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Research Article

Mycotoxins Associated with Fungal Pathogens and Their Impact on the Phytochemical Composition of Kola Nut (*Cola nitida*) in Yola, Adamawa State, Nigeria

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ABSTRACT
Kola nut (*Cola nitida*) is a vital cash crop in Nigeria, significantly impacting socio-economic conditions. This study investigated the fungi associated with kola nut rot, their potential for mycotoxin production, and the implications of fungal infection on the nut's phytochemical composition. Thirty samples of infected and uninfected kola nuts were collected from wholesalers in Jimeta Modern Market, Yola, and analyzed in the Department of Plant Science at Modibbo Adama University, Yola. Fungal isolation was conducted using Potato Dextrose Agar, and mycotoxins were detected via thin-layer chromatography (TLC), with extraction performed using Potato Dextrose Broth. Data were analyzed using ANOVA and means were separated with LSD. Four pathogenic fungal species were identified: *Aspergillus parasiticus*, *Aspergillus flavus*, *Fusarium oxysporum*, and *Rhizopus stolonifer*. TLC analysis indicated that *A. parasiticus and A. flavus* produced aflatoxins (Rf = 0.398 and 0.709), while *F. oxysporum* produced metabolites resembling zearalenone or trichothecenes (Rf = 0.695), and *R. stolonifer* produced compounds suggestive of rhizoxin (Rf = 0.179 and 0.571). Qualitative phytochemical screening revealed the presence of various bioactive compounds, while quantitative analysis showed significant reductions in key constituents due to fungal infection ($P \leq 0.05$). Saponins decreased from 0.836% in uninfected nuts to below 0.046% in infected nuts, with similar declines noted in flavonoids, tannins, and other compounds. Overall, fungal colonization caused severe phytochemical degradation and contamination with harmful mycotoxins, emphasizing the need for improved post-harvest handling and effective measures to prevent fungal infestation in kola nuts.

Keywords: *Cola nitida;* Fungal Pathogens; Kola Nut; Mycotoxins; Phytochemicals

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INTRODUCTION

Kola nut is widely used in Africa as a masticatory stimulant, and plays important roles in social and ceremonial practices, including marriages, child naming, chieftaincy installations, funerals, and religious rituals (Ugwu *et al*., 2020, Ikechi-Nwogu *et al*., 2023). *Cola nitida*, a major commercial crop in Africa. The seed of *C. nitida* fruit (pod) is referred to as the kola nut. The nuts occur in white, red, and pink varieties, and are rich in essential nutrients and secondary metabolites such as polyphenols, alkaloids, saponins, and terpenoids (Aduama-Larbi *et al*., 2022). In West Africa, kola is second only to palm oil among indigenous cash crops, with about 40 *Cola* species identified, although *C. acuminata* and *C. nitida* are the most economically important in Nigeria (Idris *et al*., 2017). Kola cultivation, which dates back to the 19th century, supports a significant portion of the Nigerian population involved in farming, trade, and industrial use, and Nigeria produces about 88% of the world's kola nuts, amounting to roughly 200,000 metric tons annually, mostly from the southwest (Idris *et al*.,

2017). Both *C. acuminata* and *C. nitida* also remain important crops in other tropical regions, including the Caribbean, Mauritius, Sri Lanka, and Malaysia (Idris *et al*., 2017).

In Adamawa State, particularly Yola, kola nut trading and consumption are widespread, yet the nuts are highly vulnerable to postharvest fungal infections that cause rot and reduce their market quality (Idris *et al*., 2017). Preliminary investigations in Jimeta Modern Market have identified phytopathogenic fungi responsible for kola nut deterioration (Idris *et al*., 2017), but significant knowledge gaps remain regarding how these pathogens affect the nut's nutritional composition and phytochemical constituents within this specific region. Furthermore, fungal colonization is often accompanied by the production of mycotoxins, which are harmful secondary metabolites, (Makhuvele *et al.,* 2020). Therefore, the study aims at investigating the effect of mycotoxins associated with fungal pathogens of kola nut and their impact on phytochemical compositions in Yola, Adamawa State, Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted in Yola North Local Government Area of Adamawa State. Yola lies between latitudes 9°11'N to 9°19'N and longitudes 12°20'E to 12°30'E (UBRBDA, 1999). Figure 1 shows map of the study area and the respective Local Government Area of the state. The city has a tropical climate marked by dry and rainy seasons. The rainy season starts around May and ends in late October, while the mean total rainfall is 1,113.3 mm (UBRBDA, 1999). Maximum temperature in Yola is about 40° C in April, while minimum temperature could be as low as 18.3° C between December and early January, while relative humidity is lowest (26%) in the month of January and February, and increases to 58, 69, and 79 from May to October respectively (UBRBDA, 1999). The research was carried out in the Plant Pathology Laboratory, Department of Plant Science, Faculty of Life Science, Modibbo Adama University, Yola, Adamawa State, Nigeria.

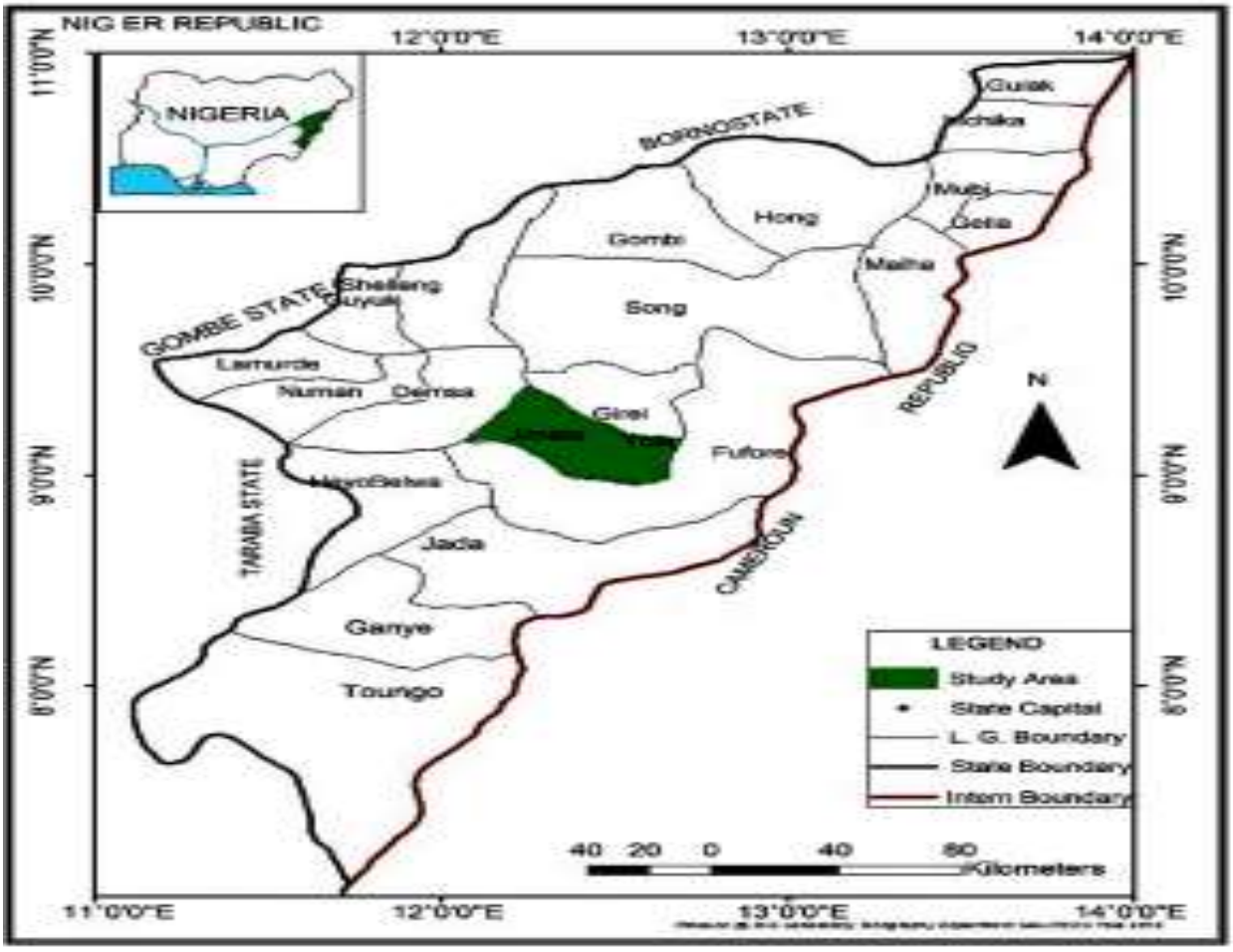

Figure 1: Map of Adamawa State and the Study Area

(Zubairu *et al.*, 2022)

Experimental Design

Completely Randomized Design was adopted, and treatments replicated thrice for all experiments.

Sample Source

Thirty Kola nut (*Cola nitida*) samples were randomly collected from different kola nut wholesalers in Jimeta modern Markets in Yola. Uninfected nuts and infected nuts were collected and packed into sterilized polyethylene bags and taken to the Department of Plant Science Laboratory at Modibbo Adama University (MAU), Yola for isolation and other studies.

Isolation and Identification of Fungal Pathogens

The nuts were cut into small pieces of about 3 mm using a sterilized scalpel. The cut samples were surface sterilized in 2% sodium hypochlorite for 30 s, rinsed in three changes of sterile distilled water, and blotted dry on sterile Whatman No. 1 filter paper. The samples were inoculated on freshly prepared Potato Dextrose Agar (PDA) augmented with streptomycin to suppress any bacterial growth. The PDA plates were incubated at 28 ± 2°C. Emerging fungal colonies were subsequently sub-cultured into freshly prepared PDA until pure cultures were obtained. Macro and micro-morphological characteristics of seven days old cultures were observed, and identification was done based on descriptions of Watanabe (2005), and Watanabe (2010)

Preparation of Fungal Suspensions

Fungal suspensions were prepared following the procedures reported by Burgess (2008). Seven-day old cultures of the fungal isolates were flooded with 25 mL of sterile distilled water. With the aid of a Carmel hair brush, the spores were carefully brushed off the sporophores and decanted into a sterile petri dish. Fifteen millilitres of sterile distilled water was added and filtered through 0.2×0.2 mm nylon mesh to get rid of mycelial fragments. This filtrate containing the spores were adjusted to a concentration of 1×10^6 spores per mL using haemocytometer.

Pathogenicity Test

Fresh kola nuts were surface sterilized with 0.1% $HgCl_2$ for 30 s and rinsed in three (3) changes of sterile distilled water according to the method of Chukwuka *et al*. (2010). A sterile cork borer (2 mm in diameter) was used to puncture and inject healthy kola nuts with spores' suspension of each isolated fungus in three replicates. Removed tissue was replaced and vasper jelly was smeared to completely seal each hole to avoid contamination. It was kept at room temperature of 33±2 ^{0}C. A similar set up was placed as control using distilled water to complement the fungal inocula. The set up was arranged in a completely randomized design. It was incubated for seven (7) days to allow for possible rot development and the isolates were re-isolated from the new host and compared to the originally isolated pathogen.

Extraction and Detection of Mycotoxin

Pathogenic fungi from the pathogenicity test were selected for mycotoxin assays, in which 100 mL of Potato Dextrose Broth (PDB, Himedia, Mumbai, India) in 250 mL Erlenmeyer flasks were inoculated with 5 mm mycelial agar discs drawn from advancing margins of seven-days old cultures. In total, 2.5 L of medium was inoculated. All the flasks were incubated at 26 ± 2°C with 12 h photoperiod for 25 days. After incubation, the cultures were filtered through three layers of cheesecloth and Whatman No. 1 filter paper. Culture filtrates thus collected were cleaned by passing through 0.45 µm membrane filter discs. The culture filtrates were concentrated to 10% of their original volume by using a flash evaporator at 50°C (He *et al.,* 2019). An equal volume of methanol was added to the concentrated solution, and then extracted with chloroform (double the amount of methanol). The chloroform layer was separated in a separatory funnel, and the extraction with chloroform layer was repeated twice. The combined chloroform layers were evaporated at room temperature, and crude extract obtained. The crude extract was dissolved in methanol to have a 10% toxin solution. Thereafter, eight mL of the solution were diluted to 160 mL by adding the solution drop-wise to double distilled water with continuous stirring to obtain a stock toxin solution, having 5% of final methanol concentration (Mackay *et al.,*1994).

Thin Layer Chromatography

TLC was employed using thin layer plates, without fluorescence indicators. About 10 µL of crude toxin extract were applied on plates and developed using different combinations of solvents (chloroform: methanol) 5.0:5.0; 5.5:4.5; 6.0:4.0; 6.5: 3.5; 7.0:3.0; 7.5:2.5; 8.0;2.0; 8.5:1.5; 9.0:1.0, then each plate was analyzed under UV light at 365 nm. The Refractive index (Rf) was calculated using the formula:

$$\mathrm{Rf} = \frac{\text{Distance (cm) moved by the solute from the origin}}{\text{Distance (cm) moved by the solvent from the origin}}$$

Phytochemical Analyses of Uninfected and Infected Kola Nuts

Phytochemical analysis of uninfected and infected kola nuts (*Cola nitida*) was carried out to determine

the effect of mycotoxins on the phytochemical content of the kola nuts.

Using two sets of experiments, firstly, fresh kola nuts were obtained and surface sterilized with 0.1% $HgCl_2$ for 30s and rinsed in three changes of sterile distilled water. A sterile dissecting needle was used to puncture and inject the kola nut with 0.3 mL of crude mycotoxins preparations, using a syringe (Idris *et al.*, 2017). Kola nuts injected with sterile distill water (second set) served as control. Crude fibre, crude protein, carbohydrate contents were determined using the method of AOAC (2007), percentage of oil/ lipid, moisture, and ash content were determined using the methods of Ani *et al*. (2012), and AOAC (2007).

Quantitative and qualitative phytochemical analyses of the mycotoxin-infected kola nuts were conducted according to the procedures of Sofowora (2013).

Data Analysis

The data obtained was subjected to Analysis of Variance (ANOVA) at 5% level of probability using the Paleontological Statistics (PAST) software (Version 4.03). Means were separated using the Least Significant Difference (LSD)

RESULTS

Based on cultural and microscopic characteristics, four fungal species isolated from infected Kola nut seeds were identified as *Aspergillus parasiticus*, *Fusarium oxysporum*, *Rhizopus stolonifer,* and *Aspergillus flavus* (Table 1, Plates 1- 4).

Error! Reference source not found. presents the thin-l ayer chromatographic results. Using the solvent system composed of chloroform, acetone, and n-hexane in a 7:2:1 ratio, each organism displayed distinct retention factor (Rf) values, with *A. parasiticus* having an Rf value of 0.398, corresponding to Aflatoxin B1 and G1 respectively. *F. oxysporum* isolate yielded a much higher Rf value of 0.695, with Fumonisins, Trichthecenes and Zearaleenone as the suspected mycotoxins. In the case of *R. stolonifer*, the chromatogram revealed two distinct bands. The first had a very low Rf value of 0.179, with Rhizonin as the suspected mycotoxin, and a second spot for *R. stolonifer* appeared at an Rf of 0.571. The isolate of *A. flavus* produced a spot with an Rf of 0.709, with Aflatoxins B1and B2 as the suspected mycotoxins.

Table 3 shows qualitative phytochemical analysis of infected and uninfected *Cola nitida* revealed notable variations in the distribution of secondary metabolites following fungal colonization. All phytochemicals examined; alkaloids, flavonoids, glycosides, saponins, steroids, tannins, and terpenoids, were detected in the uninfected kola nuts. Alkaloids, flavonoids, glycosides, steroids, and tannins were consistently present across all infected samples. In contrast, saponins and terpenoids exhibited marked variability. Saponins were absent in nuts infected with *Fusarium oxysporum* and *Rhizopus stolonifer*. Terpenoids were detected only in nuts infected by *A. parasiticus*, while they were absent in all other infected samples.

The results in table 4 shows the quantitative phytochemical analysis which is significant at $p \leq 0.05$. The findings indicated that saponins in uninfected kola nuts measured 0.836%, but this value was markedly reduced following fungal infection. *Aspergillus parasiticus* produced the greatest reduction to 0.046%, followed by *Rhizopus stolonifer* (0.048%), *Aspergillus flavus* (0.051%), and *Fusarium oxysporium* (0.073%).

Tannin content in uninfected kola nuts was reported as 0.133%. The most pronounced reduction occurred with *A. parasiticus*, which decreased tannins to 0.080%, followed by *R. stolonifer* (0.091%), *A. flavus* (0.106%), while *F. oxysporium* maintained a level closely comparable to the control at 0.125%.

Glycosides were quantified at 0.472% in the uninfected samples. The largest reduction was observed with *A. parasiticus* (0.263%), followed by *R. stolonifer* (0.309%) and *A. flavus* (0.369%). In contrast, *F. oxysporium* slightly increased glycoside content to 0.507%.

Flavonoid content in the control sample was 0.118%. All fungal pathogens caused reductions, with *A. parasiticus* showing the greatest decline to 0.055%, followed by *R. stolonifer* (0.068%), *F. oxysporium* (0.079%), and *A. flavus* (0.084%).

Phenols measured 0.251% in uninfected kola nuts. The greatest reduction occurred with *R. stolonifer*, which lowered phenols to 0.178%, followed by *A. flavus* (0.193%), *F. oxysporium* (0.214%), and *A. parasiticus* (0.246%).

Alkaloids were reported at 0.213% in the uninfected samples and decreased across all infected nuts. The strongest reduction occurred with *A. parasiticus* (0.154%), followed closely by *A. flavus* (0.152%), *F. oxysporium* (0.150%), and *R. stolonifer*, which showed the least reduction (0.172%).

Table 1: Cultural and Morphological Characteristics of Fungi Isolated from the Kola Nut Rot

Fungal Isolate	Cultural Characteristics	Morphological Characteristics
Aspergillus parasiticus	Colonies grow rapidly on PDA, surface initially yellow-green to dark green; some strains produce sclerotia.	Conidial heads radiate, biseriate; conidiophores roughened; vesicles globose; conidia spherical, rough-walled, yellow-green.
Aspergillus flavus	Colonies fast growing, yellowish-green to olive green, powdery to floccose; reverse pale to colorless; produces abundant conidia.	Conidial heads radiate, typically uniseriate; vesicles subglobose; conidia rough, spherical; sclerotia may form in some isolates.
Fusarium oxysporum	Colonies grow moderately fast, white to pinkish cottony mycelia; some isolates produce violet pigmentation.	Produces abundant macroconidia (sickle-shaped, 3–5 septa); microconidia oval, mostly non-septate, borne on short conidiophores; chlamydospores may be present.
Rhizopus stolonifer	Colonies are very fast-growing, initially white cottony, later gray to black as sporangia mature; they develop stolons and rhizoids.	Sporangiophores erect, arise opposite rhizoids; sporangia spherical, black when mature; columellae hemispherical; sporangiospores globose to ellipsoidal, smooth.

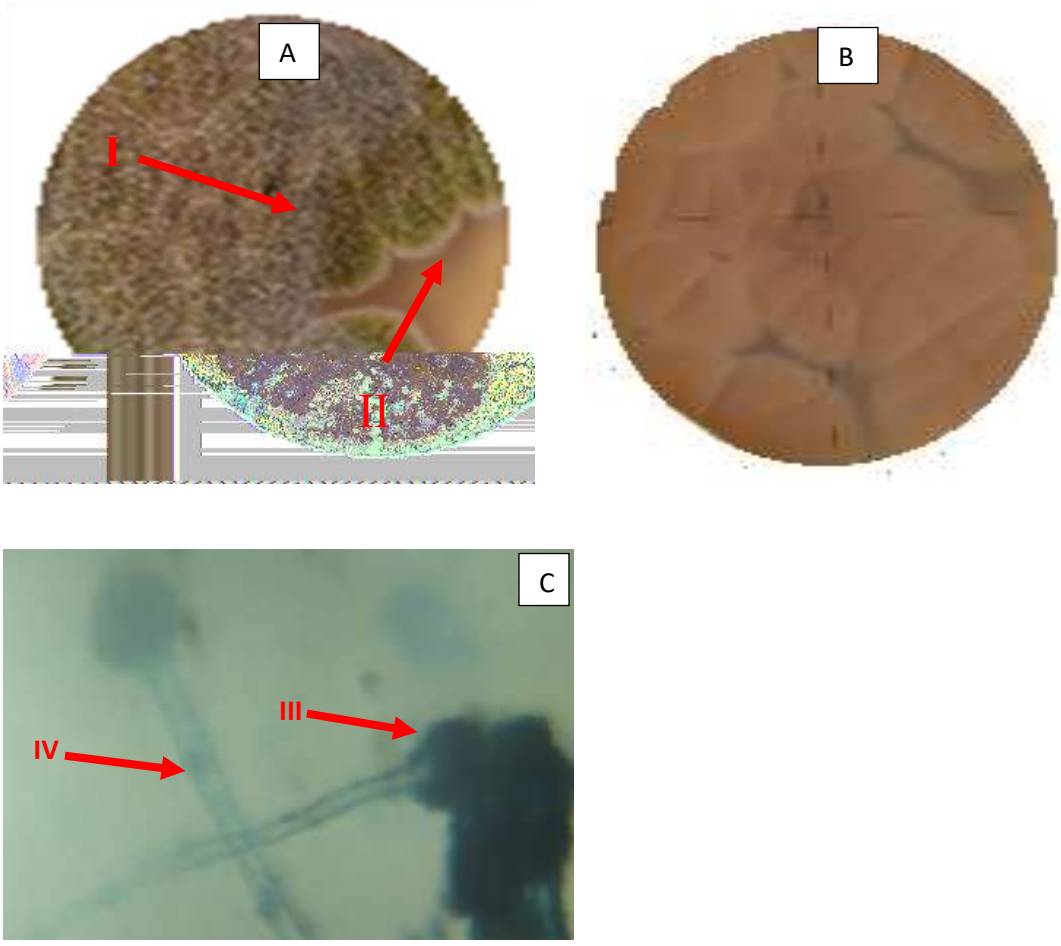

Plate 1: (a) Front view of a seven-day-old *Aspergillus parasiticus*, (b). Reverse view, (c). Micrograph view under light microscope (X40) (I & II- old greenish and white advancing *mycelia*, III- *conidia* and IV- *conidiophore*)

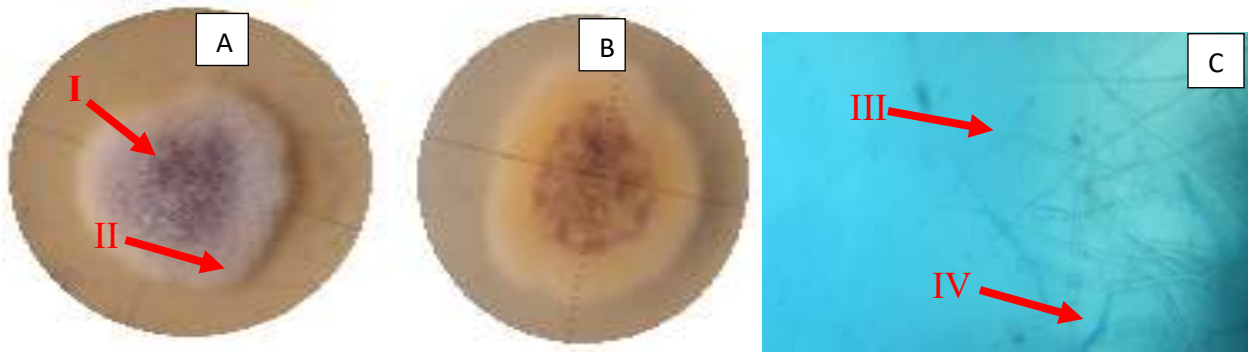

Plate 2*:* (a) Front view of a seven-day-old *Fusarium oxysporium*, (b). Reverse view, (c). Micrograph X40) (I & II- pink and pinkish white advancing *mycelia*, III- conidium and IV- mycelium)

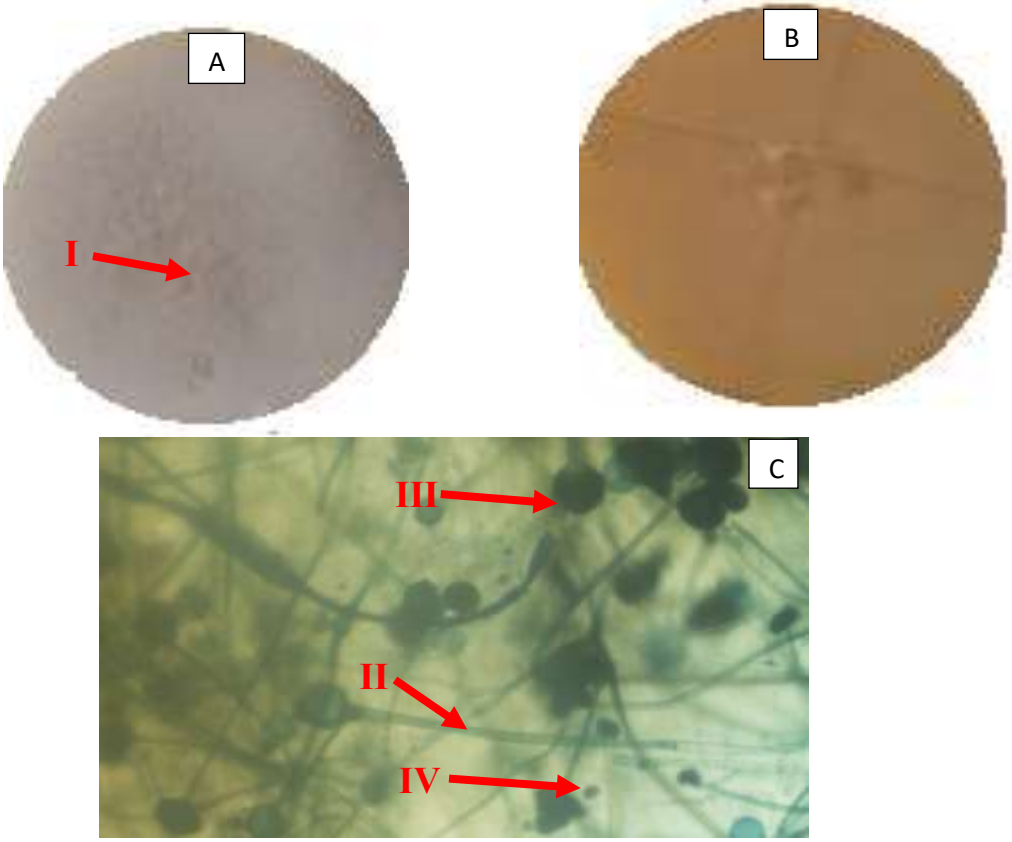

Plate 3*:* (a) Front view of a seven-day-old *Rhizopus stolonifer*, (b). Reverse view, (c). Micrograph (X40) (I- white advancing mycelia, II- sporangiosphore, III- *sporangium* and IV- sporangiospores)

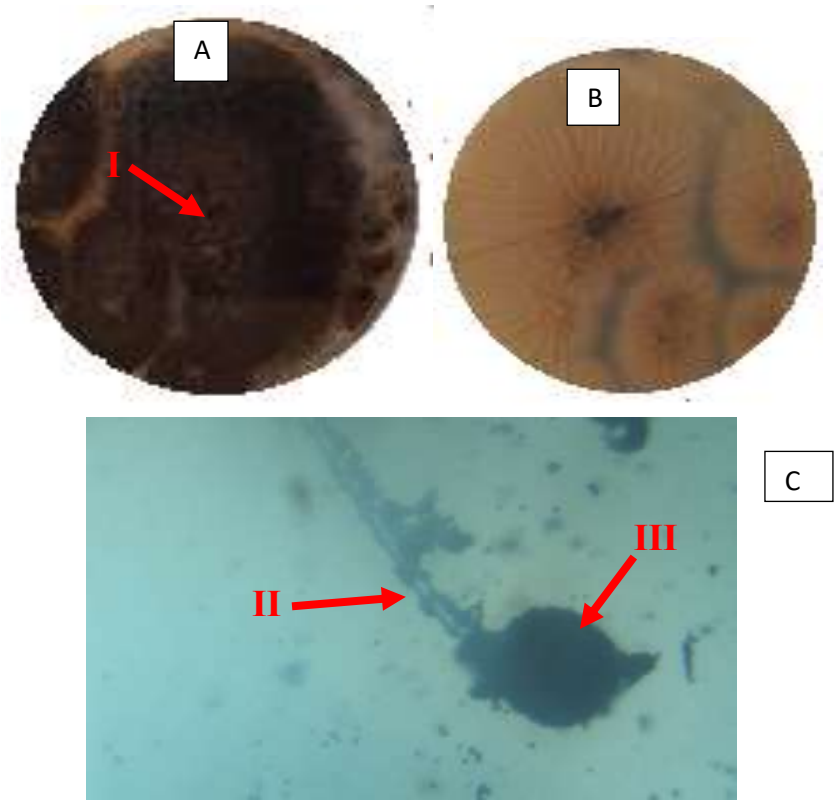

Plate 4: (a) Front view of a seven-day-old *Aspergillus flavus*, (b). Reverse view, (c). Micrograph (X40) (I- black advancing mycelia, II- conidiophore and III- conidiospore)

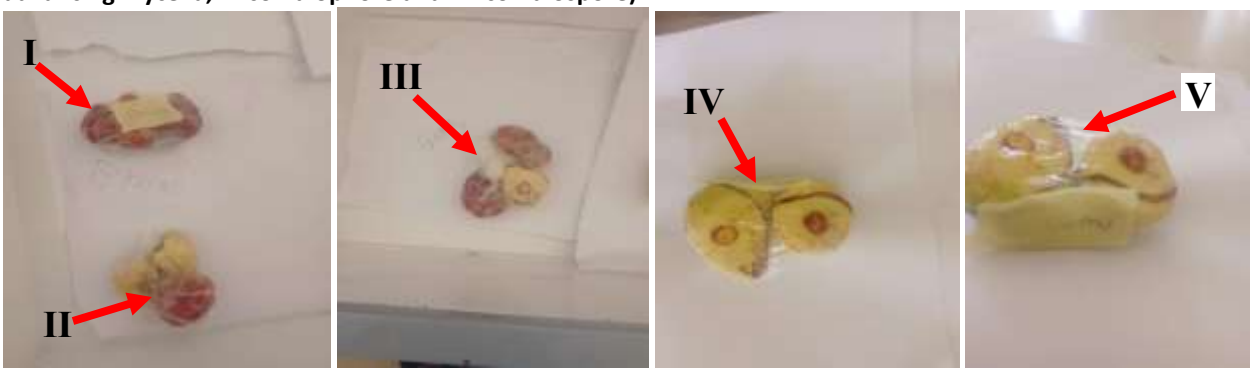

PLATE 5: Pathogenicity after one week to allow for possible rot development and the isolates were re-isolated from the new host and compared to the originally isolated pathogen

Kola nuts infected with (I- *Aspergillus flavus, II-Rhizopus stolonifer, and III- Aspergillus parasiticus)* spores, respectively; Kola nuts infected with (IV-*Fusarium oxysporum* spores; V-distilled water) control

Table 2: Mycotoxins Produced by Fungal Pathogens of Kola Nuts

Fungi	Solvent system	Retention factor	Suspected mycotoxin
Aspergillus parasiticus	chloroform 7: acetone: 2 N-hexane:1	0.398	Aflatoxin B_1 and G_1
Fusarium oxysporium	chloroform 7: acetone: 2 N-hexane:1	0.695	Fumonisins, Trichothecenes, and Zearalenone,
Rhizopus stolonifer	chloroform 7: acetone: 2 N-hexane:1	0.179	Rhizoxin
Rhizopus stolonifer 2	chloroform 7: acetone: 2 N-hexane:1	0.571	
Aspergillus flavus	chloroform 7: acetone: 2 N-hexane:1	0.709	Aflatoxins B_1 and B_2

Table 3: Qualitative Phytochemical Content of Infected Kola Nut

Component	*Aspergillus flavus*	*Aspergillus parasiticus*	*Fusarium oxysporium*	*Rhizopus stolonifer*
uninfected	+	+	+	+
Alkaloids	+	+	+	+
Flavonoids	+	+	+	+
Glycoside	+	+	+	+
Saponins	+	+	–	–
Steriods	+	+	+	+
Tannins	+	+	+	+
Terpernoid	–	+	–	–

KEY: + Present, - Not detected.

Table 4: Quantitative Phytochemical Content Analysis of Uninfected and Infected Kola Nut (*Cola nitida*)

Samples	Saponin %	Tanins %	Glycoside %	Flavonoid %	Phenol %	Alkaloid %
Uninfected	0.836	0.133	0.472	0.118	0.251	0.213
Aspergillus parasiticus	0.046	0.080	0.263	0.055	0.246	0.154
Fusarium oxysporium	0.073	0.125	0.507	0.079	0.214	0.150
Rhizopus stolonifer	0.048	0.091	0.309	0.068	0.178	0.172
Aspergillus flavus	0.051	0.106	0.369	0.084	0.193	0.152
Mean	0.211	0.107	0.384	0.081	0.216	0.168
P<0.05	0.0001	0.0002	0.0001	0.0003	0.0002	0.0001
LSD	0.0165	0.0091	0.0104	0.0024	0.0102	0.0072

Note: P ≤ 0.05 = Significant

DISCUSSION

The study revealed that *A. parasiticus, F. oxysporum, R. stolonifer, and A. flavus* were the fungi associated with kola nut rot in Jimeta Modern Market, with *Aspergillus* species being the most prevalent. Similarly, Ikechi-Nwogu *et al.* (2023) identified *Aspergillus niger* as a causal organism of post-harvest kola nut spoilage at Ogbunabali Fruit Garden Market, Port Harcourt Local Government Area of Rivers State. Furthermore, Oduwaye *et al*. (2023) also reported *A. niger*, *A. flavus*, *F. oxysporum*, and *R. stolonifer* among the key fungi involved in kola nut decay. These findings also parallel the findings from other Nigerian regions where similar fungal species have been isolated and identified as responsible for kola nut spoilage (Aasa, 2021). Darade *et al*. (2022) and Guang *et al*. (2023) emphasized wound damage during harvesting and storage as critical predisposing factors for fungal infection, which is a plausible mechanism for the infections observed in this study. These consistent findings reflect a consensus in recent literature that these fungi are pivotal in post-harvest losses of kola nuts. Moreover, Navale *et al.* (2021), and Aduama-Larbi *et al*. (2022) highlighted the toxicological concerns due to the production of mycotoxins by *Aspergillus* strains, which underscores the public health relevance of these pathogens in kola nuts.

The results of the thin-layer chromatographic (TLC) analysis indicated the production of secondary metabolites, specifically suspected mycotoxins, by fungi isolated from kola nuts, with distinct retention factor (Rf) values corresponding to each fungal species. *Aspergillus parasiticus* exhibited an Rf value of 0.398, suggesting the production of aflatoxins B and G. In contrast, *Fusarium oxysporum* demonstrated a higher Rf value of 0.695, indicative of the presence of fumonisins, trichothecenes, and zearalenone. *Rhizopus stolonifer* displayed two distinct bands with Rf values of 0.179 and 0.571, which are linked to the production of rhizoxin, while *Aspergillus flavus* showed an Rf value of 0.709, also indicating the presence of aflatoxins B and B1. These findings are consistent with Szonyi *et al*. (2025), Lorán *et al*., (2022) regarding mycotoxin production by these fungal species. *Aspergillus parasiticus* and *Aspergillus flavus* are extensively documented as major producers of aflatoxins, notably the highly potent carcinogenic aflatoxins B1 and G. This is further supported by research conducted by Pfliegler *et al.* (2020), which discusses the metabolic pathways and diversity of aflatoxin production in *Aspergillus* species, emphasizing *A. flavus* and *A. parasiticus* as primary producers. The production of fumonisins, trichothecenes, and zearalenone by *Fusarium oxysporum* is well-established in studies summarized by Eltariki (2023), highlighting the significant role of

Fusarium species in the generation of various mycotoxins that pose substantial health risks within agricultural commodities.

Additionally, the detection of rhizoxin associated with *Rhizopus stolonifer* aligns with previous reports identifying this compound as a significant mycotoxin produced by *Rhizopus* fungi, known for its phytotoxic effects and potential toxicity to mammals (Cabrera-Rangel *et al*., 2022). When compared with other findings, the retention factors and associated toxins observed in this study mirror those reported in similar TLC-based investigations involving agricultural fungi. Studies focused on stored grains and other crops (Heba and Zakaria, 2025; Kortei *et al*., 2022) exhibit comparable Rf ranges and confirm the production of aflatoxins by Aspergillus species, alongside zearalenone and fumonisins produced by *Fusarium* and *Rhizopus* species. The presence of multiple mycotoxins produced by different fungal species isolated from kola nuts corroborates the ongoing concerns regarding co-contamination and the compounded risks posed to food safety and human health (Akinmoladun *et al*., 2025).

The phytochemical analyses of kola nut (*Cola nitida*) reveal that fungal infection markedly alters the qualitative and quantitative composition of secondary metabolites. Qualitatively, all the fungal isolates tested positive for key metabolites such as alkaloids, flavonoids, glycosides, steroids, and tannins, while some variations were observed for saponins and terpenoids. saponins were absent in kola nuts infected with *Fusarium oxysporium* and *Rhizopus stolonifer*, while terpenoids were detected only in *Aspergillus parasiticus* infections

This observation aligns with findings by Olawuyi *et al*. (2021), who reported that fungal invasion selectively suppresses or modifies certain secondary metabolites, depending on the pathogen's enzymatic machinery and metabolic needs.

Quantitatively, the results show a dramatic reduction in key phytochemicals following fungal infection. Saponin levels, for example, dropped from 0.836% in uninfected kola nuts to as low as 0.046% in *Aspergillus parasiticus*-infected samples, indicating that fungal metabolism either degrades or suppresses saponin biosynthesis. This agrees with the work of Okoye *et al*. (2020), who observed significant saponin losses in yam tubers infected with *Aspergillus* spp., suggesting that the fungi either utilize these compounds for growth or detoxify them to evade plant defense. Similarly, tannins and flavonoids, which play critical roles in antioxidative defense, were consistently reduced in all infected samples, mirroring the findings of Akpoka *et al*. (2022), who noted decreased flavonoid levels in maize grains infected with *Fusarium* and *Aspergillus*.

Interestingly, the study shows a slight increase in glycoside content in kola nuts infected with *Fusarium oxysporium* (0.507%) compared to the uninfected control (0.472%). This anomaly suggests that some fungal pathogens may induce the accumulation of specific metabolites, possibly as a host defense response or due to fungal enzymatic activity releasing bound glycosides. A comparable observation was reported by Akinmoladun *et al*. (2019), who recorded elevated glycosides in cassava roots infected with *Fusarium*, attributing it to stress-induced metabolic shifts in the host. The consistent reduction in alkaloid content across all infected kola nuts is notable since alkaloids are known for their antifungal properties. Their depletion suggests fungal suppression of these compounds, a phenomenon also reported in cocoa beans by Adeniji *et al*. (2023), where *Aspergillus flavus* infection reduced alkaloid levels, thereby weakening host defense. The observed decrease in phenolic compounds across infections further underscores the role of fungi in compromising kola nut antioxidant capacity. Similar trends were documented by Akinbode and Komolafe (2021) in tomato fruits, where fungal rot reduced total phenolic content, making the fruits more susceptible to further deterioration.

CONCLUSION

The study identified four fungal pathogens responsible for the rot of kola nut (*Cola nitida*) in Jimeta Modern Market. Fungi isolated included *A. parasiticus*, *A. flavus*, *F. oxysporum*, and *R. stolonifer*. The confirmation through pathogenicity tests emphasizes the significance of these fungi in affecting kola nut quality, which can have economic implications for producers and sellers.

TLC results showed that the fungal isolates were producers of potent mycotoxins, (Aflatoxin B_1 and G_1, Fumonisins, Trichothecenes, and Zearalenone) posing significant health risks to consumers,while phytochemical analysis showed that fungal infection significantly altered the biochemical profile of kola nuts. Overall, these findings demonstrate that fungal pathogens do not merely contaminate kola nuts, but actively deplete their valuable phytochemical content, thereby potentially diminishing their nutritional, therapeutic, and commercial quality.

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