve as mechanical vectors for fungal spores (Beuchat, 1995).

Several studies have shown that microbial contamination of fresh-cut fruits can occur during washing, peeling, trimming, packaging, and handling. The high moisture and sugar content of fruits like watermelon and pineapple further enhance fungal proliferation under warm and humid conditions. Street vendors often reuse the same washing water multiple times, enabling cross-contamination. Some may even engage in unhygienic practices such as handling food without washing hands after urination, thereby facilitating the spread of harmful fungi and bacteria. Although fruits offer numerous health benefits, improper handling and storage conditions may increase the risk of microbial contamination. Previous studies have shown that fungal species such as *Aspergillus spp*, *Rhizopus spp*, *Penicillium spp*, *Alternaria spp*, *Rhodotorula spp*, and *Mucor spp* are frequently isolated from freshcut fruits sold under poor hygienic conditions. Some members of these fungal genera can contribute to fruit spoilage, while certain species have been associated with mycotoxin production or opportunistic infection (Tournas, 2005).

Therefore, this study aims to evaluate and compare the fungal contaminants associated with sliced watermelon (*Citrullus lanatus*) and pineapple (*Ananas comosus*) sold in selected markets within Jos South Local Government Area of Plateau State, Nigeria

MATERIALS AND METHODS

Experimental Site

This research was carried out in the Central Diagnostic Laboratory of National Veterinary Research Institute, Vom

Experimental Materials

Sliced watermelon and pineapple, sterile blade, sterile distilled water, sterile plastic bags, Sabouraud dextrose agar and Potato Flake Agar, incubator, petri-dishes, disinfectant, hand gloves, tissue, marker and masking tape. **Sample Collection**

Three (3) samples each of packaged, sliced watermelon and pineapple were randomly purchased from randomly selected street vendors in four (4) markets (Vom, Bukuru, Building Materials and Abattoir) in Jos South Local Government Area. Samples were collected in June 2023, with each market visited on two occasions, one for watermelon and the other for pineapple. A total of twentyfour (24) samples, comprising twelve (12) sliced watermelon and twelve (12) sliced pineapple samples, were collected. The samples were placed in sterile plastic bags, appropriately labelled, transported in a cooler, and taken to the laboratory within one hour of collection.

Experimental Procedure Culture media and Fungal Isolation

Sabouraud dextrose agar (SDA) and Potato Flake Agar (PFA) were prepared according to the manufacturer's instructions and used for the isolation and enumeration of fungal contaminants from the sliced fruit samples. Approximately 1 g of each fruit sample was aseptically transferred into 9 ml of sterile diluent, serially diluted. One (1) ml aliquot from the appropriate dilution was inoculated onto the prepared media using the spread plate method. The inoculation was carried out in duplicate. The inoculated plates were incubated at 25°C for five (5) days and examined daily for fungal growth. The fungal load was expressed as colonyforming units per gram (CFU/g) and calculated using the formula: CFU/g = number of colonies × dilution factor ÷ volume plated (ml). **Fungal Identification**

The fungal isolates were identified based on their macroscopic and microscopic characteristics. Macroscopic identification was based on colony appearance, colour, texture, and growth characteristics, while

microscopic examination was carried out using light microscopy to observe the nature of the hyphae, including septate and nonseptate hyphae, as well as the characteristic reproductive or fruiting structures. The observed characteristics were compared with standard morphological descriptions for fungal identification. Where species-level identification could not be established confidently from the morphological characteristics, the isolates were reported at the genus level.

Fungal colony Enumeration

Fungal colony enumeration was carried out by counting the colonies that developed on the inoculated plates, and the fungal load was expressed as colony-forming units per gram (CFU/g).

Parameters collected

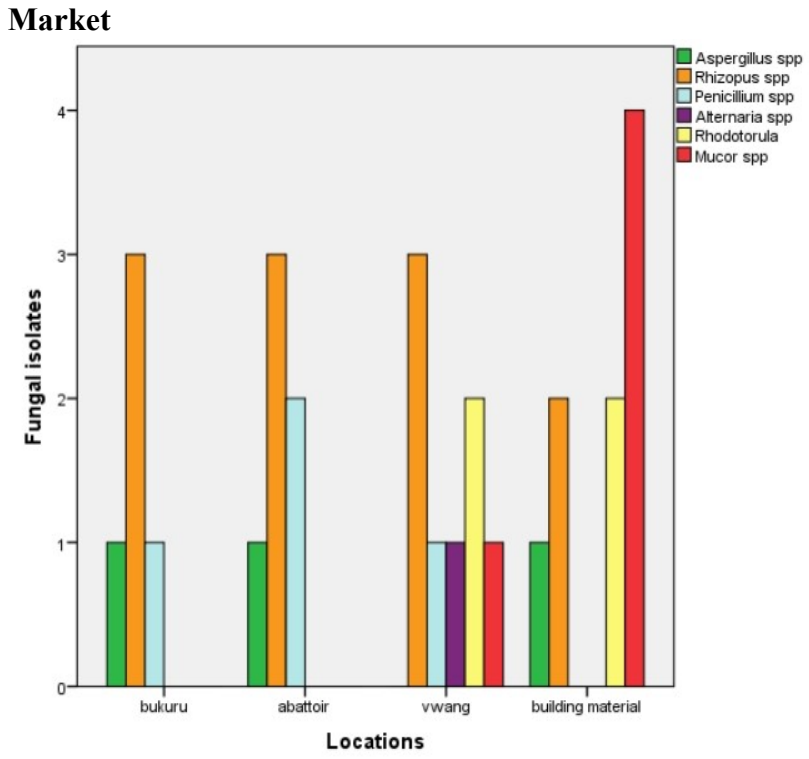
Parameters collected include: Isolation and Identification of Fungi isolates

Statistical Analysis

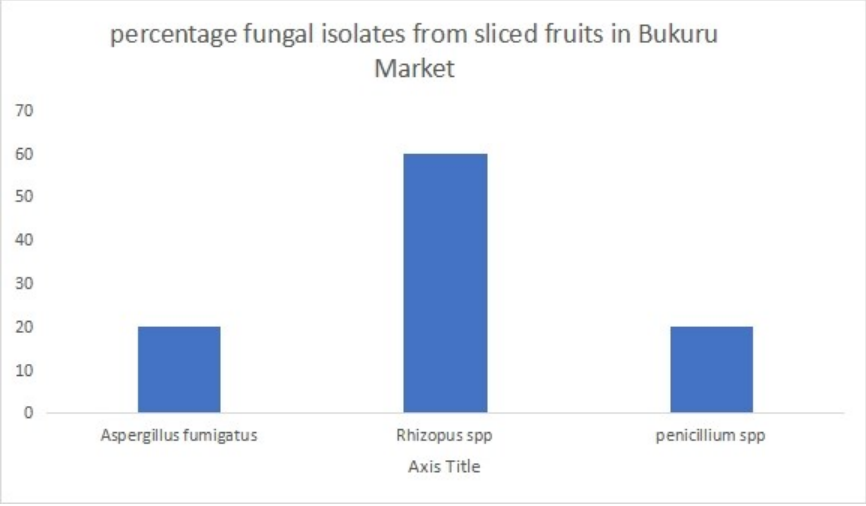
Data obtained from the study were analyzed using the Statistical Package for the Social Sciences (SPSS 23.0). Descriptive statistics, including frequencies and percentages, were used to summarize the occurrence and distribution of fungal isolates in the sliced watermelon and pineapple samples collected from the different markets. The Chi-square test was used to assess the association between fungal contamination and market, while Fisher's exact test was used where expected cell frequencies were small. Statistical significance was set at $p < 0.05$.

RESULTS

The fungal isolates recovered from the sliced watermelon and pineapple samples included *Aspergillus spp.*, *Rhizopus spp.*, *Penicillium spp.*, *Alternaria spp.*, *Rhodotorula spp.* and *Mucor spp. Mucor spp.* had the highest frequency of occurrence among the fungal isolates recorded in Building Materials market (44.44%). *Alternaria spp.* was isolated only from samples collected in Vom market, where it accounted for 12.5% of the fungal isolate occurrences. *Rhodotorula spp.* was recorded in Vom and Building Materials markets, accounting for 25.0% and 22.22% of the fungal isolate occurrences, respectively. Vom market recorded the highest diversity of fungal isolates, with five fungal genera identified.

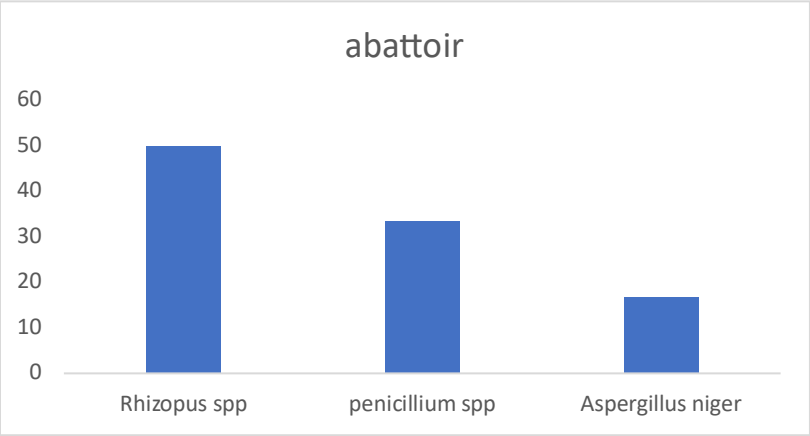


Graph 1: Shows the types of fungal contaminants present in sliced watermelon and pineapple from Bukuru, Abattoir, Vom and Building Materials markets. The fungal isolates identified were *Aspergillus spp.*, *Rhizopus spp.*, *Penicillium spp.*, *Alternaria spp.*, *Rhodotorula spp.* and *Mucor spp.*

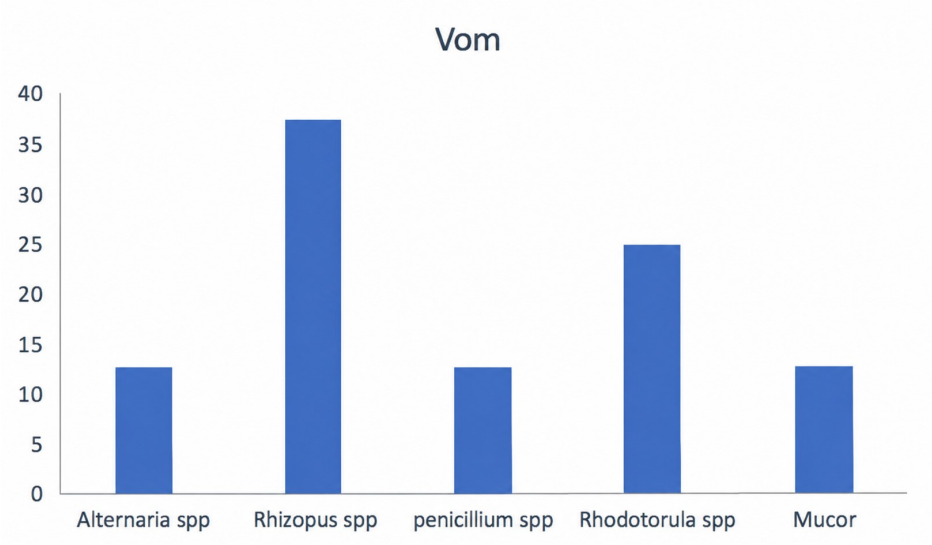


Graph 2: Shows the percentage of fungal contaminants of sliced fruits from Bukuru market. The graph shows that three fungal isolates were present in the sliced fruits from Bukuru market, which are *Aspergillus spp.*, *Rhizopus spp.* and *Penicillium spp.*, with frequencies of 20%, 60% and 20%, respectively.

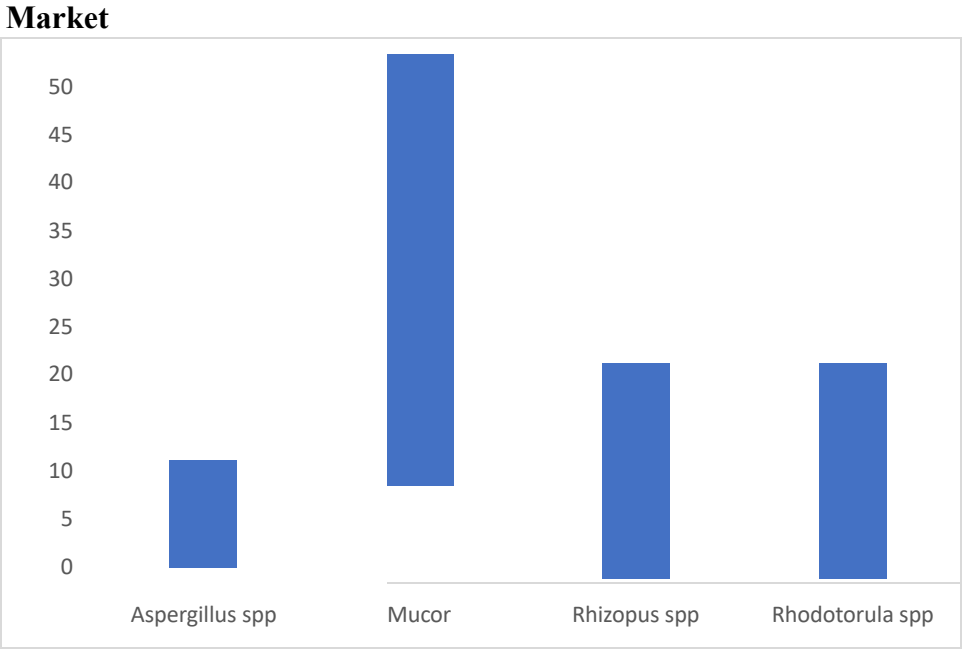
Market



Graph 3: Shows the percentage of fungal contaminants of sliced fruits from Abattoir market. The graph shows that three fungal isolates were present in the sliced fruits from Abattoir market, which are; *Rhizopus spp, Penicillium spp* and *Aspergillus spp* with frequencies of; 50%, 33.33% and 16.67% respectively.



Graph 4; Shows the percentage of fungal contaminants of sliced fruits from Vom market. The graph shows that five fungal isolates were present in the sliced fruits from Vom market, which are *Alternaria spp.*, *Rhizopus spp.*, *Penicillium spp.*, *Rhodotorula spp.* and *Mucor spp.*, with frequencies of 12.5%, 37.5%, 12.5%, 25% and 12.5%, respectively.



Graph 5: Shows the percentage of fungal contaminants of sliced fruits from Building Materials market. The graph shows that four fungal isolates were present in the sliced fruits from Building Materials market, which are *Aspergillus spp.*, *Mucor spp.*, *Rhizopus spp.* and *Rhodotorula spp.*, with frequencies of 11.11%, 44.44%, 22.22% and 22.22%, respectively.

Market

TABLE 1: Fungal counts of Sliced Watermelon and Pineapple Samples from the Four Markets

Market	Fruit	Sample	Raw count (10^{-3})	Fungal count (CFU/g)	Fungal isolate(s)
Bukuru	Watermelon	BW1	179	1.8×10^5	*Aspergillus spp.*, *Rhizopus spp.*
Bukuru	Watermelon	BW2	0	0	No fungal growth
Bukuru	Watermelon	BW3	65	6.5×10^4	*Rhizopus spp.*
Bukuru	Pineapple	BP1	12	1.2×10^4	*Rhizopus spp.*
Bukuru	Pineapple	BP2	0	0	No fungal growth
Bukuru	Pineapple	BP3	21	2.1×10^4	*Penicillium spp.*
Abattoir	Watermelon	AW1	18	1.8×10^4	*Rhizopus spp.*, *Penicillium spp.*
Abattoir	Watermelon	AW2	0	0	No fungal growth
Abattoir	Watermelon	AW3	92	9.2×10^4	*Penicillium spp.*
Abattoir	Pineapple	AP1	83	8.3×10^4	*Rhizopus spp.*
Abattoir	Pineapple	AP2	12	1.2×10^4	*Aspergillus spp.*, *Rhizopus spp.*
Abattoir	Pineapple	AP3	0	0	No fungal growth
Vom	Watermelon	VW1	21	2.1×10^4	*Alternaria spp.*, *Rhizopus spp.*
Vom	Watermelon	VW2	23	2.3×10^4	*Rhizopus spp.*
Vom	Watermelon	VW3	11	1.1×10^4	*Penicillium spp.*
Vom	Pineapple	VP1	28	2.8×10^4	*Rhodotorula spp.*, *Mucor spp.*
Vom	Pineapple	VP2	0	0	No fungal growth

Market

Market	Fruit	Sample	Raw count (10^{-3})	Fungal count (CFU/g)	Fungal isolate(s)
Vom	Pineapple	VP3	14	1.4×10^4	*Rhizopus spp.*, *Rhodotorula spp.*
Building Materials	Watermelon	BW1	19	1.9×10^4	*Aspergillus spp.*, *Mucor spp.*
Building Materials	Watermelon	BW2	82	8.2×10^4	*Rhizopus spp.*
Building Materials	Watermelon	BW3	12	1.2×10^4	*Rhizopus spp.*
Building Materials	Pineapple	BP1	19	1.9×10^4	*Rhodotorula spp.*, *Mucor spp.*
Building Materials	Pineapple	BP2	17	1.7×10^4	*Rhodotorula spp.*, *Mucor spp.*
Building Materials	Pineapple	BP3	18	1.9×10^4	*Mucor spp.*

The fungal counts of the sliced fruit samples ranged from 1.1×10^4 to 1.8×10^5 CFU/g among the fungal-positive samples. The highest fungal count was recorded in watermelon sample BW1 from Bukuru market (1.8×10^5 CFU/g), while the lowest count was recorded in watermelon sample VW3 from Vom market (1.1×10^4 CFU/g). Fungal growth was not detected in five (5) of the twenty-four (24) samples examined. The fungal counts varied among individual samples and markets, with both watermelon and pineapple samples showing detectable fungal growth.

COMPARISON OF FUNGAL CONTAMINATION IN WATERMELON AND PINEAPPLE

The results showed that fungal contamination occurred in both sliced watermelon and pineapple samples. Of the twelve (12) watermelon samples examined, ten (10) showed fungal growth, representing 83.3%, while nine (9) of the twelve (12) pineapple samples showed fungal growth, representing 75.0%. Thus, watermelon recorded a slightly higher proportion of fungal-positive samples than

Market

pineapple. However, the difference in fungal positivity between the two fruit types was not statistically significant (Fisher's exact test, $p = 1.000$).

Table 2: Distribution of Fungal-positive Sliced Fruit Samples Across the Four Markets

Market	Watermelon positive/total	Watermelon (%)	Pineapple positive/total	Pineapple (%)	Overall positive/total	Overall (%)
Bukuru	2/3	66.7	2/3	66.7	4/6	66.7
Abattoir	2/3	66.7	2/3	66.7	4/6	66.7
Vom	3/3	100.0	2/3	66.7	5/6	83.3
Building Materials	3/3	100.0	3/3	100.0	6/6	100.0
Total	**10/12**	**83.3**	**9/12**	**75.0**	**19/24**	**79.2**

The distribution of fungal-positive samples across the four markets is presented in Table 2. Of the twelve (12) watermelon samples examined, ten (10) showed fungal growth, representing 83.3%, while nine (9) of the twelve (12) pineapple samples showed fungal growth, representing 75.0%. Building Materials market recorded the highest proportion of fungal-positive samples (6/6; 100%), followed by Vom market (5/6; 83.3%), while Bukuru and Abattoir markets each recorded 4/6 (66.7%). The results therefore showed a slightly higher proportion of fungal-positive samples in watermelon than in pineapple, although the difference was not statistically significant (Fisher's exact test, $p = 1.000$).

DISCUSSION

The results of this study revealed that a variety of fungal species were isolated from sliced watermelon (*Citrullus lanatus*) and pineapple (*Ananas comosus*) obtained from different markets in Jos South Local Government Area, including Bukuru, Abattoir, Vom, and Building Materials markets. The major fungal isolates identified across the samples were *Aspergillus spp.*, *Rhizopus spp.*, *Penicillium spp.*, *Alternaria spp.*, *Rhodotorula spp.*, and *Mucor spp*. The presence of these fungal isolates indicates that sliced fruits sold in open markets are susceptible to fungal contamination. Some members of these fungal genera have been associated with mycotoxin production or opportunistic infection, highlighting the importance of appropriate hygiene and handling practices.

Market

The findings of the present study are comparable with reports of fungal contamination in ready-to-eat fruits sold in Nigerian markets. Angaye *et al.* (2024) reported fungal contamination in watermelon and pineapple sold in Yenagoa metropolis, with fungal counts varying among the different fruit types and collection sites. In the present study, fungal growth was observed in 10 of 12 (83.3%) watermelon samples and 9 of 12 (75.0%) pineapple samples, while variation was also observed among the markets. The present study also identified *Aspergillus spp.*, *Rhizopus spp.* and *Penicillium spp.*, which have been reported among fungi associated with fruit contamination. Onuorah *et al.* (2013), in a study of pineapple fruits sold in Eke Awka Market, identified *Aspergillus*, *Rhizopus* and *Penicillium* among the fungi associated with the fruits. Similarly, Oku *et al.* (2020) reported *Mucor spp.* among the fungal isolates recovered from ready-to-eat fruits sold in Yenagoa metropolis. These findings support the observation that sliced and readyto-eat fruits may harbour a variety of fungal contaminants, although the types and levels of contamination may vary according to fruit type, sampling location and study methods.

The findings showed that *Mucor spp.* had the highest frequency of occurrence among the fungal isolates recorded in the Building Materials market, accounting for 44.44% of the fungal isolate occurrences. This is

consistent with the report of Chuku and Ejechi (2019), who noted that *Mucor* species are common spoilage fungi in fruits due to their ability to grow rapidly in moist, nutrient-rich environments. Some members of the Mucorales are associated with mucormycosis, particularly in immunocompromised individuals; however, the isolation of *Mucor spp.* in the present study does not by itself establish a risk of infection (Richardson & Lass-Flörl, 2008). The high occurrence of *Mucor spp.* in the Building Materials market may be associated with handling and environmental conditions; however, specific factors such as the hygiene of cutting equipment, exposure to airborne spores, and humidity were not directly assessed in the present study.

Rhizopus species were also frequently isolated, with relatively high frequencies across the sampled markets. The predominance of Rhizopus in fruits has been reported in previous studies, as these fungi are associated with fruit spoilage and can grow rapidly on nutrient-rich substrates (Adesemoye & Adedire, 2005). *Rhizopus* species can cause soft rot, leading to rapid spoilage and deterioration of fruit texture and taste. The high contamination rate observed in both fruits may be associated with handling practices and prolonged exposure of sliced fruits to the market environment.

The occurrence of *Aspergillus* and *Penicillium* species across the markets also indicates the presence of common fungal contaminants associated with fruits. In Bukuru market, *Rhizopus spp.* recorded the highest frequency (60%), while *Aspergillus spp.* and *Penicillium spp.* each accounted for 20%. In Abattoir market, *Rhizopus spp.* remained dominant with 50%, followed by *Penicillium spp.* (33.33%) and *Aspergillus spp.* (16.67%). Some species within the genus *Aspergillus* are known to produce mycotoxins, including aflatoxins, which are important food-safety concerns (Pitt & Hocking, 2009). The detection of *Penicillium* species may be associated with storage or environmental conditions that favour fungal growth, as members of this genus can grow under moist conditions (Onuorah & Orji, 2015).

In Vom market, where five fungal genera were recorded, *Rhizopus spp.* had the highest occurrence (37.5%), followed by *Rhodotorula spp.* (25%) and equal proportions of *Alternaria spp.*, *Penicillium spp.* and *Mucor spp.* (12.5% each). The diversity of fungal isolates in this market may be associated with differences in handling practices or environmental exposure, although these factors were not directly assessed in the present study. *Rhodotorula* species, although generally considered lowvirulence organisms, can act as opportunistic pathogens in immunocompromised hosts and may also be associated with spoilage of fruits (Wirth & Goldani, 2012). *Alternaria* species, which were only isolated in Vom market, are common saprophytic fungi and some species can produce secondary metabolites such as alternariol and tenuazonic acid (Logrieco et al., 2009). Their presence may be associated with cross-contamination from soil or improper storage before slicing; however, these factors were not directly assessed in the present study.

The Building Materials market recorded four fungal genera: *Aspergillus spp.*, *Mucor spp.*, *Rhizopus spp.* and *Rhodotorula spp.*, with *Mucor spp.* having the highest frequency of occurrence (44.44%). All six samples from this market showed fungal growth, giving the market the highest proportion of fungalpositive samples (100%). The observed

contamination may be associated with environmental and handling conditions. According to Odebode and Salami (2017), open markets with poor sanitary conditions often serve as breeding grounds for fungal spores that easily settle on exposed foods.

Comparatively, Vom market recorded the highest diversity of fungal isolates, with five fungal genera identified, followed by the Building Materials market with four genera. The observed variation in fungal distribution among the markets may be associated with differences in environmental conditions, fruit sourcing and handling practices, although these factors were not directly assessed in the present study. Fruits sold in open environments may be susceptible to contamination through exposure to dust, air currents, insects and contaminated surfaces (Singh et al., 2010). In addition, slicing removes the protective outer surface of whole fruits and exposes internal tissues to the surrounding environment. These factors may contribute to the observed diversity and distribution of fungal isolates across the study sites.

The consistent detection of *Aspergillus*, *Rhizopus*, *Mucor*, and *Penicillium* species across selected markets underscores the public health concern posed by consuming ready-to-eat sliced fruits sold under unhygienic conditions. The fungal isolates identified in the present study are consistent with the occurrence of several fungal genera commonly associated with fruit contamination and spoilage. In summary, the variations observed in fungal distribution among the different markets may be influenced by environmental factors, sanitation levels, and the hygienic practices of fruit vendors. These findings highlight the importance of appropriate hygiene and handling practices during the preparation, display and sale of sliced fruits.

CONCLUSION AND RECOMMENDATION CONCLUSION

This study showed that ready-to-eat sliced watermelon and pineapple sold in selected markets in Jos South Local Government Area were contaminated with a variety of fungal isolates, including *Aspergillus spp.*, *Rhizopus spp.*, *Mucor spp.*, *Penicillium spp.*, *Rhodotorula spp.* and *Alternaria spp.* Fungal growth was observed in 10 of 12 (83.3%) watermelon samples and 9 of 12 (75.0%) pineapple samples, although the difference between the two fruit types was not statistically significant. Building Materials market recorded the highest proportion of fungal-positive samples (100%), while Vom market recorded the highest diversity of fungal isolates. The findings indicate the occurrence of fungal contamination in the sampled sliced fruits. The high contamination levels observed may be associated with handling, exposure to open environments, and storage conditions.

Some members of the fungal genera identified have been associated with mycotoxin production or opportunistic infection; however, the present study did not assess mycotoxin production or pathogenicity.

RECOMMENDATIONS

Based on the findings of this study, fruit vendors should maintain good hygiene during the preparation and sale of sliced fruits, including the use of clean utensils and safe water for washing fruits and equipment. Sliced fruits should be stored and displayed in clean, covered containers to minimize unnecessary exposure to the market environment. Fruit handlers and vendors should receive appropriate food-safety education on hygienic fruit preparation, handling and storage practices. Regular

sanitation of market environments and proper waste disposal should be encouraged to improve general food-hygiene conditions.

Relevant government agencies and health

monitoring and organize training programmes for vendors involved in the preparation and sale of ready-to-eat fruits. Consumers should be encouraged to purchase sliced fruits from vendors who maintain good hygiene and appropriate storage practices.
authorities should strengthen food-hygiene

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