FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 1, January, 2026, pp 161 – 165
DOI: https://doi.org/10.33003/fjs-2026-1001-4523

# POST-HARVEST FUNGAL PATHOGENS OF ONION BULBS SOLD IN MARKETS IN JOS METROPOLIS, NIGERIA

**[*1]Dinchi P. Telzin, [1]Nanven A. Damdam, [2]Ibrahim I. Iro, [1]Shakirdeen M. Obidola, [3]Ojochogu Dogun and [1]Lawal I. Habib**

[1]Crop Production Technology Department, Federal College of Forestry, Jos, Plateau State, Nigeria.
[2]Agricultural Technology Department, Federal College of Forest Resources Management Maiduguri, Borno State, Nigeria.
[3]Science Laboratory Department, Federal College of Forestry, Jos, Plateau State, Nigeria.

*Corresponding authors' email: dinchizwalnan@gmail.com…Phone: +2348060198849

## ABSTRACT

Onions (*Allium cepa* L.) are an important vegetable crop in Nigeria, contributing substantially to food security and economic sustainability. However, post-harvest fungal spoilage remains a major constraint, resulting in considerable losses. This study investigated the fungal pathogens associated with onion bulb deterioration in markets within the Jos metropolis, Plateau State, Nigeria. A total of 180 onion bulbs were sampled from four major markets, including 120 visibly spoiled bulbs collected directly from vendors and cultured on Potato Dextrose Agar. In addition, 120 apparently healthy bulbs from the same markets were monitored for fungal infection and spoilage progression over a three-week period, while 40 bulbs (10 per market) served as controls. Data were analyzed using descriptive statistics, including frequencies and percentages. Four fungal species were isolated and identified: *Aspergillus niger*, *Cladosporium cladosporioides*, *Fusarium oxysporum*, and *Penicillium citrinium*. *Aspergillus niger* was the predominant pathogen, recording the highest frequency of occurrence, spoilage rate (99.9%), disease incidence, and associated weight loss. This was followed by *C. cladosporioides* (40%), *F. oxysporum* (33.33%), and *P. citrinium* (19.97%). The results confirm that these fungi are key contributors to post-harvest onion bulb decay in the study area. Some of the isolated fungi are also of public health concern, while others accelerate product deterioration. Effective control of contamination during harvesting, handling, storage, and distribution is therefore essential to reduce spoilage, minimize economic losses, and lower the risk of food-borne illnesses associated with raw onion consumption.

**Keywords**: Isolation, Fungi, Spoilage, Post-harvest, *Allium cepa* (Onion bulb)

## INTRODUCTION

Onion (*Allium cepa* L.) is an important vegetable crop in Nigeria based on consumption and economic value to farmers. It is one of the most important and familiar spice crops that is consumed throughout the world (Zhao *et al.*, 2021). The crop is grown for its bulbs, which are harvested in most countries once a year and are used daily in every home for seasoning and flavoring of food (Onuorah and Ifeanyi, 2015). Onion is a valuable ingredient in the diet due to its content of sugar, vitamins and minerals, electrolytes, protein, and dietary fiber (Adeoye *et al*., 2022).

Onion is one of the major vegetable bulb crops of the word and important commercial crop grown. (Roopa *et al*., 2014). At the global scale, onion is one of the highest-volume vegetable crops. Recent analyses by (FAO 2024) place world onion production as the second most produced vegetable at 111 million tonnes annually and has shown a strong increase (40-56%) between the year 2010- 2023. Major producers remain countries such as India and China, and production and value-chain studies show the crop's growing market importance and policy attention in countries across Africa, Asia and beyond. In Nigeria, production is concentrated mostly in the dry tropical zone of the north and it is a major source of income for farmers (Tambuwal, 2011).

Numerous benefits have been attributed to onion which includes; prevention of cancer and cardiovascular disorder, reduction in the blood levels of cholesterol, reduction in osteoporosis, reduction in stomach ulcers, inhibition of the proliferation of cultured ovarian, breast and colon cancer cell, inhibition of platelets media and thrombosis, prevention of inflammatory processes associated with asthma treatment of fever, common cold, cough, sore threat and its use as an antimicrobial agent (Adebajo and Uzeh, 2009). A study by Jola, 2013 revealed that onions also possess the ability of building connective tissue and bone health due to a newly identified substance in it called Growth Plate Chondrocytes (GPCs). Hence onions are very beneficial for women who are at risk for osteoporosis. Onion is known to be useful in treating urinary disorders because of the diuretic properties. Onions are good source of dietary fiber and pre-biotic that encourage the growth of good bacteria (probiotics) in the digestive system, thereby improving digestive function.

During storage, some losses occur due to sprouting, drying and rotting. Bulb rots are a common cause of onion loss during storage. They are caused by micro-organisms particularly fungi. The black mold disease caused by *Aspergillus niger* is a limiting factor in onion production worldwide (Tyson, 2014). *Aspergillus niger* has been reported to survive between onion crops as a soil saprophyte in or on bulbs in field or storage and is ubiquitous in nature. The fungi invade bulbs of onion in field or storage whenever they find injured tissues by producing various enzymes or toxin. The fungus has also been associated with onion seed produced in hot climates and heir transmission from soil and naturally contaminated seeds to onion seedlings cause 30 – 80% loss or spoilage of onion bulbs. Unfavorable environmental conditions during harvest transit, storage and marketing may favor spoilage (Muhammad *et al.*, 2004). *Aspergillus niger* also causes black mold at the necks of onion. Bruised onions are more susceptible to this fungus, although low temperature storage delays growth of the fungus exposure of infected onions to temperatures above 15 $^{0}$C, as occurs during marketing will accelerate its growth. Onion are susceptible to Botryis neck blue mold caused by Penicillium rot, during storage, the infection usually spreads quickly through the whole onion. Bruising of onion bulbs during harvesting, storing under humid condition and exposing the inner tissue due to breakage of outer scales increase the incidence of Botrytis neck rot. Curing onions prior to storage and minimizing mechanical damage often reduces the incidence of this fungus (Shika & Dough, 2001).

Fungal infections can also increase the chances of contamination by mycotoxins which are potential hazards to human and animal health. These toxins have been reported to cause neurological disorders, cancer of the liver and lung. Storage rots leads to a reduction in the quality and quantity of onion which affects the market value and creates a great problem (Muhammad and Shehu 2004). The objective of the study therefore is to determine the fungi associated with the post-harvest spoilage of onion bulbs and to determine the rate of spoilage caused by the fungi identified.

## MATERIALS AND METHODS

### Study Site

This study was conducted within Jos Metropolis, the administrative and commercial center of Plateau State, located in the North-Central region of Nigeria. The city experiences a temperate tropical climate characterized by relatively cool temperatures (18–25°C), distinct wet and dry seasons, and moderate relative humidity. These environmental conditions influence both agricultural production and the storage behavior of perishable commodities such as onion bulbs.

### Samples Collection

Thirty (30) samples of spoiled onions were collected each from four different Jos Metropolis markets, including katako Market, Farin-Gada Market, New market and Building Materials Market. Sixty (60) fresh onions were later collected from each market, making it a total of 360 onion samples. Using the technique outlined by Okungbowa and Shittu (2014), selection criteria were based on obvious spoiling symptoms such as softening, discoloration, moldy spots, watery disintegration, and disagreeable odor. Each sampled bulb was placed into sterile, clearly labeled polyethylene bags and brought to the microbiology laboratory of the federal college of forestry, Jos in an ice-filled cooler for further analysis.

### Sample Preparation

Standard mycological methods were used to prepare the sample in order to accurately isolate the fungi linked to onion bulb post-harvest deterioration.

Each onion bulb's exterior scales were cleansed in the lab to get rid of any dirt or debris that might have stuck to them. According to Fawole and Oso (2004), surface sterilization was carried out by submerging the bulbs in 70% ethanol for 30 seconds and then rinsing them in sterile distilled water. Only internal or infection-related fungi were isolated. The bulbs were aseptically sliced open with a sterile knife, and tissue pieces exhibiting active spoiling were removed from the area (Barnett & Hunter, 1998).

### Preparation of Potato Dextrose Agar (PDA) for Isolation of Fungi

Three hundred grams (300g) of peeled potatoes, 30g of agar, 22.5g glucose and 1.5 litres of distilled water were used to prepare Potato Dextrose Agar. The peeled potato tubers were cut into pieces with a sterile knife, weighed, washed and boiled. The potato was then mashed in the boiling water and sieved to obtain the potato extract. The 22.5g of glucose was then added to the potato extract and stirred thoroughly, using a stirrer. The agar was melted in the potato glucose mixture in a beaker and was then topped with distilled water to a 1.5litre. it was then sterilized in an autoclave for 30min left to cool and dispensed into sterilized petri dishes.

### Isolation of Spoilage Organisms

Following normal procedure for fungal isolation, the tissue pieces were subsequently inoculated onto Potato Dextrose Agar (PDA) treated with chloramphenicol (50 mg/L) to inhibit bacterial growth (Aneja, 2003). For three to seven days, inoculated plates were incubated at 25-28 °C, and fungal growth was checked every day, emerging fungal colonies were sub-cultured onto brand-new PDA plates to create pure cultures. Using the taxonomic keys of Barnett and Hunter (1998), each isolate was then preserved for later morphological and microscopic identification.

### Identification of Fungal Isolates

The fungi isolate was identified using microscopic examination. This was carried out using a drop of lacto-phenol on a clean grease - free slide and a fragment of the test fungus removed and introduced onto the slide with the aid of sterile straight wire loop. The fungus was spread properly on the slide, and then covered with a cover slip, while avoiding bubbles in the process. The excess stain was blotted with filter paper and the slide was then viewed under the microscope.

### Pathogenicity Test of the Fungal Isolates

The pathogenicity test was carried out using the methods of Baiyewu *et al*., 2007 and Chukwuka *et al*., 2010. Fresh health onion bulbs were disinfected with ethanol, a sterile `cork-borer was used to make holes in each onion bulb and each of the isolated fungi was inoculated into the onion bulbs after which the cork of the onion bulb was replaced. Vaseline jelly was used to seal the holes to prevent contamination. Some onion bulbs were also wounded with the cork borer but were not inoculated with the fungi rather with water, this was used as a control. The inoculated onion bulbs and the controls were placed in a sterile environment for seven days.

### Determination of Disease Incidence Percentage

The rate of spoilage of onion bulbs was determined within four (3) weeks of storage and readings were taken after every (3) days. The extent of spoilage was determined using the formula of Raju & Naik (2007) stated below:

$$\text{Percentage of disease incidence} = \frac{\text{Number of infected bulbs}}{\text{total number of bulbs}} \text{ X } 100 \quad (1)$$

### Statistical Analysis

Descriptive statistics such as frequency, means, and percentages were used in the analysis of collected data.

## RESULTS AND DISCUSSION

The study was focused on the identification and isolation of post-harvest fungi on onion bulbs where four (4) different fungi were identified and isolated from four different markets. The fungi isolated and identified were: *Aspergillus niger*, *Fusarium solani*, *Cladosporium cladosporioides* and *Penicillium chrysogenum* as shown in Plates 1-4 below.

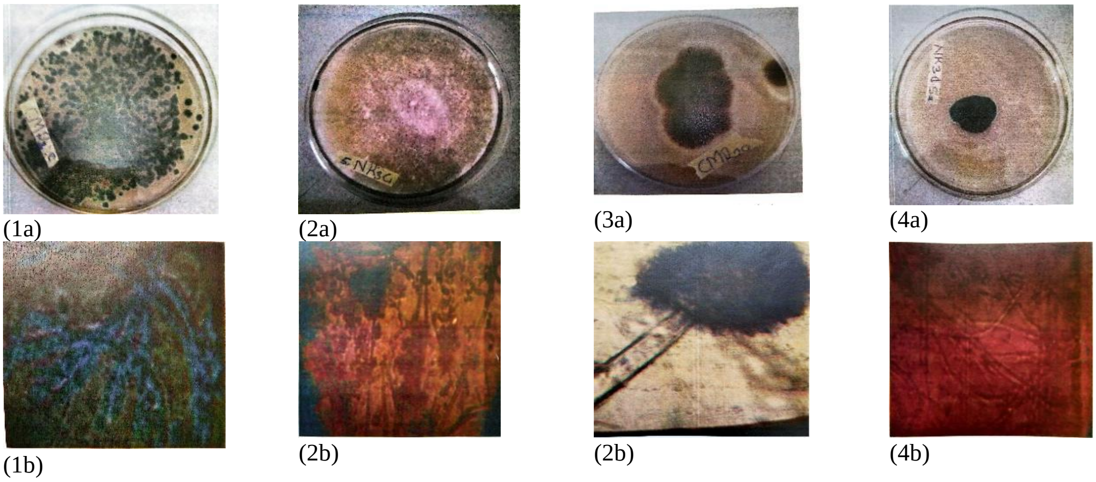


Figure 1: Macroscopic and Microscopic characteristics of *Penicillium chrysogenum*(1a ,b), *Fusarium solani* (2a,b), *Aspergillus niger* (3a, b) and *Cladosporium cladosporiodes*

Table 1 shows the fungal isolates that were obtained from deteriorated onion bulbs from the four sampled markets. The results identified *Aspergillus niger* appearing in three locations, Building Material, Chobe Market, and Farin-gada Market making it the most widespread and dominant fungal specie across the areas sampled. *Fusarium oxysporum* was found in the Building Material and Farin-gada Market locations, indicating that it is moderately distributed. New Market showed the highest fungal diversity, with three different fungi (*Aspergillus niger.*, *Penicillium citrinium*, and *Fusarium solani*), suggesting a more varied environmental contamination compared to the other markets. Chobe Market and Farin-gada Market each contain two species, but one of these is *A. niger*, further highlighting its prevalence. Some fungi such as *Cladosporium cladosporioides* and *Penicillium chrysogenum* appeared only in one specific location, implying that their presence may be influenced by local environmental conditions. Overall, the table suggests that while several fungal species are present, *A. niger* is the most commonly encountered across the different markets.

**Table 1: Fungal Species Isolated from Spoiled Onion Bulbs across Various Markets**

| Markets | Fungal Species isolated |
|---|---|
| Building material | *Aspergillus niger ,Fusarium solani* |
| New market | *Aspergillus niger, Penicillium chrysogenum ,Fusarium solani* |
| Chobe market | *Aspergillus niger & Claadosporium cladosporioides* |
| Farin-gada market | *Aspergillus niger & Fusarium solani.* |

The percentage distribution on table 2 shows that *Aspergillus niger* was the most dominant fungal species across all markets, accounting for 44.4% of the total isolates and appearing in every sampled location. *Fusarium solani* is the second most common specie, representing 33.3% of the isolates and occurring in three of the markets. The other species *Penicillium chrysegenum* and *Cladosporium cladosporioides* each contributed 11.1%, indicating that they were less frequently encountered and limited to specific environments.

**Table 2: Percentage Distribution of the Fungal Isolates in Relation to the Markets**

| Fungal Species | Frequency | Percentage (%) |
|---|---|---|
| *Aspergillus niger* | 4 | 44.4 |
| *Fusarium solani* | 3 | 33.3 |
| *Penicillium chrysogenum* | 1 | 11.1 |
| *Cladosporium cladosporioides* | 1 | 11.1 |

The study on percentage weight loss (table 3) showed that after three weeks, the onions from the building materials area lost the most weight, at 33%, while the onions from New market lost the least weight, at 24%.

**Table 3: Percentage Weight Loss of Onion Bulbs at Four Different Markets**

| | Market | Initial weight (g) | Final weight (g) | % Weight loss |
|---|---|---|---|---|
| 1 | Building material | 1124 | 777 | 31 |
| 2 | New market | 1123 | 848 | 24 |
| 3 | Chobe market | 1126 | 745 | 27 |
| 4 | Farin-gada market | 1105 | 830 | 25 |

Table 4 shows the percentage incidence of disease on onion bulbs which varied widely across the four markets surveyed. The Building Material market recorded the highest incidence at 100%, indicating that all onion bulbs examined were infected. Chobe Market showed a moderately high incidence of 40%, New Market had an incidence of 20%, while Farin-gada Market recorded a lower incidence of 3.3%.

**Table 4: Percentage Incidence of the Disease on Onion Bulbs in Four Different Markets**

| Market | Number of onion collected | Number of infected onion bulb | Average no of infected bulbs | Percent incidence (%) |
|---|---|---|---|---|
| Building material | 15 | 15 | 5 | 100 |
| New market | 15 | 3 | 1 | 20 |
| Chobe | 15 | 6 | 2 | 40 |
| Farin-gada | 15 | 5 | 2 | 3.3 |
| **Total** | **60** | **29** | **10** | |

**Discussion**

The present study identified four different species of fungi which are *Aspergillus niger, Fusarium solani, Penicillium* chrysogenum and *Cladosporium cladosporiodes*. Similar findings were reported by Jidda and Benjamin (2016) except the presence of *Pencillium spp* and *Cladosporium spp.* However, they hence reported the presence of *Sclerotium cepivorium, Rhizopus stolonifer, Scopulariopsis brevicaulis, Candida tropicalis* and *Saccharomyces cerevisiae* in the rotten tissue of the onion bulbs. Overall, the results highlight *Aspergillus niger* as the most widespread contaminant, with *Fusarium spp* also showing significant presence, while the remaining fungi appear more sporadically. This is in agreement with the findings of Ara *et al*., (2008), Adongo *et al*., (2015), and Ko *et al*., (2002). According to (Tyson 2014), the black mould disease caused by *Aspergillus niger* is a limiting factor in onion production Worldwide.

Disease incidence in onion bulbs varied widely across the surveyed markets, the Building Material market showed the highest infection rate at 100%, suggesting highly unfavorable storage environments that promote pathogen spread. Chobe Market recorded a moderately high incidence of 40%, while Farin-gada Market had a very low incidence of 3.3%, likely due to improved curing, sanitation, and reduced humidity. The New Market, with 20% incidence, occupied an intermediate position, indicating better management than Building Material and Chobe but less effective than Farin-gada.

these findings illustrate that disease incidence in onion bulbs is not uniform across markets but is strongly influenced by storage conditions, handling practices, and environmental factors. The stark contrast between the Building Material market and Farin-gada could be as a result of differences in postharvest management which can dramatically alter disease outcomes. This has significant implications for food security and market economics, as high levels of postharvest loss reduce both the quantity and quality of onions available for domestic consumption and export as observed by (Shehu *et al.*, 2024; Avani 2024)

The investigation confirmed that *Aspergillus niger* is the most aggressive fungal pathogen associated with onion bulbs, during postharvest storage. It was consistently observed to cause extensive rot and black mold, making it the dominant contributor to postharvest losses. This finding is in agreement with earlier reports by Samuel and Ifeanyi (2015), Muhammad *et al*, 2014, Dimkpa and Onuegbu, 2010 and Sharma (2023), who all identified *A. niger* as the principal pathogen responsible for black mold in onions. Recent studies further support this conclusion. Esuola *et al*., (2025) demonstrated that strains of *Aspergillus* including *A. niger*, are prevalent in onion bulbs sold in Nigerian markets, producing secondary metabolites such as fumonisins and ochratoxins that exacerbate bulb deterioration. Similarly, Shehu *et al*., (2024) documented multiple fungal species associated with onion rot in northwestern Nigeria, with *A. niger* consistently emerging as one of the most pathogenic fungal organisms. Earlier work by Ko *et al*., (2002) and Sowle *et al*., (2019) suggested that black mold caused by *A. niger* becomes particularly severe under ambient storage conditions, implying that environmental factors strongly influence disease severity. Narayana *et al.*, (2007) also highlighted the toxic spectrum of *A. niger*, noting its phytotoxic and cytotoxic effects on onions and other crops.

The present research indicates that the aforementioned fungi are responsible for the post-harvest spoilage in onion bulbs, these fungi constitute a menace in the storage of many agricultural commodities including fruit, vegetables and nuts.

**CONCLUSION**

This study establishes fungal infestation as a major cause of post-harvest onion bulb spoilage in Nigeria, with *Aspergillus niger*, *Fusarium solani*, *Penicillium chrysogenum*, and *Cladosporium* spp. identified as the principal pathogens associated with bulb rot in market samples. These fungi not only accelerate post-harvest deterioration and economic losses but also present significant public health concerns due to their potential to produce harmful mycotoxins. The findings underscore the critical role of contamination control throughout the onion value chain, particularly during harvesting, handling, storage, transportation, and market distribution. Effective post-harvest management practices, including proper curing, hygienic handling, careful packaging, and improved storage conditions, are essential to minimize fungal proliferation and reduce consumer exposure to contaminated bulbs. Furthermore, the study highlights the importance of pre-harvest production decisions, which strongly influence post-harvest quality and shelf life. Since onion quality cannot be enhanced after harvest but only preserved, an integrated approach that combines sound agronomic practices with improved post-harvest handling is imperative for reducing spoilage, safeguarding public health, and enhancing the overall quality and marketability of onions in Nigeria.

**REFERENCES**

Adebajo, S. A., & Diyaolu, S. A. (2003). Mycology and spoilage of retail cashew nuts. *African Journal of Biotechnology, 2*(10), 369–373. https://www.ajol.info/index.php/ajb/article/view/14941

Adeoye, I. B., Oyedele, O. O., Adebisi-Adelani, O., Idris, B. A., & Shuaibu, M. (2022). Assessment of information, training needs and challenges of onion producers in Kano and Kebbi States, Nigeria. *Nigerian Journal of Horticultural Science*, *26*(3), 118–130. https://hortson.org.ng/images/Journals/2022volume/Adeoye_et_al_2022_compressed.pdf

Adongo, B. A., Kwoseh, C. K and Moses, E. (2015). Storage rot fungi and seed-borne pathogens of onion. *Journal of Bangladesh Agricultural University,* 35(2): 13-21. DOI: https://10.4314/just.v35i2.2.

Ara, M. A. H., Khatun, M. L., & Ashrafuzzaman, M. (2008). Fungi causing rot in onions at storage and market. *Journal of*

*Bangladesh Agricultural University*, *6*(2), 245–251. https://www.banglajol.info/index.php/JBAU/article/view/4826.

Baiyewu, R. A., Musa, N. A., Ayoola, O. A., & Babalola, O. O. (2007). Survey of the post-harvest disease and aflatoxin contamination of marketed pawpaw fruit (*Carica papaya* L.) in South Western Nigeria. *African Journal of Agricultural Research*, *2*(4), 178–181. http://www.academicjournals.org/AJAR/PDF/pdf2007/Apr/Baiyewu%20et%20al.pdf

Barnett, H. L. and Hunter, B. B. (1998). Illustrated Genera of Imperfect Fungi. 4th edition. APS Press, St Paul, Minnesota.C. https://apsnet.org/apsstore/Pages/41922.aspx

Benkelia N. (2004). Antimicrobial activity of essential oil extracts of various onions (*Allium cepa*) and garlic (*Allium sativum*). Food science and technology, 37(2):263-268. DOI: https://10.1016/j.lwt.2003.09.001.

Chukwuka K. S., Okonko I. O., and Adekinle A. A (2010). Microbial ecology of organism causing Paw-paw (*Carica Papaya L*.) fruit decay in Oyo State, Nigeria. *American Eurasian Journal of toxicological science* 2(1):43– 50. http://www.idosi.org/aejts/2(1)10/7.pdf

Dimkpa S. and Onuegbu B. A. (2010). Microflora of copra and effect of bringing on some properties of copra in Nigeria. *Agriculture and biology Journal of North America*. 1(3): 391-394. http://www.idosi.org/abjna/abjna1(3)10/17.pdf

Emam, A. A. (2011). Evaluating marketing efficiency of tomato in Khartoum State, Sudan. *Journal of Agriculture & Social Sciences*, *7*(1), 21–24. https://www.fspublishers.org/published_papers/41634.pdf

Esuola C. O and Ortega-Beltran A. (2025). Fumonisin and ochratoxin-producing strains of *Aspergillus* sector Nigri are associated with onion (*Allium cepa* L.) bulbs sold in markets in Southwest Nigeria. *Frontiers Fungal biology*. 6:1563824. DOI: https://10.3389/ffunb.2025.1563824.

FAO. (2024). Agricultural production statistics 2010–2023. FAOSTAT Analytical Briefs, No. 96. Rome. https://openknowledge.fao.org/handle/20.500.14283/cd3755en.

Jidda, M. and Benjamin F. (2016), Identification of Fungi Associated with Storage Bulb Rot and Seed of Onion (*Allium cepa* L.) in Maiduguri, Northeastern Nigeria, *International Journal of Modern Botany*, 6 (2), pp. 26-30. DOI: https://10.5923/j.ijmb.20160602.02

Ko. S., Huang. J., Wang, J., Subramanyam. S. and Chang, W. (2002). Evaluation of onion cultivars for resistance to A*spergillus niger*. the causal agent of black mold. *Journal of American Society of Horticultural Science. 127(4): 697-702.*

Muhhamd S., Shehu K., Amusa N. A. (2004). survey of market disease and aflatoxin contamination of fruit and vegetable in Sokoto, North Western Nigeria. *Nutrition and food science*, 34(2):72-76. DOI: https://10.1108/00346650410529032.

Narayana K. J, Srikanth M., Vijayalakshmi M, *et al*. (2007). Toxic Spectrum of *Aspergillus niger* causing black mold rot of Onions. *Research Journal of Microbiology*. 2(11):881-884. DOI: https://10.3923/jm.2007.881.884.

Onuorah S. and Ifeanyi O. (2015). Fungi Associated with the deterioration of Post-Harvest Onion bulb sold in some markets in Akwa, Nigeria. *Bioengineering and Bioscience* (CEASE PUBLICATION), 3(5) 90-94. DOI: https://10.13189/bb.2015.030503.

Raju K., and Naik M.K. (2006). Effect of pre-harvest spray of fungicides and botanicals on storage disease on onion. *Indian phyto- pathology* ,59(2)133-141. URL :https://epubs.icar.org.in/index.php/IPPJ/article/view/17322

Raju K. and Naik. M. K. (2007). Survey and assessment for the post-harvest diseases of onion in North-Eastern Karnataka. *Karnataka Journal of Agriculture Science. 20(1): 16-1-165.* Retrieved from https://www.ecologyjournal.in/assets/archives/2020/vol2issue4/2-3-151-976.pdf

Roopa V.N., Suvarna, V.C. and Natesh N. (2014). Antimicrobial activity of plant extract against post-harvest spoilage of onion. *International Journal of current microbiology and applied science*. 3, (55):388-394. URL (full PDF): https://ijcmas.com/vol-3-5/V.M.Roopa%2C%20et%20al.pdf

Sampath K.P., DebjitBhowmik, C.B. and Pankaj, T. (2010). *Allium cepa:* A traditional medical herb and its health benefits. *Journal of chemical and Pharmaceutical research.* (1):283-291. https://www.jocpr.com/articles/allium-cepa-a-traditional-medicinal-herb-and-its-health-benefits.pdf

Shehu K. and Muhammad, S. (2011). Fungi associated with storage rots of onion onion bulbs in Sokoto, Nigeria. *International Journal of Modern Biology 1(1): 1-3*. DOI: https://10.5923/j.ijmb.20110101.01.

Shehu, K. Salau, I. A. and Kasimu, S.M (2024). Fungi associated with Post-Harvest Deterioration of Stored Onion Bulbs in North-Western Nigeria. Savana Journal of Basic and Applied Science. 6(2):191-195. https://www.sjbas.com.ng/journal/044753Shehu%20et%20al.pdf

Shika A. and Doug, W. (2001). Onion post-harvest and storage. Department of plant science, university of Sask, Chewen. www.usask.ca/agriculture/plantsci/vegetable/resources

Srinivasan, R., Shanmugham, V., Kamalakannan, A. and Surendran, M. (2002). Influence of fertilizer, host factors and storage conditions in relation to disease severity; a case study of black mold rot of onion. *Acta-Phytopathologies Entomological Hungarica*, 37:119-135. DOI: https://10.1556/APHYT.37.2002.1-3.13.

Tyson J.R., and Fullerton R.A. (2004). Effect of soil borne inoculum on incidence of onion black mold (*Aspergillus niger*). *New Zealand plant protection* 57,138-141. DOI: https://10.30843/nzpp.2004.57.6923.

Uzeh R.E., Alade F.A., and Bankole M. (2009). The microbial quality of pre-packed mixed vegetable salad in some retail outlet of Lagos, Nigeria. *African Journal of foods science*, 3(9): 270 – 271. URL:https://www.internationalscholarsjournals.org/articles/the-microbial-quality-of-prepacked-mixed-vegetable-salad-in-some-retail-outlets-in-lagos-nigeria.pdf

Zhao X, Lin F, Li H, Li H.B, Wu D, Geng F, Ma W, Wang Y, Miao B and Gan R (2021).Recent Advances in Bioactive Compounds, Health Functions, and Safety Concerns of Onion (*Allium cepa* L.), EVIEW article Front. Nutrition. Accessed on Feb, 2022.DOI: https://10.3389/fnut.2021.669805