Original Research Article

Nigerian Journal of Biotechnology and Life Sciences
ISSN: 2814-0281
Vol. 3 No 2b (2026) p. 577 - 584
http://www.njbls.fud.edu.ng/

Fungi Associated with Postharvest Spoilage of Irish Potato (*Solanum tuberosum* L.) and Their Pathogenicity in Dutse, Northwestern Nigeria

Hassan Bashir Mukhtar* and Mahmud Ahmed

Department of Microbiology and Biotechnology, Federal University Dutse, Jigawa State, Nigeria

*Corresponding Author: hassanbmukhtar@gmail.com

https://doi.org/10.67601/njbls.v3i2b.91

Article info

Date received
28/08/2026
Date accepted
16/09/2026
Available online
18/09/2026

Keywords
Rhizopus stolonifer; storage rot; tuber decay; mycobiota; Jigawa State

Abstract

Postharvest fungal spoilage reduces the quality and marketability of potato tubers. This study investigated fungi associated with spoiled Irish potato (*Solanum tuberosum* L.) tubers obtained from markets in Dutse, Jigawa State, Nigeria, and assessed the pathogenicity of the recovered isolates on healthy tubers. Ten spoiled tubers were collected from five sellers/shops at Dutse Ultra-Modern Market and Investment (*Yan Tifa*) Market, each seller/shop being treated as one sampling unit (sample groups A–E). Rotten tissues were processed by serial dilution (10^{-1} and 10^{-2}) and cultured on Potato Dextrose Agar (PDA), followed by purification and morphology-based identification using cultural characteristics and lactophenol cotton blue microscopy. Five fungal taxa were morphologically identified: *Aspergillus niger*, *Rhizopus stolonifer*, *Fusarium oxysporum*, *Aspergillus flavus* and *Mucor racemosus*. Thirty-one isolates were recovered, and the percentages reported below are relative frequencies among these 31 isolates rather than the proportion of tubers infected. *R. stolonifer* was the most frequent (10; 32.3%), followed by *A. niger* (7; 22.6%), *F. oxysporum* (6; 19.4%), *A. flavus* (4; 12.9%) and *M. racemosus* (4; 12.9%). In the pathogenicity assay, a single representative isolate of each taxon was inoculated into five healthy tubers, and all five taxa produced visible rot. The mean rot diameters recorded after 10 days were 32 mm for *R. stolonifer*, 25 mm for *A. niger*, 20 mm for *A. flavus*, 16 mm for *F. oxysporum* and 14 mm for *M. racemosus*. The findings indicate that several fungi were associated with potato spoilage in the sampled Dutse markets and that each of the five taxa was able to initiate rot in healthy tubers under the assay conditions. Because measures of variation and inferential statistics were not available, the differences in mean rot diameter are reported descriptively and not as an established ranking of virulence. Improved handling, protection from tuber injury, segregation of decayed tubers and suitable storage conditions are recommended. Molecular identification and fully replicated, statistically analysed pathogenicity experiments would strengthen future studies.

Introduction

Potato (*Solanum tuberosum* L.) is an important food crop cultivated widely in temperate, subtropical and highland tropical regions. The cultivated potato belongs to *Solanum* section *Petota* and has a complex domestication and taxonomic history (Spooner et al., 2005; Ovchinnikova et al., 2011). Potatoes are a carbohydrate-rich food and also provide vitamin C, vitamin B6 and potassium, contributing to their nutritional importance (Camire et al., 2009).

Potato tubers are vulnerable to postharvest deterioration caused by physical injury, physiological changes and microbial pathogens. Fungal decay can reduce tuber quality and marketable yield, and postharvest decay is influenced by interacting biological and environmental factors (Bojanowski et al., 2013; Liu et al., 2022). Wounds created during harvesting, transportation, grading and marketing can facilitate fungal invasion by providing access to susceptible internal tissue.

Several fungi have been associated with potato deterioration. *Fusarium* species are major causes of potato dry rot (Xue et al., 2023), while genera including *Rhizopus*, *Aspergillus*, *Mucor* and *Penicillium* have also been recovered from potato tubers with postharvest damage (Bojanowski et al., 2013; Gherbawy & Gashgari, 2013). Stefańczyk et al. (2016) demonstrated considerable diversity among *Fusarium* species associated with potato dry rot, illustrating that fungal communities associated with diseased tubers can vary among locations.

Studies in Nigeria have documented several fungi associated with potato rot. Ibrahim et al. (2014) recovered *Rhizopus stolonifer*, *Aspergillus niger*, *Aspergillus flavus*, *Penicillium* spp., *Mucor racemosus*, *Fusarium oxysporum* and *Alternaria alternata* from rotten Irish potato tubers in Sokoto, northwestern Nigeria, with *R. stolonifer* as the most frequent isolate. Mohammed et al. (2017) similarly recovered *R. stolonifer*, *F. oxysporum*, *A. niger*, *A. flavus*, *Penicillium* spp. and *M. racemosus* from potatoes obtained from selected markets in Kaduna metropolis.

International investigations have used both classical morphology and molecular approaches to characterise potato-associated fungi. Gashgari and Gherbawy (2013) used internal transcribed spacer (ITS) sequencing to identify fungi associated with potato blemishes and evaluated the pathogenicity of *Fusarium* isolates. García-Ávila et al. (2018) also documented organisms associated with postharvest damage of potato tubers. These studies demonstrate the value of combining morphological observations with molecular confirmation when species-level resolution is required.

Recent Nigerian studies continue to report fungal spoilage and pathogenicity in marketed potatoes. Fayinminu et al. (2025) investigated fungi causing postharvest decay of Irish potato tubers sold in Makurdi, while Jabaka et al. (2025) examined fungal isolates from Irish potatoes marketed in Birnin Kebbi. Although the fungal composition and frequencies varied among locations, these studies support the relevance of local investigations of postharvest potato spoilage.

Despite evidence from other Nigerian locations, information specific to fungi associated with potato spoilage in Dutse is limited. The present study therefore investigated fungi associated with spoiled Irish potato tubers sold in selected Dutse markets and assessed the pathogenicity of the recovered isolates on healthy potato tubers.

Materials and Methods

Study Area

Samples were obtained from Dutse Ultra-Modern Market, located along Ibrahim Aliyu Bye-pass Road (approximately 11.7600° N, 9.3400° E), and Investment (*Yan Tifa*) Market (approximately 11.7486° N, 9.3403° E), within Dutse metropolis, Dutse Local Government Area (approximately 11.7215° N, 9.3590° E), Jigawa State, northwestern Nigeria. All laboratory work was carried out at Federal University Dutse (approximately 11.7137° N, 9.3686° E).

Sample Collection

Ten spoiled Irish potato tubers were collected from five grocery shops/seller stalls at the two markets and transported in sterile sample bags to the

Microbiology Laboratory, Federal University Dutse. Five tubers were collected from each of the two markets, and the ten tubers were distributed equally among the five shops/stalls, with two tubers obtained from each shop/stall. Each shop/stall was treated as a single sampling unit, and the five shops/stalls correspond one-to-one to the five sample groups designated A–E used throughout this study, with each group therefore comprising two tubers.

Isolation and Purification of Fungi

The spoiled portions of the potato samples were surface-disinfected with 70% alcohol, after which portions of rotten tissue were aseptically excised. One gram of rotten tissue from each sample group (A–E) was homogenised in 9 mL of sterile distilled water, giving a first dilution of 10^{-1}, and a further tenfold dilution was prepared to give a second dilution of 10^{-2}. A 20 mL aliquot of the diluted homogenate was pour-plated onto Potato Dextrose Agar (PDA) per plate, using three plates per sample group corresponding to the two dilutions prepared. This isolation procedure was carried out separately for each of the five sample groups and was repeated five times, giving 15 plates per repetition and a total of 75 plates across the study. Plates were incubated at 28–30 °C for 5–7 days. Following incubation, fungal colonies were examined on the basis of macroscopic characteristics, including colour, size, shape, margin, elevation and texture. Colonies exhibiting distinct morphological characteristics were selected and subcultured onto fresh PDA to obtain pure cultures. Culture-based isolation on potato dextrose agar followed by morphological identification has been reported in related Nigerian potato-spoilage studies (Ibrahim et al., 2014; Mohammed et al., 2017).

The three plates per sample group were distributed as evenly as possible between the two dilution factors, with two plates prepared from the first dilution (10^{-1}) and one plate from the second dilution (10^{-2}).

Morphological and Microscopic Identification

Fungal isolates were identified on the basis of colony morphology, pigmentation, growth pattern and microscopic characteristics, with reference to the Fungal Atlas identification key. A small portion of mycelium was mounted in lactophenol cotton blue and examined microscopically using 10× and 40× objectives. Because no DNA sequencing was performed, the identifications reported in this study are morphology-based and were not molecularly confirmed; species-level assignments are therefore presented as provisional throughout the manuscript.

Pathogenicity Test

One representative isolate of each of the five identified fungal taxa was selected for the pathogenicity assay, on the basis of the distinct colony morphology observed for that taxon during purification, and five healthy tubers were inoculated per fungal taxon. Healthy potato tubers were washed and surface-disinfected. A 5-mm cork borer was used to make an inoculation hole. Approximately 4 mm of agar containing a seven-day-old fungal culture was introduced into the hole and sealed with sterile Vaseline. Five control tubers received uninoculated agar prepared in the same way. Treated tubers were placed singly in sterile polythene bags and incubated at 28–30 °C for 10 days. The tubers were then cut open and the diameter of the resulting rot was measured; the value reported for each taxon is the mean of the measurements taken from the five tubers inoculated with that taxon. No rot developed on the control tubers over the same incubation period. This procedure is comparable to the pathogenicity approach reported by Ibrahim et al. (2014).

Data Analysis

Fungal occurrence was summarised as isolate counts and percentages of the total 31 isolates recovered. Percentages were calculated as the number of isolates of each taxon divided by the total number of isolates and multiplied by 100; they therefore express relative frequency among the recovered isolates and not prevalence among the tubers sampled. Pathogenicity was presented descriptively as the mean rot diameter, in millimetres, of the five tubers inoculated per taxon. Measures of dispersion for the individual tuber measurements were not retained in the available

study record, and no inferential statistical tests were carried out; accordingly, no standard deviations, p-values or claims of statistically significant differences are reported, and differences in mean rot diameter are described rather than tested.

Results

Five fungal taxa were identified from the spoiled potato samples on the basis of cultural and microscopic characteristics: *Aspergillus niger*, *Rhizopus stolonifer*, *Fusarium oxysporum*, *Aspergillus flavus* and *Mucor racemosus*. The number of isolates of each taxon recovered from each of the five sample groups is presented in Table 1.

Table 1. Number of fungal isolates recovered from each sample group, and the relative frequency of each taxon among the 31 isolates recovered.

Fungal taxon	Sample A	Sample B	Sample C	Sample D	Sample E	Total	Frequency (% of 31 isolates)
Aspergillus niger	2	2	0	2	1	7	22.6
Rhizopus stolonifer	3	0	3	2	2	10	32.3
Fusarium oxysporum	0	2	1	3	0	6	19.4
Aspergillus flavus	1	1	2	0	0	4	12.9
Mucor racemosus	1	1	0	2	0	4	12.9
Total	7	6	6	9	3	31	100.0

Samples A–E denote the five sample groups, each corresponding to one seller/shop from which the spoiled tubers were obtained. Values in columns A–E are counts of individual fungal isolates, not numbers of tubers.

The frequencies were calculated from the 31 isolates recovered in the study. *Rhizopus stolonifer* was the most frequently recovered fungus, accounting for 10 isolates (32.3%), followed by *Aspergillus niger* with 7 isolates (22.6%) and *Fusarium oxysporum* with 6 isolates (19.4%). *Aspergillus flavus* and *Mucor racemosus* each accounted for 4 isolates (12.9%). These percentages express the relative frequency of each taxon among the recovered isolates and are not a measure of the proportion of potato tubers infected by each taxon, since more than one isolate could be recovered from the same tuber.

All five isolates tested produced visible rot on the inoculated healthy tubers. *Rhizopus stolonifer* produced the largest mean rot diameter (32 mm), followed by *Aspergillus niger* (25 mm), *Aspergillus flavus* (20 mm), *Fusarium oxysporum* (16 mm) and *Mucor racemosus* (14 mm). The mean rot diameters recorded for each taxon are presented in Table 2.

No rot developed on the control tubers over the 10-day incubation period, confirming that the rot observed in the inoculated tubers resulted from the introduced fungal isolates rather than from the inoculation procedure itself.

Table 2. Mean rot diameter recorded 10 days after inoculation of healthy potato tubers; five tubers were inoculated per fungal taxon.

Fungal taxon	Mean rot diameter (mm), n = 5 tubers
Aspergillus niger	25
Rhizopus stolonifer	32
Fusarium oxysporum	16
Aspergillus flavus	20
Mucor racemosus	14
Control (uninoculated)	0

Discussion

The recovery of five fungal taxa from spoiled potato tubers in Dutse indicates that the sampled market tubers harboured a diverse fungal community. The organisms identified were *Aspergillus niger*, *Rhizopus stolonifer*, *Fusarium oxysporum*, *Aspergillus flavus* and *Mucor racemosus*. This pattern is broadly consistent with reports from other potato-producing and market environments, where several fungal genera may occur together in postharvest-decayed tubers (Ibrahim et al., 2014; Mohammed et al., 2017; García-Ávila et al., 2018). Recovery from naturally spoiled tubers establishes an association between these fungi and market spoilage; it does not by itself show that every recovered taxon caused the spoilage observed in the market, and the wording used throughout this manuscript distinguishes association from the experimental evidence obtained in the pathogenicity assay.

Rhizopus stolonifer was the most frequently recovered isolate in the present study, accounting for 10 of the 31 isolates recovered (32.3%). This predominance agrees with Ibrahim et al. (2014), who reported *R. stolonifer* as the most frequent fungus recovered from rotten Irish potato tubers in Sokoto. The recurrence of *R. stolonifer* in studies from northwestern Nigeria suggests that it is an important potato-associated postharvest fungus. Nevertheless, the relative frequency of individual fungi can vary with location, potato source, environmental conditions, handling practices and sampling design.

Aspergillus niger accounted for seven isolates (22.6%) and was the second most frequently recovered taxon in this study. Its recovery is also consistent with previous reports of *Aspergillus* species from spoiled potato tubers. *Fusarium oxysporum* accounted for six isolates (19.4%), while *Aspergillus flavus* and *Mucor racemosus* each accounted for four isolates (12.9%). The presence of these taxa is comparable with Nigerian studies that have recovered combinations of *Rhizopus*, *Aspergillus*, *Fusarium*, *Mucor* and *Penicillium* from postharvest-rotted potatoes (Ibrahim et al., 2014; Mohammed et al., 2017).

The differences in frequency among the fungal taxa may reflect differences in their ability to colonise damaged tuber tissues and their response to conditions present before and after harvest. Mechanical injury, storage environment and handling practices can influence the development of postharvest decay (Bojanowski et al., 2013; Liu et al., 2022). These explanations are plausible for the present findings, but the study did not experimentally measure the storage conditions or determine the factors responsible for the observed differences; therefore, they should not be interpreted as demonstrated causes.

The pathogenicity assay showed that a representative isolate of each of the five taxa produced visible rot on healthy potato tubers under the conditions used, which is experimental evidence that these taxa can initiate rot in sound tuber tissue. *Rhizopus stolonifer* produced the largest mean rot diameter (32 mm), followed by *A. niger* (25 mm), *A. flavus* (20 mm), *F. oxysporum* (16 mm) and *M. racemosus* (14 mm). This indicates variation in the observed extent of rot produced by the isolates during the assay. Similar experimental approaches have been used to demonstrate pathogenicity among fungi associated with potato deterioration (Gashgari & Gherbawy, 2013; Fayinminu et al., 2025; Jabaka et al., 2025).

The pathogenicity results still require cautious interpretation. Although five tubers were inoculated per taxon, the individual tuber measurements underlying each mean were not retained in the available study record, so measures of variation could not be calculated and no statistical comparison between taxa was possible. The order of mean rot diameters should therefore be treated as a descriptive observation and not as a statistically established ranking of virulence. Experiments in which the individual replicate measurements are retained and analysed statistically would be needed to determine whether the differences between taxa are real.

The morphology-based identification used in this study was suitable for preliminary laboratory characterisation, but it has limitations for definitive species-level identification. Closely related fungi may show overlapping cultural and microscopic

features, and molecular methods such as ITS sequencing can provide stronger taxonomic resolution. Previous potato studies have combined morphological and molecular approaches for characterisation of associated fungi (Gashgari & Gherbawy, 2013; Stefańczyk et al., 2016).

The occurrence of *Aspergillus flavus* is relevant to food safety because some strains of this species can produce aflatoxins, and *Fusarium* species associated with potato dry rot are likewise capable of mycotoxin production (Xue et al., 2023). However, the present study did not test isolates for mycotoxin production. Therefore, the detection of *A. flavus* should not be interpreted as evidence that the isolates produced aflatoxin or other mycotoxins. Future work would need dedicated chemical or molecular analyses to address that question.

From a postharvest management perspective, the findings support the importance of minimising tuber injury, maintaining hygienic handling and storage conditions, and removing visibly spoiled tubers from healthy stocks. Such measures are consistent with broader approaches to reducing potato postharvest decay (Bojanowski et al., 2013; Liu et al., 2022).

This study has several limitations. Only ten spoiled tubers from five sellers in two markets were examined, which restricts generalisation to other markets, seasons and potato sources. Identification was based on cultural and microscopic characteristics and was not confirmed by molecular methods such as ITS sequencing, so species-level assignments remain provisional. Although five tubers were inoculated per taxon, the individual replicate measurements were not retained, so variation could not be quantified and the taxa could not be compared statistically. Finally, mycotoxins were not measured, so the recovery of *Aspergillus flavus* or any other taxon cannot be read as evidence of toxin production.

Several points follow for future work and for practice. Larger sample sizes, more markets and repeated sampling across seasons would improve the representativeness of findings for Dutse and Jigawa State. Isolates of interest should be confirmed by validated molecular methods, such as ITS-region sequencing, alongside morphological examination. Pathogenicity experiments should retain and report the individual replicate measurements and apply appropriate statistical analysis so that rot development between taxa can be compared objectively. In handling and marketing, bruising and other mechanical injury should be minimised and visibly decayed tubers separated from healthy stock. Practical postharvest interventions and storage conditions that limit fungal development deserve direct evaluation, and where food safety is at issue, mycotoxin production should be measured analytically rather than inferred from the identity of the fungi recovered.

Conclusion

Five fungal taxa which are *Aspergillus niger*, *Rhizopus stolonifer*, *Fusarium oxysporum*, *Aspergillus flavus* and *Mucor racemosus*, were identified by morphology from spoiled Irish potato tubers sold in two Dutse markets. *R. stolonifer* was the most frequently recovered taxon, accounting for 10 of the 31 isolates (32.3%), ahead of *A. niger* (7; 22.6%), *F. oxysporum* (6; 19.4%), *A. flavus* (4; 12.9%) and *M. racemosus* (4; 12.9%).

A representative isolate of each taxon produced rot when inoculated into healthy tubers, with mean rot diameters after 10 days ranging from 14 mm for *M. racemosus* to 32 mm for *R. stolonifer*. The study therefore identifies the fungi associated with potato spoilage in the markets sampled and shows that each of the five taxa can initiate rot in sound tubers under the assay conditions used. Because identification rested on morphology alone and the individual replicate measurements were not available, the differences in mean rot diameter are offered as descriptive observations rather than as an established ranking of pathogenicity, and the findings should not be generalised beyond the markets sampled.

Acknowledgement

The author is grateful to the staff of the Microbiology Laboratory, Federal University Dutse, for providing access to the laboratory facilities used in this study. No external funding was received for this research.

Author Contributions

HBM conceived and designed the study, collected the samples, carried out the laboratory work, MA analysed the data, and prepared the manuscript. All the authors read and approved the final version.

Conflict of Interest

The author declares that there is no conflict of interest.

References

Bojanowski, A., Avis, T. J., Pelletier, S., & Tweddell, R. J. (2013). Management of potato dry rot. *Postharvest Biology and Technology*, 84, 99–109. https://doi.org/10.1016/j.postharvbio.2013.04.008

Camire, M. E., Kubow, S., & Donnelly, D. J. (2009). Potatoes and human health. *Critical Reviews in Food Science and Nutrition*, 49(10), 823–840. https://doi.org/10.1080/10408390903041996

Fayinminu, A. O., Liamngee, K., Gbira, T., Fru, N. G., Rekiya, Y., Mohammad, A., Kum, A. B., Mbateng, L. W., Ligom, T. G., & Awua, D. T. (2025). Identification and pathogenicity of fungi causing postharvest decay of Irish potato (*Solanum tuberosum* L.) tubers sold in Makurdi. *European Journal of Ecology, Biology and Agriculture*, 2(1), 1–13. https://doi.org/10.59324/ejeba.2025.2(1).01

García-Ávila, C. J., Valenzuela-Tirado, G. A., Florencio-Anastasio, J. G., Ruiz-Galván, I., Moreno-Velázquez, M., Hernández-Macías, B., López-Buenfil, J. A., Bravo-Pérez, D., Pineda-Ríos, J. M., Quezada-Salinas, A., & Ávila-Quezada, G. (2018). Organisms associated with damage to post-harvest potato tubers. *Revista Mexicana de Fitopatología*, 36(2), 308–320. https://doi.org/10.18781/R.MEX.FIT.1801-1

Gashgari, R. M., & Gherbawy, Y. A. (2013). Pathogenicity of some *Fusarium* species associated with superficial blemishes of potato tubers. *Polish Journal of Microbiology*, 62(1), 59–66. https://doi.org/10.33073/pjm-2013-007

Gherbawy, Y. A., & Gashgari, R. M. (2013). Mycobiota associated with superficial blemishes of potato tubers. *Food Biotechnology*, 27(2), 137–151. https://doi.org/10.1080/08905436.2013.781947

Ibrahim, M., Shehu, K., Sambo, S., Tukur, U., Umar, I. A., & Tafinta, I. Y. (2014). Identification of fungi associated with storage rots of Irish potato (*Solanum tuberosum* L.) tubers in Sokoto Metropolis. *Annals of Biological Sciences*, 2(2), 1–4.

Jabaka, R. D., Benjamin, R., Suleiman, A., Nuhu, U. D., Muhammad, A., Isah, M., Tomo, F. A., Yanna, Y., Saadu, M., & Galadima, S. I. (2025). Pathogenicity testing of fungal species isolated from Irish potatoes. *International Journal of Pathogen Research*, 14(4), 98–106. https://doi.org/10.9734/ijpr/2025/v14i4380

Liu, J., Sun, Z., Zou, Y., Li, W., He, F., Huang, X., Lin, C., Cai, Q., Wisniewski, M., & Wu, X. (2022). Pre- and postharvest measures used to control decay and mycotoxigenic fungi in potato (*Solanum tuberosum* L.) during storage. *Critical Reviews in Food Science and Nutrition*, 62(2), 415–428. https://doi.org/10.1080/10408398.2020.1818688

Mohammed, S. S. D., Ndalati, A. G., Wartu, J. R., Afangide, C. S., & Aigbogun, E. I. (2017). Mycological assessments of postharvest rot of Irish potato tubers from selected markets within Kaduna metropolis, Nigeria. *Asian Journal of Science and Technology*, 8(6), 4981–4984.

Ovchinnikova, A., Krylova, E., Gavrilenko, T., Smekalova, T., Zhuk, M., Knapp, S., & Spooner, D. M. (2011). Taxonomy of cultivated potatoes (*Solanum* section *Petota*: Solanaceae). *Botanical Journal of the Linnean Society*, 165(2), 107–155. https://doi.org/10.1111/j.1095-8339.2010.01107.x

Spooner, D. M., McLean, K., Ramsay, G., Waugh, R., & Bryan, G. J. (2005). A single domestication for potato based on multilocus amplified fragment length polymorphism genotyping. *Proceedings of the National Academy of Sciences of the United States of America*, 102(41), 14694–14699. https://doi.org/10.1073/pnas.0507400102

Stefańczyk, E., Sobkowiak, S., Brylińska, M., & Śliwka, J. (2016). Diversity of *Fusarium* spp. associated with dry rot of potato tubers in Poland. *European Journal of Plant Pathology*, 145, 871–884. https://doi.org/10.1007/s10658-016-0875-0

Xue, H., Liu, Q., & Yang, Z. (2023). Pathogenicity, mycotoxin production, and control of potato dry rot caused by *Fusarium* spp.: A review. *Journal of Fungi*, 9(8), 843. https://doi.org/10.3390/jof9080843