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Research Article

Evaluation of fungi contamination of fruits and vegetables

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Background: The study investigated fruit and vegetable contamination by fungi in Abia State's three senatorial zones. That was being studied experimentally.

Methods: Based on the appearance, structure, and features of the colonies, the microbial content of 360 sample sizes of fruits and vegetables were gathered from various markets throughout the state.

Results: Five different fungal isolates showed different levels of prevalence.: *Aspergillus niger, Aspergillus flavus, Fusarium Solani, Rhizopus stolonifer* and *Penicillium citrinum. Aspergillus niger* and *Fusarium Solani* had the broadest distribution as they were isolated from the three zones and in five markets except Ekeamiyi Market: *Aspergillus niger* was the most prevalent among the samples analysed. *Aspergillus flavus* was the highest occurring in Abia South (38%), *Aspergillus niger* was most prevalent in Abia central (35%) and North (28%) occurrence rates. *Fusarium Solani* was the second most prevalent in Abia central and South (24%) and (25%) occurrence in samples analysed. *Penicillium citrinum* was the second highest prevalent isolate in Abia North (23%) but was the last in the zone (8%) in South. *Rhizopus stolonifer* was highest in South (19%) and least in South (12%).

Conclusion: There was no significant statistical difference in occurrence of fungal isolates in the three Senatorial zones of Abia State.

Keywords: *fungi, contamination, fruits, vegetables, Abia state*

Introduction

Fruits and vegetables are important sources of crucial nutrients that are necessary for human growth and development, including vitamins, minerals, and easily utilisable carbohydrates (Daphey et al., 2023). These nutrients have advantages for health, such as preventing diet-related shortages, lowering the chance of developing chronic illnesses, and aiding in the body's detoxification process (Shola et al., 2022). Vegetables and fruits support healthy living worldwide. Fruits and vegetables represent a diverse group of plant foods that differ significantly in terms of their nutritional and energy content (Vincent et al., 2022). Additionally, fibre is found in fruits and vegetables, and consuming them is linked to a decreased risk of obesity and cardiovascular disease. In addition to adding vitamins and minerals to the diet, fruits and vegetables are also good sources of phytochemicals, which act as anti-inflammatory and antioxidant agents and sometimes support defence processes (Bahir et al., 2020). Due to high concentrations of vitamins, especially C and A; minerals, especially electrolytes; and extra phytochemicals, especially antioxidants, fruits and vegetables normally govern a portion of the diet (Ezenwaka & Amuzie, 2020). Nigeria is endowed with a climate and seasons that are conducive to the growth of a wide variety of fruits and vegetables. They are inexpensive, easily obtainable, and available to clients right now. In comparison, tropical fruits and vegetables are offered for sale as prepared items in synthetic resin luggage or as complete meals. Remarkably, high patronage has led to the proliferation of ready-to-eat sliced fruit and vegetables in Nigeria and other developing nations; many of these fruits and vegetables are not cleaned

before consumption. The majority of vendors don't care about personal hygiene, therefore they occasionally use filthy packaging bags, wash or moisten their items in non-potable water, expose their goods to bad environments, and contaminate the air (Onuorah & Orji, 2015). The rise of enteric infections as a result of contaminated fruits and vegetables cannot be overstated, which has prompted researchers to look into the microbic safety profile of fruits and vegetables sold in marketsEnteric infections are becoming more common in both industrialised and developing nations as a result of eating more raw foods, especially salads from markets, chopped fruits and vegetables, and sprouts. Microbe contamination of fruits and vegetables can happen throughout any step of handling, including growing, harvesting, transporting, processing, packing, and even eating (Rabiu et al., 2021). Its contamination is mostly caused by things like using tainted wash water and utensils and the untidy environment (markets). In addition to the direct interaction with dust particles in the air, the open display of fruits in markets during handling and processing may stimulate frequent visits by flies and other disease vectors.

Materials and Methods

Collection of Samples

A total of 180 fruits and 180 vegetable samples (5 different types of fruits and vegetables from each market) were collected in sterile bags from 6 open markets (2 markets from each senatorial zone). The markets are; Eke-Amiyi and Eke Elu (Abia North), Ubani Central market and Orie Ntigha (Abia Central), Ahiaohuru and Ariaria (Abia North). The fruit samples were Guava (*Psidium guajava*), Orange (*Citrus sinensis*), Lemon (*Citrus limon*), Apple (*Malus domestica*) and Mango (*Mangifera indica*) while the vegetable samples were Waterleaf (*Talinium triangulare*), Fluted pumpkin (*Telfairia occidentalis*), Carrot (*Daucus carota*), Cabbage (*Brassica oleracea*) and Eggplant (*Solanum melongena*). The samples were immediately taken to the microbiology laboratory for analysis.

Microbial Analysis

Preparation of materials

The media were sterilized to avoid contamination from media: glassware, petri-dishes, test tubes, pipettes, flasks and bottles were all sterilized in a hot oven at 170^0C for two hours and distilled water sterilized by autoclaving for 15mins at 121^0C.

Isolation and identification

Ten (10) grams of the selected raw vegetables and fruits each were measured and finely chopped aseptically. They were then enriched in sterile sabouraud dextrose broth for twenty four hours. Ten- fold serial dilutions of the samples were thereafter carried out and pour plate method was used for inoculation. One ml of the serially-diluted sample (10^4) was dispensed into a conical flask containing sterile sabouraud dextrose agar (SDA) and two percent chloramphenicol to inhibit bacterial growth. The contents were properly mixed and dispensed aseptically into sterile petri-dishes. Incubation was carried out in an inverted position at 28^oC for five days. The colonies that developed were counted and sub-cultured repeatedly on Sabouraud Dextrose Agar plates to obtain pure cultures. They were later stored on SDA slants for characterization and identification (Orji et al., 2016). The pure cultures of the fungi were identified on the basis of their colony growth pattern, conidial morphology and pigmentation using the slide culture technique and microscopic examination.

Results

Table 1. Identification of fungal isolates

Colony Characteristics	Microscopic Features	Isolate
Compact clusters of dark colonies	Septate hyphae with dark walled conidia and hyaline conidiophore	*Aspergillus niger*
Greenish-yellow and hairy elevated surface	Long conidiophores with septate hyphae	*Aspergillus flavus*
Oval shaped	Thickwalled conidia with septate hyphae	*Fusarium solani*
Clustered whitish surface	Sporangia with non-septate hyphae	*Rhizopus stolonifer*
Blue green colony at the surface with yellow colour at reverse side	Conidiophores with branches	*Penicillium citrinum*

Figure 1 displays fungal counts from fruit samples. Highest counts were observed in isolates from oranges bought at Ahiaohuru market with a count of 4.5 X 10^4. In contrast to the high count observed in oranges at Ahiaohuru, fungal counts in oranges from Orie Ntigha had the lowest counts together with counts from apple from Ariaria market (1.8 X 10^4).

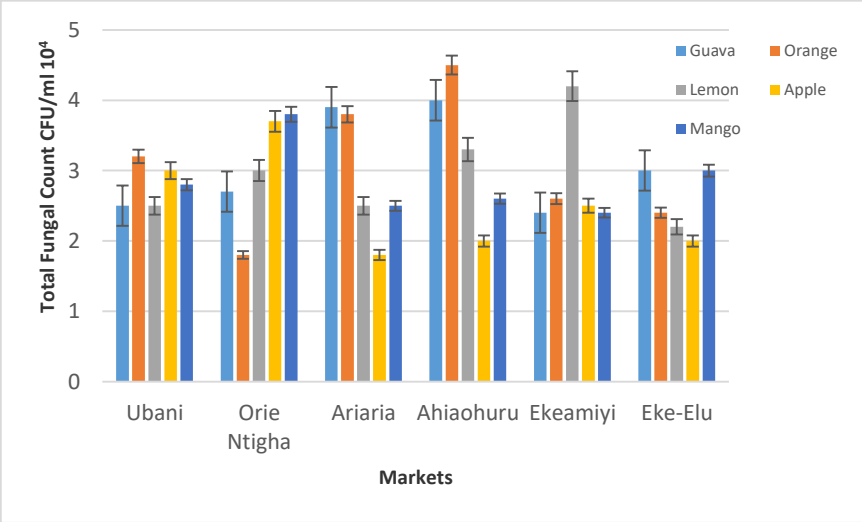

Figure 1. Total fungal (viable plates count) of fruit samples (CFU/ml X 10^4)

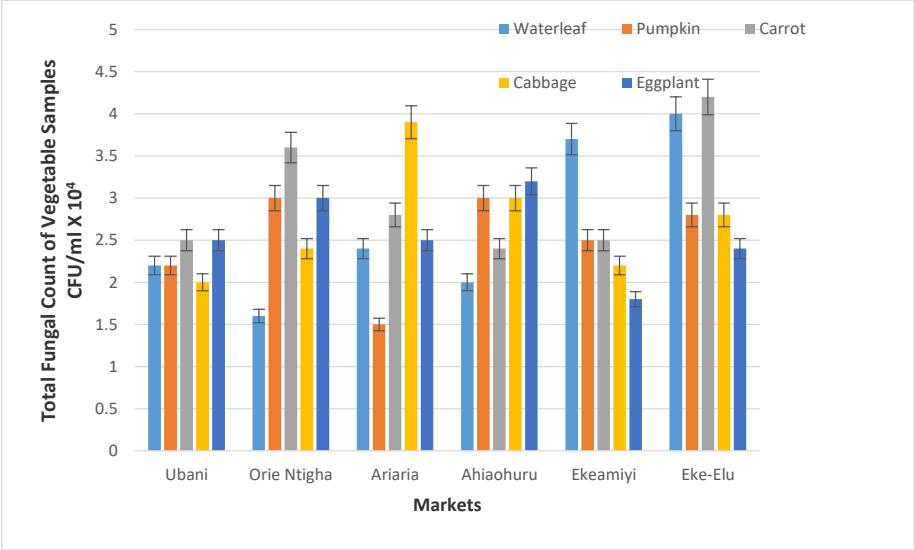

Figure 2. Total fungal (viable plate) of vegetable samples (CFU/ml X 10^4)

Figure 2 displays the average fungal count in fruits from markets analysed in the three senatorial zones of Abia State. Highest mean counts were observed in Abia south zone with a count of 4.2 from orange samples. High counts were also observed from guava fruits in Abia South (3.9) lowest mean counts were observed in apple samples from same Abia south zone (1.9).

Identification of Fungal isolates in the three senatorial zones

Fungal isolates were identified using colony characteristics and microscopic features. Fungi identified were *Aspergillus niger*, *Fusarium solani*, *Aspergillus flavus*, *Penicillium citrinum* and *Rhizopus stolonifer*.

Percentage occurrence of fungal isolates in the three senatorial zones

Figure 3 displays the percentage occurrence of fungal isolates in Abia Central Senatorial zone. *Aspergillus niger* was the highest occurring with 35% occurrence. It was followed by *Fusarium solani (24%). Penicillium citrinum* was the least

occurring (12%). There was significant statistical difference among fungal isolates from samples analysed in Abia Central. *Aspergillus flavus* 15%, *Rhizopus stolonifer* 19%.

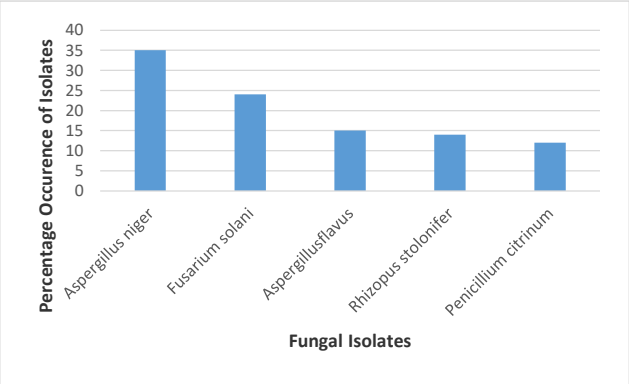

Figure 3. Percentage occurrence of fungal isolates in fruit and vegetable samples in Abia Central Senatorial Zone

Figure 4 displays occurrence of fungal isolates from fruit and vegetable samples in Abia South zone. *Aspergillus flavus* was the highest occurring (38%). The other isolates had an occurrence percentage of; *Fusarium solani* (25%), *Aspergillus niger* (17%), *Rhizopus stolonifer* (12%) and *Penicillium citrinum* (8%). There was significant difference in the occurrence of the isolates.

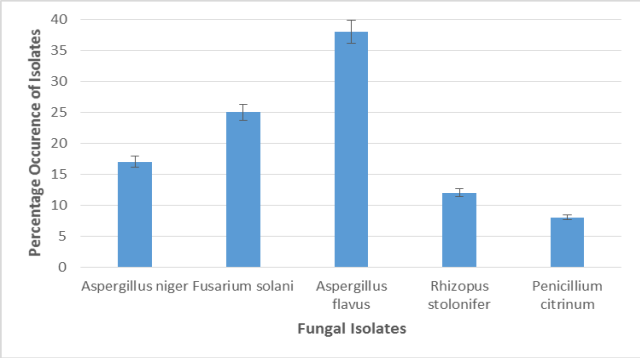

Figure 4. Percentage occurrence of fungal isolates in fruit and vegetable samples in Abia South Senatorial Zone

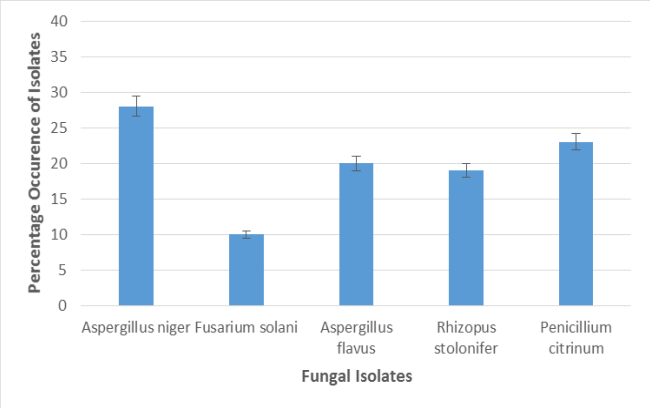

Figure 5. Percentage occurrence of fungal isolates in fruit and vegetable samples in Abia North Senatorial Zone

From figure 5, it is observed that *Aspergillus niger* was the highest occurring fungal isolate (28%) while *Fusarium solani* was the least occurring (10%) from analysed samples from Abia North. There was statistical significant difference in the occurrence of the isolated fungi species, *Aspergillus flavus 20%, Rhizopus stolonifer 19% and Penicillium ctrinum 23%.*

Comparative occurrence of fungal isolates in the three Senatorial Zones

The five fungal isolates displayed different prevalent rates in the fruit and vegetable samples analysed across markets in the three senatorial zones of Abia State. Figure 4.6 displays the comparative occurrence of fungal isolates in the three

zones. *Aspergillus flavus* was the highest occurring isolate in a zone with 38% prevalence in Abia South. *Aspergillus niger* was most prevalent in markets in Abia Central And Abia North with 35% and 28% occurrence rates. *Fusarium solani* was the second most prevalent in Abia Central and Abia South with 24% and 25% occurrence respectively in samples analysed. *Penicilium citrinum* was the second highest prevalent isolate in Abia North with 23% occurrence but it was the least occurring in a zone with 8% prevalence in Abia South. *Rhizopus stolonifer* had its highest prevalence in Abia north(19%) and its least in Abia South (12%). There was no significant statistical difference in the occurrence of the fungal isolates in the three senatorial zones.

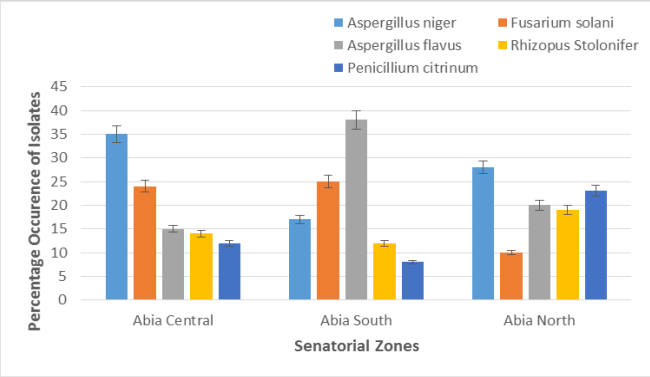

Figure 6. Comparative percentage occurrence of fungal isolates in the three senatorial zones

Discussion

Poorly washed or unwashed fruits and vegetables in Abia State has been identified to contain fungal organism which when consumed are detrimental to the health of the people. This study isolated from fruits and vegetables sold in the markets in Abia State the following fungal species: *Aspergillus niger*, *Aspergillus flavus*, *Fusarium solani*, *Rhizopus stolonifer* and *Penicillium citrinum*, the finding is in consonance with the findings of Chowadappa & Kumar (2012) in Kano metropolis, Nigeria. Mohammed et al., (2016) in Makurdi and Otukpo, Benue State. Highest fungal counts were observed in orange samples from Ahiaohuru market which attested to poor sanitation. Aspergillus niger was the most prevalent fungal isolate amongst the samples analysed. *Aspergillus flavus* was the highest occurring fungi isolate in Abia South markets. This high occurrence of *Aspergillus* sp. was similar to findings by Obebe et al., (2020) in Otuke Ogbia Bayelsa, Nigeria. Presence of *Fusarium solani* was similar to findings by Serra et al., (2011). Also isolated *Rhizopus stolonifer* and *Penicillium* sp. from oranges and tomatoes. Comparatively, *Aspergillus niger* was the most prevalent isolate in Abia central and Abia north zones while *Aspergillus flavus* was most prevalent in Abia south zone. *Fusarium solani* was the second most prevalent in Abia Central and Abia South in the samples analysed. *Penicilium citrinum* was the second highest prevalent isolate in Abia North but had the lowest prevalence in Abia south. The presence of *Aspergillus niger* and *Aspergillus flavus* which cause Aspergillosis is a health concern especially for immunocompromised individuals where they can cuase serious lung infections. *Aspergillus flavus* also produces aflatoxin, a mycotoxin which is carcinogenic. *Fusarium* sp. have been reported to produce mycotoxins which cause toxic effects on animals and humans in Kwara Central, Nigeria (Bekele et al., 2017). The isolated fungi cause spoilage in fruits and vegetables hence reducing their economic value (Karshima, 2018; LI et al., 2020).

Conclusion

In addition to poor vendor hygiene, fruits and vegetables are typically exhibited on unclean tabletops and the ground, and they are often cleaned with tainted water. Fruits and vegetables are constantly contaminated by fungi due to these reasons. Another way that fungi can contaminate crops is by using tainted water when growing fruits and vegetables. In order to inform the public about the health dangers connected with eating infected fruits and vegetables as well as strategies to avoid contamination, public health professionals and the state government should develop awareness programmes.

Author contributions

Uka-Okali Angela Juliet: original draft writing, methodology, Ozims, Stanley James: conceptualization, Eberendu, I.F; investigation, formal analysis, methodology, Supervision, validation. Uka Kalu Okali ;software, investigation and Kalu Joy; data curation.

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Conflict of interest

The author declares no conflict of interest. The manuscript has not been submitted for publication in other journal.

Ethics approval

Not applicable

Competing Interests

The author declares no conflict of interest. The manuscript has not been submitted for publication in other journal.

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