Original Article

MYCOTIC CONTAMINATION OF GROUNDNUT (*Arachis hypogaea*) SEEDS IN MAKURDI, NIGERIA AND ITS EFFECTS ON THE PROXIMATE COMPOSITION

Patrick Ije Ode[1]* Ibrahim Mohammed[2]; Elizabeth Odije Ogbogo[1] Cephas Iye Owina[1] and Daniel Ikpe Acha[3]

[1]Department of Biological Sciences, Faculty of Science, Rev. Fr. Moses Orshio Adasu University Makurdi, Nigeria.
[2]Genomic and Molecular Laboratory, Kano Independent Research Centre Trust, Kano State, Nigeria.
[3]Department of Biochemistry, Bayero University, Kano, Nigeria.

ABSTRACT

Groundnut (Arachis hypogaea) is a vital nutrient-dense legume widely consumed in Nigeria, yet highly susceptible to post-harvest mycotic deterioration. This study investigated the fungal contamination of stored groundnut seeds in Makurdi, and evaluated its impact on the seed proximate composition. Groundnut samples were collected from Wurukum Market, Makurdi. Fungal contaminants were isolated using the standard Blotter Method, and identified based on morphological characteristics. Healthy seeds were artificially inoculated with pure isolates, and proximate parameters were determined using standard methods of Association of Official Analytical chemist (AOAC), and compared via ANOVA ($p < 0.05$). Four fungal species were identified: Alternaria sp. (45.00%), Aspergillus niger (30.00%), Aspergillus flavus (15.00%), and Phytophthora species. (10.00%). Fungal infection was observed to cause significant nutritional degradation across all isolates ($p < 0.05$). Compared to healthy control seeds, infected seeds exhibited significant reductions in crude fat (from 7.27% to 1.80–4.02%), crude protein (from 21.60% to 7.24–9.82%), crude fibre (from 1.13% to 0.46–0.60%), and ash content. Conversely, moisture content (8.36–10.07% vs. 3.64%) and carbohydrate content (75.83–77.42% vs. 62.64%) increased significantly in infected seeds. The Principal Component Analysis (PCA) showed that PC1 (84.58%) and PC2 (11.75%) together accounted for 96.34% of the total variance. This study showed that, mycotic contamination severely impairs the nutritional and commercial value of stored groundnuts by depleting essential lipids and proteins. To preserve nutritional quality and safeguard consumer health, improved post-harvest handling, adequate drying, and hygienic storage practices are strongly recommended.

KEYWORDS: Arachis hypogaea, Fungal Deterioration, Proximate Composition, Storage Fungi.

Open Access
Correspondence;

Email: iode@bsum.edu.ng
Phone: +234 813 533 5837

Specialty Section; This article was submitted to Sciences a section of NAPAS.

Citation: *Patrick Ije Ode, Ibrahim Mohammed, Elizabeth Odije Ogbogo, Cephas Iye Owina, and Daniel Ikpe Acha (2026) Mycotic Contamination of Groundnut (Arachis hypogaea) Seeds in Makurdi, Nigeria and its Effects on the Proximate Composition*

Date of Publication:
Vol. 9 (1), 2026

pp 168-177

INTRODUCTION

Groundnut (*Arachis hypogaea*), commonly known as peanut, is an economically important leguminous crop cultivated worldwide for its edible seeds (Syed *et al*., 2021). Groundnuts represent a nutrient-dense food source, containing approximately 25–30% protein by weight and 40–50% healthy unsaturated fats, making them a crucial plant-based protein and lipid source (Mistry *et al*., 2022). Across all demographic groups in Nigeria, processed groundnut seeds are widely consumed as popular Ready-To-Eat (RTE) snacks (Ostadrahimi *et al*., 2014; Guchi, 2015).

Despite their agricultural and nutritional importance, groundnut seeds are highly susceptible to mycotic contamination. They are often colonized by molds and yeasts during both the pre-harvest and post-harvest processing phases; as well as in storage (Darwish, 2019; Awuchi *et al*., 2022). High moisture content during production, elevated environmental humidity, poor processing techniques, and inadequate storage facilities create optimal microenvironments for fungal proliferation. Fungal invasion is predominantly driven by species belonging to genera such as *Aspergillus*, *Penicillium*, *Fusarium*, and *Alterneria* many of which are mycotoxins producers (Tripathi and Alam, 2020). The ingestion of mycotoxin-contaminated groundnuts poses severe public health hazards, including hepatotoxicity, pulmonary distress, and carcinogenesis, while simultaneously causing severe economic losses through product deterioration and reduced marketability (Omotayo *et al*., 2019; Awuchi *et al*., 2022).

Beyond food safety hazards, fungal deterioration significantly compromises the nutritional quality of groundnut seeds. Active fungal growth utilizes host biochemical components as metabolic substrates, leading to distinct alterations in primary nutrients including proteins, lipids, and carbohydrates (Adejumo and Hakeem, 2014; Ode *et al*., 2024). While the general risks of mold infestation are acknowledged, localized empirical data detailing how specific fungal isolates alter the proximate profile of market groundnut seeds within North-Central Nigeria remains limited.

Therefore, this study was undertaken to isolate and identify the predominant fungal species associated with the deterioration of groundnut seeds in Makurdi metropolis, Nigeria, and to evaluate their specific comparative effects on the proximate composition.

MATERIALS AND METHODS

Study Area

This study was conducted in Makurdi the capital city of Benue state, Nigeria. Makurdi is located between latitude 60 25’N and 80 8’N of the equator; and longitude 70 45’E and 100 0’E of the Greenwich Meridian. It falls within the tropical humid and mega thermal climate with an average annual rainfall of 1,200 mm; and temperature range of 25°C to 35°C (Aov *et al*., 2017).

Sample Collection

One hundred and Fifty grams (150 g) of groundnut seeds were collected from Wurukum Market in Makurdi, Benue State and conveyed in sterile polyethylene bags to the Plant Science and Biotechnology Laboratory of Rev. Fr. Moses Orshio Adasu

University, Makurdi, for microbial evaluation.

Isolation of Fungi from the Seeds

Fungal isolation was conducted using the Standard Blotter Method described by Al-Amod, (2015). The groundnut seeds were surface sterilized with 1% Sodium hypochlorite solution for 5 minutes and rinsed several times with sterile distilled water. Five groundnut seeds were then inoculated in each Petri-dish lined with 3 layers of moistened sterile Whatman's filter paper (9cm), and incubated at room temperature (25±2^{o}C) in the laboratory for 7 days.

Media Preparation

Potato Dextrose Agar (PDA) was used for the study, and was prepared by strictly adhering to the manufacturer's instructions. Thirty-nine grams (39 g) of dehydrated PDA was dissolved in 1 litre of distilled water in a sterile conical flask and stopper made of cotton wool and aluminum foil paper was used to seal it. The medium was heated for a few minutes using heating mantle to dissolve the medium. The medium was autoclaved at 121°C and a pressure of 760 mmHg for 15 minutes; and was allowed to cool to the point where it could be held with bare hands. After cooling, two drops of streptomycin were added to inhibit bacterial growth. The prepared medium was dispensed into the individual petri dishes of 20 mL and swirled gently on the bench to homogenize the media.

Identification of fungi

Distinct colonies of fungi observed in the primary culture were sub-cultured to obtain pure cultures. A sterilized inoculation needle was used to pick fungi colonies onto sterile PDA plates and incubated at room temperature (37 °C). After 5-7 days, the incubated plates were observed for fungi growth. A speck of each fungus colony was aseptically placed on a sterile slide using an inoculation needle and smeared on a glass slide. A drop of lactophenol in cotton blue was added, covered with a cover slip and viewed under the microscope, using the ×40 magnification (Ekefan *et al*., 2018). The fungi were identified using their cultural and morphological features such as colony growth, conidial morphology and pigmentation. The observed characteristics were compared with a standard chart for identification by Li *et al*. (2023).

Inoculum Preparation and Seed Infestation

Standardized spore/mycelial suspensions of pure 7-day-old cultures of each fungal isolate were grown on Potato Dextrose Agar (PDA). Ten milliliters (10 mL) of sterile distilled water containing 0.05% (v/v) Tween-80 was added to each culture dish, and the surface was gently dislodged with a sterile glass spreader. The suspension was filtered through double-layered sterile gauze to remove agar debris and adjusted to a standardized concentration of approximately 1×10^{6} spores/mL (Agrios, 2005).

Healthy groundnut seeds were surface-sterilized by immersion in 1% sodium hypochlorite solution for 1 minute, rinsed thrice with sterile distilled water, and allowed to air-dry on sterile Whatman No. 1 filter paper. The seeds were then inoculated by complete immersion in the respective fungal spore suspension for 15 minutes to

allow uniform fungal adhesion. For the uninfected Control (T_0), seeds were submerged in sterile distilled water under identical conditions. Inoculated and control seeds (5 seeds per dish) were placed on sterile filter paper in Petri dishes, moistened with 2 mL of sterile distilled water, and incubated at 25±2 ^{0}C for 7 days to facilitate fungal colonization before proximate analysis.

Experimental Design

The study employed a Completely Randomized Design (CRD) with five experimental treatment groups evaluated in triplicates. The experimental setups consisted of:

T_0 (Control): Healthy, uninfected groundnut seeds (*Arachis hypogaea*).

T_1: Groundnut seeds artificially inoculated with *Aspergillus niger*.

T_2: Groundnut seeds artificially inoculated with *Aspergillus* flavus.

T_3: Groundnut seeds artificially inoculated with *Alternaria* species.

T_4: Groundnut seeds artificially inoculated with *Phytophthora* species.

Determination of Proximate Analysis

The proximate composition (Moisture content, crude protein, crude fat, crude ash, and fibre contents) of the infected and healthy groundnut seeds were determined according to the standard methods of the Association of Official Analytical Chemist (AOAC) (2012).

Statistical Analysis and Data Visualization

All data processing, statistical modeling, and high-resolution data visualizations were conducted within the R statistical computing environment (version 4.3.1). To assess the univariate effects of fungal infection on groundnut seed proximate parameters, raw experimental data collected in triplicate were first subjected to distributional diagnostic checks. Normality of residuals was evaluated using the Shapiro-Wilk test, while the homogeneity of variances across treatment groups was assessed using Levene's test.

Having satisfied parametric assumptions, a one-way Analysis of Variance (ANOVA) was executed to test for significant differences in proximate components across healthy groundnut seeds and the infected ones. Tukey's Honest Significant Difference (HSD) post-hoc test was conducted for parameters displaying significant main effect variations ($p < 0.05$). Mean values alongside their corresponding standard deviations were plotted in grouped bar charts using the package. To account for inter-variable correlations and uncover multi-trait patterns across healthy and infected seeds, multivariate analytical techniques were integrated into the analytical pipeline. Because proximate parameters were measured across different percentage scales, raw datasets were standardized prior to multivariate modeling using unit-variance scaling (column-wise Z-score transformation)

RESULTS

Occurrence of Fungal Isolates

Fungal result revealed four distinct fungal genera/species. *Alternaria* species. exhibited the highest frequency of occurrence 9(45%), followed by *Aspergillus niger* 6(30%), *Aspergillus flavus* 3(15%), and *Phytophthora* species. Which had the least occurrence of 2(10%) (Fig. 1).

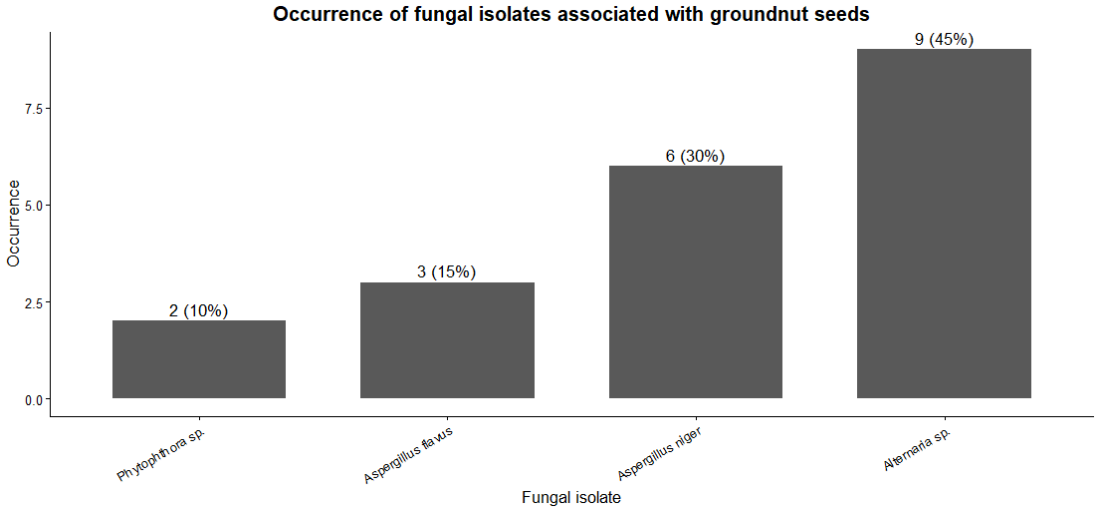


Figure 1. *Absolute occurrence and percentage frequency distribution of fungal species isolated from infected groundnut seeds.*

Proximate Composition of Healthy and Fungus-Infected Groundnut Seeds

Fungal infection was observed to cause significant alterations across all measured proximate parameters compared to the healthy control seeds ($p < 0.05$). Healthy groundnut seeds possessed the highest baseline concentrations of crude protein (21.5%), crude fat (7.2%), crude fibre (1.1%), and ash (3.8%) (Fig. 2). Fungal infection resulted in significant reductions in protein, fat, and fibre across all infected groups ($p < 0.05$). Conversely, moisture content was markedly higher in infected seeds (ranging from 8.3% in *Phytophthora* species. to 10.2% in *Aspergillus flavus*) compared to healthy seeds (3.7%). Carbohydrate content was also significantly elevated in fungus-infected groups relative to healthy controls ($p < 0.05$).

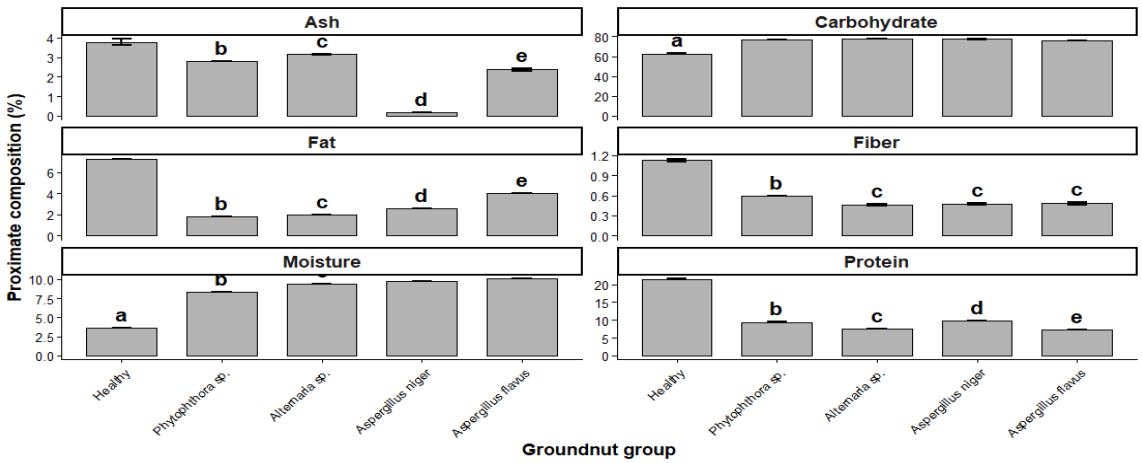


Figure 2. Proximate composition of healthy and fungus-infected groundnut seeds. Values represent the mean standard deviation. Different lowercase letters (*a*, *b*, *c*, *d*, *e*) above the bars within each parameter indicate statistically significant differences between groups based on Tukey's HSD post-hoc test ($p < 0.05$).

Multivariate Clustering and Principal Component Analysis

Principal Component Analysis (PCA) demonstrated clear segregation between healthy and fungus-infected groundnut seeds, with the first two principal components explaining 96.34% of the total variation (PC1: 84.58%, PC2: 11.75%; Figure 3). PC1 was positively associated with moisture (loading = 0.435) and carbohydrate (0.440), and negatively associated with fibre (-0.440), protein (-0.430), and fat (-0.405). Healthy samples clustered separately along the negative axis of PC1, aligning directly with high vector loadings for protein, fat, and fibre. Infected sample groups clustered along the positive axis of PC1, corresponding to elevated moisture and carbohydrate content. PC2 was strongly defined by variation in ash content (loading = 0.935).

These multivariate separation patterns were corroborated by the standardized heatmap (Figure 4), which highlighted severe depletion of fat, fibre, and protein alongside elevated moisture scores in seeds infected by *Alternaria* sp., *Aspergillus flavus*, *Aspergillus niger*, and *Phytophthora* sp.

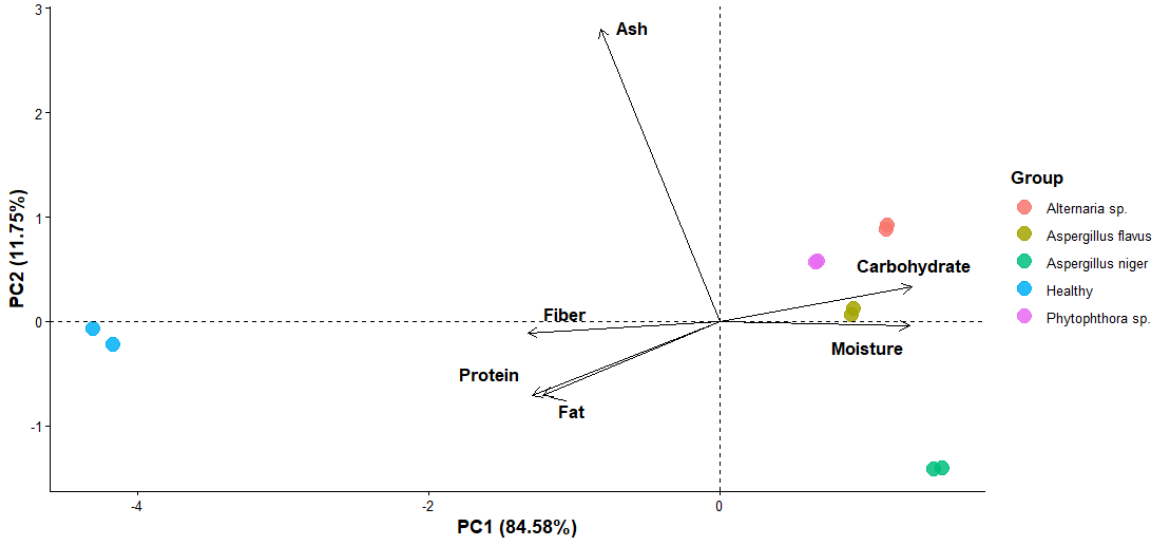


Figure 3. Principal component analysis (PCA) biplot displaying multivariate relationships in the proximate composition of healthy and fungus-infected groundnut seeds. PC1 (84.58%) and PC2 (11.75%) together account for 96.34% of the total variance. Vectors indicate the direction and magnitude of proximate variable loadings.

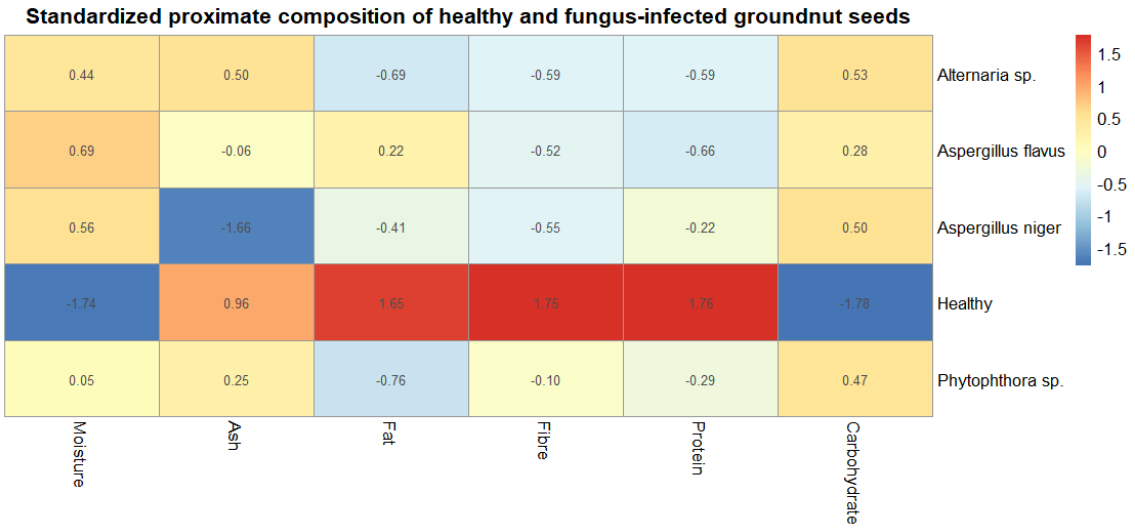


Figure 4. Standardized heatmap showing relative variations in proximate composition across healthy and fungus-infected groundnut seeds. Color intensity and cell numerical values represent column Z-scores (standardized values)

DISCUSSION

This study provides critical insights into the prevalence of seed-borne fungi and their direct impact on the proximate quality of groundnut (*Arachis hypogaea*) seeds. Four fungal species: *Alternaria* species, *Aspergillus niger*, *Aspergillus flavus, and Phytophthora* species were isolated. Notably, *Alternaria* species was the most prevalent isolate. This observation contrasts with the findings of Omugu *et al*. (2018) and Omugu *et al*. (2021), who reported *Aspergillus* species as the predominant mycoflora in stored groundnuts in Owerri, South-Eastern Nigeria. These spatial disparities in fungal distribution are likely attributable to variations in regional climatic conditions, post-harvest handling practices, and relative humidity differences between tropical ecology zones.

The comparative analysis between healthy and fungus-infected seeds demonstrated significant reductions in essential nutritional components, including crude fat, crude protein, crude fibre, and ash contents. Nutrient depletion in groundnut seeds infected with *Aspergillus* species was also reported by Ekhuemelo and Abu, (2018). The degradation of host lipids, proteins, and structural polysaccharides is mediated by extracellular hydrolytic enzymes such as lipases, proteases, and cellulases secreted by the invading pathogens to utilize host biochemical compounds as metabolic substrates (Adejumo and Hakeem, 2014; Ode *et al*., 2024). The significantly higher moisture and carbohydrate contents observed across all treatments may be primarily driven by fungal aerobic respiration which yields water as a metabolic byproduct. This metabolic moisture accumulation creates a humid microenvironment that further accelerates fungal proliferation, enzymatic breakdown, and potential mycotoxin production (Asama and Channya, 2017; Akram *et al*., 2018).

The heatmap visualization and column-wise scaled profiles clearly illustrate the distinct, species-specific patterns of

proximate alteration across the isolated mycoflora. While moisture content increased in all infected seeds, *A. flavus* induced the highest moisture accumulation (10.07%), whereas seeds infected with *Phytophthora* species maintained a relatively lower moisture content (8.36%), indicating a comparatively slower rate of respiratory water generation by the latter (Musa *et al*., 2023). Regarding mineral composition, *A. niger* infection caused the most severe depletion in ash content (0.18%), whereas *Alternaria* species retained higher mineral residues (3.14%). The extensive ash reduction by *A. niger* suggests substantial disruption and uptake of inorganic minerals necessary for fungal cellular activities (Odeniyi *et al*., 2019).

The visual clustering in the heatmap further highlights major variations in macronutrient degradation. While crude fat was depleted across all infected seeds relative to healthy controls (7.27%), *Phytophthora* species. (1.80%) and *Alternaria* species (1.96%) exerted the most pronounced lipolytic degradation. This rapid depletion of lipids reflects high extracellular lipase activity, converting seed triacylglycerols into free fatty acids and glycerol for metabolic energy (Boli *et al*., 2013). Crude fibre levels showed subtle variation among isolates (0.46–0.60%), corroborating the findings of Musa *et al*. (2023), who noted that short-term fungal infection causes minimal disruption to structural cellulose matrix compared to lipids and proteins.

Protein degradation was most severe in seeds infected with *A. flavus* (7.24%) and *Alternaria* sp (7.60%). The intense proteolytic activity of *A. flavus* severely compromises the dietary quality of groundnuts as a primary plant-based protein source (Baraka and Tobin-West, 2019). Finally, the apparent percentage increase in carbohydrate content observed in seeds infected with *A. niger*, *Alternaria* sp, and *Phytophthora* sp (77.02–77.42%) relative to *A. flavus* (75.83%) and healthy controls (62.64%) represents a relative proportion shift caused by the severe depletion of total lipid and protein biomass. Nevertheless, the lower carbohydrate value in *A. flavus*-infected seeds indicates that *A. flavus* preferentially utilizes host soluble sugars for its high metabolic demands alongside protein hydrolysis (Omugu *et al*., 2021)

This study demonstrates that groundnut (*Arachis hypogaea*) seeds marketed in Makurdi metropolis harbor diverse seed-borne mycoflora, predominantly *Alternaria* species, *Aspergillus niger Aspergillus flavus, and Phytophthora* species. Artificial inoculation reveals that active fungal colonization significantly impairs the proximate quality of groundnut seeds. Fungal infection induces marked depletion in essential macronutrients specifically crude fat, crude protein, crude fibre, and ash contents while driving increase in seed moisture content via metabolic respiration. Multivariate heatmap analysis further confirms species-specific degradation dynamics, with *A. flavus* causing the highest moisture accumulation and protein loss, *A. niger* causing the most severe ash depletion, and *Phytophthora* sp driving the highest fat breakdown.

REFERENCES

Adejumo, T. O. and Hakeem, D. A. (2014). Evaluation of mycoflora and proximate composition of groundnut (*Arachis hypogaea* L.) seeds from

local markets. *International Journal of Current Microbiology and Applied* Sciences, 3(4), 1018–1028.

Agrios, G. N. (2005). Plant Pathology (5th ed.). Elsevier Academic Press, San Diego, California, USA.

Akram, N. A., Shafiq, F. and Ashraf, M. (2018). Peanut (*Arachis hypogaea* L.): A prospective legume crop to offer multiple health benefits under changing climate. *Comprehensive Reviews in Food Science and Food Safety*, *17*(5), 1325-1338.

Al-Amod, M. O. (2015). Seed-borne fungi of some peanut varieties from Hadhramout and Abyan Governorates in Yemen. *International Journal of Agricultural Technology,* 11(6):1359-1370.

AOAC. (2012). Official Methods of Analysis of AOAC International (19th ed.). Association of Official Analytical Chemists, Washington, D.C., USA.

Asama, P. and Channya, F.K. (2017). Fungal Pathogens of Postharvest Rot of Groundnut (*Arachys hypogaea* L.) in Hong Local Government Area of Adamawa State Nigeria. *International Journal of Science and Research* (IJSR), 7(10):303-311.

Awuchi, C. G., Ondari, E. N., Nwozo, S., Odongo, G. A., Eseoghene, I. J., Twinomuhwezi, H. and Okpala, C. O. R. (2022). Mycotoxins' toxicological mechanisms involving humans, livestock and their associated health concerns: A review. *Toxins*, *14*(3):167.

Boli, Z. A., Zoue, L. T., Alloue-Boraud, W. M., Kakou, C. A. and Koffi-Nevry, R. (2013). Proximate composition and mycological characterization of peanut butter sold in retail markets of Abidjan (Côte d'Ivoire). *Journal of Applied Biosciences*, *72*, 5822-5829.

Darwish, A. M. G. (2019). Fungal mycotoxins and natural antioxidants: Two sides of the same coin and significance in food safety. *Microbial Biosystems*, *4*(1): 1-16.

Ekhuemelo, C. and Abu, S. O. (2018). Evaluation of the aflatoxin contamination and proximate composition of groundnut (*Arachis hypogea* L.) infected by *Aspergillus* spp. *Nigerian Journal of Biotechnology*, *35*(2), 130-138.

Guchi, E. (2015). Effect of storage time on occurrence of Aspergillus species in groundnut (*Arachis hypogaea* L.) in eastern Ethiopia. *Journal of Applied and Environmental Microbiology*, 3(1): 1-5.

Li, D.W., Magyar, D. and Kendrick, B. (2023). Color Atlas of Fungal Spores: a Laboratory Identification Guide. American Conference of Governmental Industrial Hygienists (ACGIH), 852.

Mistry, K., Sardar, S. D., Alim, H., Patel, N., Thakur, M., Jabbarova, D. and Ali, A. (2022). Plant based proteins: Sustainable alternatives. *Plant Science Today*, *9*(4): 820-828.

Musa, M., Adebola, M. O., Aremu, M. B., Abdullahi, S. U., Kabaraini, M. A., Habib, M. B. and Zanaib, A. M. B. (2023). Occurrence and Distribution of Toxigenic Mycoflora and Nutritional Composition Content of Peanut Seeds Sold in Niger State, Nigeria. *West African Journal of Life Sciences*, *1*(1), 6-6.

Ode, P., Owina, C., Awodi, S. and Ode, C. (2024). Fungal contamination and its effect on the proximate composition of stored maize (*Zea mays*). *NABDA*

Journal of Biotechnology Research, 3(1), 22–25.

Odeniyi, O., Adebayo-Tayo, B. and Olasehinde, K. (2019). Mycological, toxigenic and nutritional characteristics of some vended groundnut and groundnut products from three Northern Nigerian ecological zones. *African Journal of Biomedical Research*, *22*(1): 65-71.

Olanrewaju, O. S., Oyatomi, O., Babalola, O. O. and Abberton, M. (2021). Genetic diversity and environmental influence on growth and yield parameters of groundnut. *Frontiers in Plant Science*, *12*, 796352.

Omotayo, O. P., Omotayo, A. O., Mwanza, M. and Babalola, O. O. (2019). Prevalence of mycotoxins and their consequences on human health. *Toxicological research*, *35*, 1-7.

Omugo, J. E., Amadi, J. E., Okigbo, R. N., Ukpai, K. U., Evans-Kemka, C. I. and Nguma, M. O. (2021). Fungal isolates of groundnut (*Arachis hypogaea* L) seeds in Owerri Metropolis, Nigeria**.** *Nigerian Journal of Botany*, 34(1): 69-83.

Ostadrahimi, A., Ashrafnejad, F., Kazemi, A., Sargheini, N., Mahdavi, R., Farshchian, M. and Mahluji, S. (2014). Aflatoxin in raw and salt-roasted nuts (pistachios, peanuts and walnuts) sold in markets of Tabriz, Iran. *Jundishapur Journal of Microbiology*, *7*(1):1-9.

Syed, F., Arif, S., Ahmed, I. and Khalid, N. (2021). Groundnut (peanut) (*Arachis hypogaea*). *Oilseeds: health attributes and food applications*, 93-122.

Tripathi, A. and Alam, A. (2020). Mycotoxins, Mycotoxicosis and Managing Mycotoxin Contamination: A Review. *Bio-management of Postharvest Diseases and Mycotoxigenic Fungi*, 161-180.