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FUNGAL CONTAMINATION OF DRIED TOMATO CHIPS SOLD IN MAKURDI MARKETS, NIGERIA

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ABSTRACT
Dried tomato chips are quite popular in Nigeria for their culinary uses but their vulnerability to fungal contamination represents a mycotoxicological food risk. The study isolated and identified the fungi associated with the contamination of dried tomato chips sold in Makurdi markets in Nigeria. A total of sixty (60) dried tomato chips were gotten from Wurukum, Wadata and Modern market from which the fungi colonies were isolated and characterized using standard cultural, morphological and microscopic procedures. Out of the 60 samples analysed, fifty five (55) yielded positive fungi growth across five distinct species, while five (5) samples showed no detectable fungi growth. The fungi isolated were; *Rhizopus stolonifer, Aspergillus flavus, Aspergillus niger, Aspergillus ochraceus* and *Trichosporon mucoides*. *Rhizopus stolonife*r was observed as the most occurring fungus with the occurrence of 22 representing 40 % of the total fungi occurrence, this was followed by *Aspergillus niger* 15(27.27%), *Aspergillus flavus* 8(14.56 %), *Aspergillus ochraceus* 6(10.91 %) and *Trichosporon mucoides* 4(7.27 %) which was the least occurring fungus. A highly significant occurrence was observed in relation to the fungal isolates ($\chi 2 = 36.200$; df = 4; $p = 0.000$). The samples from wadata market were observed to have slightly higher fungal load than the other locations; no significant difference was however observed ($p > 0.05$). It is highly recommended that tomato processors and vendors should adopt elevated solar drying, storing of chips in hermetic moisture-proof containers to replace open-air market displays.

Keywords: Fungal, contamination, dried tomato, chips, market

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1.0 INTRODUCTION

Tomato (*Solanum lycopersicum*) is a vegetable that is renowned and widely consumed in various parts of the world (Kumar *et al.,* 2020). It is consumed for its rich nutrient composition and its notable well-balanced diet. Sugars, minerals, essential amino acids, vitamins and dietary fibers are some of the nutritive components that can be added to the body through the consumption of tomato fruits (Anđelini *et al*., 2023). Tomato has several uses as it can be consumed as cooked or raw as the case may be and is used in making soup, juice ketchup among others (Wu and Nelson, 2023).

Sun drying is one of the oldest means of preservation known to man (Knorr and Augustin, 2023). However, in Nigeria sun drying is often done in the open using unhygienic surfaces and oftentimes the tomato fruits are exposed to another form of attack microbial contamination while trying to reduce the moisture content through sun drying (Arah *et al.,* 2015). Fungal contaminants play a big role in the rendering tomato unsafe for consumption and is said to be the major causes of spoilage of tomato (Sola *et al.,* 2022). Several fungi are said to induce spoilage in tomato such as: *Aspergillus spp, Rhizopus stolonifer, Penicillium spp, Geotrichum spp, Trichoderma spp, Mucor spp* among others (Sola *et al.,* 2022, Saini, 2018).

Spoilage of tomatoes induced by fungal infection has been reported to be recognized as a source of possible health threat to both humans and animals (Abubakar *et al.,* 2019). This is because they produce mycotoxins, which upon ingestion or inhalation are capable of causing mycotoxicoses (Omotayo *et al.,* 2019). The infections by mycotoxins are diverse; they rapidly diffuse and contaminate all parts of the fruit, rendering them flabby for consumption. Curtailing these threats requires the water activity of the tomato fruit to be reduced by drying; and is one of the oldest and the most common forms of food preservation (Ode *et al*., 2025). There are several studies on microbial spoilage of tomatoes but few studies on the microbial spoilage of dried tomatoes chips in a low-income city as Makurdi metropolis. As such, there is need to assess the fungi associated with their spoilage.

Consumption of tomato chips infested with fungal contaminants can pose a significant health risk as fungi produce mycotoxins that upon consumption can lead to mycotoxicoses (Amadi *et al*., 2019). Therefore, this study sought to assess the fungi associated with dried tomato chips in Makurdi markets with the aim of isolating, identifying and determining the incidence of fungi from sampled dried tomato chips.

2.0 MATERIAL AND METHODS

2.1 STUDY AREA

Makurdi town is located in Makurdi local government area of Benue state, Nigeria. Makurdi is the state capital. Makurdi town is located between latitude 6^0 25ˆN and 8^0 8ˆN of the equator and longitude 7^0 45ˆE and 10^0 0ˆE of the Greenwich Meridian. It shares boundaries with Guma Local Government North East, Gwer to the South, Gwer-West to the West and Doma Local Government Area of Nasarawa State to the North-West. Makurdi falls within the tropical humid and mega thermal climate. The climate is characterized by wet and dry seasons. The wet season lasts from April to October while the dry season starts in November and ends in March, this variation in season has effect on vegetation (Ikye-Tor *et al.*, 2020).

2.2 SAMPLE COLLECTION

A total of 60 samples of dried processed tomato were collected from three major markets in Makurdi metropolis namely: Wadata, Wurukum, and Modern markets. About twenty (20) samples each were randomly bought from each market. The dried processed tomato was collected separately in polythene bags, properly labeled and were taken to the Plant Science and Biotechnology Laboratory of the Department of Biological sciences, Rev. Fr. Moses Orshio Adasu University, Makurdi for analysis.

2.3 PREPARATION OF CULTURE MEDIA

2.3.1 PREPARATION OF SABAURAUD DEXTROSE AGAR (SDA) AND POTATO DEXTROSE AGAR (PDA)

The medium that was used for isolation of fungal microorganisms was Sabauraud Dextrose Agar (SDA) and Potato Dextrose Agar (PDA). SDA and PDA were both prepared according to the manufacturer's instructions. The solution was heated on a heating mantle to dissolve the medium completely. The medium was sterilized by autoclaving at 121 °C at 15 Ibs pressure for 15 minutes. After sterilization, 4 mL of chloramphenicol (25 mg/mL) was added aseptically per 1000 mL (after the medium has cooled) of the molten SDA and PDA to inhibit the growth of bacteria before being poured into sterile Petri dishes (Fru *et al*., 2025).

2.4 ISOLATION OF FUNGI

Dilution plating method was used for isolation of fungi in this study. About 1g of the dried tomato chip was sterilized with ethanol and mixed with 10 mL of sterile distilled water. The mixture was thoroughly shaken, and 1 mL of suspension was pipetted into the sterile test tube containing 9 mL of distilled water and thoroughly mixed. The sample was serially diluted and 1 mL of aliquots of 10^4 and 10^5 was added to molten SDA plates. The plates were swirled gently to obtain a thorough mixing and was allowed to solidify and was incubated at room temperature for 3-5 days. The fungal colonies were counted. Successive emplace of the tip was transferred until a pure culture of each fungus was obtained (Ode *et al.,* 2024).

2.5 IDENTIFICATION OF FUNGI

After incubation for 3-5 days, morphology of fungi was macroscopically studied by observing the features of the colony growth pattern, conidial morphology and pigmentation. A portion of the aerial mycelium (hyphae) was picked using a sterile inoculating needle, portion of each mycelial colony was aseptically taken and placed on a clean microscopic slide and teased on a slide. It was viewed under light microscope using x10 objective lens and then x40 to detect hyphae, spores and other fungal structures. Staining was done using lactophenol cotton blue and observed under a compound microscope for the arrangement of spores, conidiophores, and conidia. The observed characteristics of the fungi were compared with standard text for identification by Li *et al.* (2023).

2.6 DATA ANALYSIS

The data generated in the study was subjected to descriptive statistics. Chi square statistical test was used to analyze the data with statistical significance established at $P<0.05$.

3.0 RESULTS

In this study, the fungal contamination of dried tomatoes chips sold in Makurdi markets was investigated.

Table 1 shows the fungi isolated from the dried tomatoes chips sold in Makurdi metropolis. Five fungal isolated were observed which include *Rhizopus stolonifer, Aspergillus flavus, Aspergillus niger, Aspergillus ochraceus* and *Trichosporon mucoides*. *Rhizopus stolonifer* was observed as the most occurring fungus with the occurrence of 22 representing 40 % of the total fungi occurrence. This was followed by *Aspergillus niger* 15(27.27 %), *Aspergillus flavus* 8(14.56 %), *Aspergillus ochraceus* 6(10.91 %) and *Trichosporon mucoides* 4(7.27 %) which was the least occurring fungus. A highly significant occurrence was observed in relation to the fungal isolates (χ^2= 36.200; df = 4; p = 0.000). Although 60 samples were bought from the market, five samples were not contamination with fungi.

Table 1: Fungi isolated from dried and store tomato chips sold in Makurdi markets, Benue State.

S/N	Fungal isolates	Occurrence	% Occurrence
1	*Rhizopus stolonifer*	22	40.00
2	*Aspergillus flavus*	8	14.56
3	*Aspergillus niger*	15	27.27
4	*Aspergillus ochraceus*	6	10.91
5	*Trichosporon mucoides*	4	7.27
	Total	55	100

χ^2=36.200; df=4; P=0.000

Table 2 shows the distribution of fungal isolates isolated among the sampled markets in Makurdi. The highest fungal occurrence was observed in Wurukum market 21(38.18 %) followed by Modern market 18(32.73 %) and Wadata Market 16(29.09 %). *Rhizopus stolonifer* and *Aspergillus niger* were observed in all markets, while *Trichosporon mucoides* was observed only in samples from Modern markets. *Aspergillus flavus* was observed in Modern market and Wurukum market while it was absent in Wadata. There was no significant relationship between fungal occurrence and isolates (χ^2 =1.220; df = 2; p = 0.543).

Table 2: Distribution of fungal isolates among the sampled markets in Makurdi.

Fungal isolates	Modern market	Wurukum market	Wadata market	Total
Rhizopus stolonifer	8	8	6	22
Aspergillus flavus	1	7	0	8
Aspergillus niger	5	2	8	15
Aspergillus ochraceus	0	4	2	6
Trichosporon mucoides	4	0	0	4
Total	18(32.73)	21(38.18)	16 (29.09)	55 (100)

χ^2=1.220; df=2; P=0.543

Table 3 shows the total number of fungal isolates from dried tomato chips sold in Makurdi Metropolis. The highest plate count was observed wadata market (3.80 ± 1.30) followed by Wurkum market (2.20 ± 2.28) and Modern market (1.60 ±0.89) which was the least. There was no significant difference observed (P > 0.05)

Table 3: Total Plate Count of fungal Isolates from Dried Tomato Chips sold in Makurdi

Location	Total Plate Count
Wadata Market	3.80 ± 1.30
Modern Market	1.60 ± 0.89
Wurukum Market	2.20 ± 2.28
FLSD (0.05)	NS

***Values are Mean ± Standard Deviation**
NS = No Significant Difference

4.0 DISCUSSION

This study was conducted to assess the fungal contamination of dried and stored tomatoes chips sold in Makurdi markets. Five fungal species were isolated which include *Rhizopus stolonifer, Aspergillus flavus, Aspergillus niger, Aspergillus ochraceus* and *Trichosporon mucoides* with *Rhizopus stolonifer* as the most occurring fungus. In Sokoto Metropolis Nigeria, Aliyu *et al*. (2018) observed *Aspergillus oryzae* as the most occurring fungi in dried tomato chips. On the other hand, Shinkafi *et al*. (2020) in their study reported *Aspergillus niger* as the most occurring fungus associated with dried tomato chips in Gusau, Zamfara State, Nigeria. The difference in the findings could be due to the difference in location (Suleiman *et al.,* 2023). Furthermore, the procedures used for the processing of the dried tomatoes, as well as the level of hygiene observed may differ among the farmers and vendors. The duration and storage facilities used, as well as the moisture level during storage are also probable factors that can affect the abundance of fungi in stored food products (Mohapatra *et al.,* 2017). These fungi identified in this study if present in abundance, could lead to mycotoxins production which may produce a wide range of harmful effects in both humans and animals (Omotayo *et al.,* 2019).

Three distinct species of *Aspergillus* (*A. flavus, A. niger* and *A. ochraceus*) were isolated in this study which represents a notable food safety risk. *Aspergillus flavus* for example has been well-established as an aflatoxin producer fungi (AFB_1 and AFB_2) (Benkerroum, 2020). Therefore, in regions like Makurdi where dried tomato serve as a requirement for soup making, consuming dried tomato infested with aflatoxin in lethal concentrations will eventually lead to hepatocellular carcinoma (Wennd *et al.,* 2023). The presence of *A. niger* and *A. ochraceus* introduces the risk of ochratoxin (OTA) contamination (Akotowanou *et al.,* 2023). It is worth noting that both aflatoxins and ochratoxin are chemically resilient polyketide molecules that resist thermal degradation during cooking (Nazareth *et al.,* 2024). The presence of these toxic moulds could result in chemical hazards even after thermal preparation. *Rhizopus stolonifer* although not a mycotoxin producer often leads to post–harvest rot. *Rhizopus stolonifer* creates the necessary environment for successful secondary colonization by secondary mycotoxinegic moulds like *A. flavus* (Awuchi *et al.,* 2021). *Trichosporon mucoides* is an opportunistic fungi which invades immunocompromised host. The presence of this fungi in dried tomato could be due to unhygienic wash water and soil contact during drying (Omorodion and Obiobu, 2025).

It was observed in this study that, the fungi isolated were not evenly distributed across the sampling locations. Higher fungal occurrence was observed in Wurukum market followed by Modern market and Wadata Market respectively. A similar result was also reported by Shinkafi *et al*. (2020). The difference in distribution of fungi across the markets could be due to differences in the environmental/weather conditions of the locations of respective markets. The high water activity of tomato, condition of storage, mode of handling, as well as the quality of the fruit could be the determinant of spoilage by fungi; thus, a great source of mycotoxin contamination (Liu *et al.*, 2020).

The highest plate count was observed in Wadata market followed by Wurkum market and Modern market which was the lowest. This finding agrees with that of Abubakar *et al.* (2019) that suggested markets having the highest plate count may be as a result of handling and processing of the tomato fruits in improper ways. Wadata and Wurukum markets are often times characterized by vehicle exhaust dust and also proximity to open gutters which could also be among the contributing factors to the fungi presence.

The result also revealed that the initial sixty (60) sample collected yielded a total of fifty-five (55) fungi isolates. This is because five (5) samples displayed absence of viable fungal colony growth. The absence of fungi growth among the five (5) samples in this study

could be attributed to intense sun drying which could have lowered the water activity below the requirement needed for spore germination (Omorodion and Obiobu, 2025).

5.0 CONCLUSION

The study showed that, *Aspergillus niger, Aspergillus flavus, Aspergillus ochraceus, Trichosporon mucoides, and Rhizopus stolonifer,* were the fungi isolated from the dried tomato chips and *Rhizopus stolonifer* was the most occurring fungus with the occurrence of 22 representing 40% of total fungi occurrence

6.0 RECOMMENDATIONS

i. Farmers and marketers should transition from the traditional ground drying methods into solar dryers and elevated mesh racks.
ii. Retailers in Wurukum, Wadata and Modern markets should avoid storing dried tomato chips in woven jutes and open-polyethene bags which allow hydroscopic moisture uptake to use of hermatic storage liners.

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