

REVIEW ON FUNGAL DETERIORATION OF SWEET POTATO

¹Bello, I.M., ¹Adebola, M.O. & ¹Musa, M.L

¹Department of Plant Biology, Federal University of Technology, Minna, Nigeria

Email: ismail.mmohd@futminna.edu.ng (Tel: +2348136366262)

Abstract: Sweet potato (*Ipomoea batatas* L. Convolvulaceae) is regarded as one of the most important food crops in the world and is an alternative source of bioenergy. The crop is of high-priority for reducing food insecurity and malnutrition in many countries especially in Nigeria. However, the yield haven't meet global demand due to loss as a result of fungal infestation during harvest, transport and storage. Majorly genera of *Aspergillus*, *Fusarium*, *Penicillium*, *Rhizopus* and *Macrophomina* species are responsible for sweet potato fungal deterioration under pre and postharvest. Following diseases have been reported they include black rot, dry rot, surface rot, foot rot, soft rot, blue mold, java black rot, circular spot and charcoal rot respectively. Several factors such as temperature, pH, moisture content, and nutritional composition are responsible for sweet potato spoilage. The shelf-life and safety of sweet potato can be significantly improved by implementing improved storage practices, such as controlled humidity and temperature. Novel methods should be developed by the farmers, agriculturist and entomologist to curb the fungal spoilage of sweet potatoes.

Keyword: Sweet potato, Deterioration, postharvest

Introduction

Sweet potato (*Ipomoea batatas* Lam) is a member of the Convolvulaceae family and *Ipomoea* genus, widely cultivated globally (Okoye *et al.*, 2024). Recognized as the fourth most crucial food crop after rice, yam, and wheat, sweet potatoes offer significant nutritional value, serving as a vital source of essential vitamins, minerals, and carbohydrates for both human and animal consumption, as well as industrial applications (Hedge *et al.*, 2012). In Nigeria, sweet potatoes hold a staple food status, frequently available at local markets in Nigeria. Therefore, this crop is now regarded as a high-priority crop targeted for reducing food insecurity and malnutrition in many countries (Sugri *et al.*, 2020). Furthermore, sweet potato is an excellent source of nutrients, including vitamins, potassium, iron, calcium, and minerals with medicinal value owing to its anti-cancer, anti-diabetic, and anti-inflammatory activities (Paul *et al.*, 2021). Extracts of sweet potato peels have also been found to have anti-cancer properties in test-tube and animal studies (Hsu *et al.*, 2022). Additionally, functional food products, such as β -carotene and anthocyanins, come from sweet potato, making it a source of novel natural health-promoting compounds (Paul *et al.*, 2021).

However, post-harvest storage and transportation challenges make sweet potatoes susceptible to spoilage, leading to substantial economic losses for farmers and vendors (Agu *et al.*, 2015). Fungal infestation stands out as a major contributor to sweet potato spoilage, rendering the tubers unfit for consumption (Okoye *et al.*, 2024). The storage of sweet potato tubers post-harvest is crucial to regulating market supply and extending the availability of fresh tubers, particularly during off-seasons or under specific economic and climatic conditions (Oyeyipo, 2012). Diseases and pests contribute to 75 percent of sweet potato yield losses, while diseases alone contribute 11.9% loss (Adera *et al.*, 2021). Fungal disease affecting the storage roots are important because they affect the yield, aesthetic quality, storage life and nutritional value of the storage roots, these pathogens create local discolouration and disruption of surrounding tissues of infected tubers (Clemente *et al.*, 2018), resulting in changes in appearances deterioration of texture and possibly flavour or taste. The activities of these pathogen results in post-harvest losses, reduction in the market value and misfortune to farmers. They also cause significant economic losses in the commercialization phase and are rendered unfit for human consumption (Okoye *et al.*, 2024).

The fungus enters storage roots through wounds. The pathogen does not infect properly cured roots. However, secondary infections may occur during storage mostly through wounds formed during handling. The secondary infections can be more destructive than primary infection especially if roots previously stored in cold temperatures are exposed to warm temperatures (Shofoluwe *et al.*, 2024). The high moisture content and low mechanical strength of fresh roots, coupled with their elevated

respiratory rate, create conditions conducive to microbial decay, predominantly caused by fungi (Okoye *et al.*, 2024). Various fungi, including *Botryodiplodia theobromae*, *Ceratocystis*, *Rhizopus oryzae*, *Aspergillus flavus*, *Fusarium solani*, and *Sclerotium rolfsii*, contribute to soft rot disease in sweet potato tubers (Agu *et al.*, 2015). This not only poses a challenge to food security but also results in significant post-harvest losses, a critical issue in developing nations grappling with food scarcity (Kana *et al.*, 2012).

Fungal deterioration of sweet potato

Fungi, ubiquitous microorganisms, play a significant role in post-harvest deterioration, emphasizing the need for a comprehensive evaluation and characterization of the fungal strains responsible for sweet potato spoilage (Adera *et al.*, 2021). Sweet potatoes, a globally consumed crop, face challenges from post-harvest spoilage, resulting in softening, drying, and discoloration (Okoye *et al.*, 2024). Minimal processing (peeling and cutting) can increase microbial spoilage of fresh-cut produce. The presence of cut surfaces provides an entry point for fungi. A vast percentage of plant produce are lost to invasion by microbial pathogens; including fungi. Several workers had reported involvement these pathogens especially fungi in destruction of plantain, banana, Tomatoes (Agu *et al.*, 2015).

Many researchers have described fungal pathogens of sweet potatoes that have become important disease-causing agents (Akinyele *et al.*, 2020; Alum and Umeh, 2020). The nutrient-laden juices from cut surfaces support micro-organism growth. Micro-organisms limit the shelf- life of fresh-cut vegetables by causing spoilage. Spoilage of fresh-cut potato has been characterized as development of soft rots and mould, discoloration of the cut surface, and production of off-odours and off-flavours (Okoye *et al.*, 2024). High populations of fungi may result in deterioration of quality and reduction in shelf-life (Alum, and Umeh 2020). Spoilage is detectable by sensory methods when the cell microbial number attains a threshold of about 10^7 – 10^8 CFU g^{-1} depending on the species concerned. Narayan *et al.* (2021) had also observed the involvement fungi including *Aspergillus* sp in the spoilage of sweet potato.

Agu *et al.* (2015) reported that *Rhizopus oryzae* as the most virulent among the fungi associated with storage rots of sweet potato tubers in South western, Nigeria. *Aspergillus niger* and *Aspergillus flavus*, are microbes associated with sweet potato as reported by Ijato *et al.* (2011). *Aspergillus niger's* dominance highlights its pivotal role in deterioration of sweet potato as reported by Okoye *et al.* (2014). *Aspergillus niger*, *Fusarium oxysporium*, *Penicillium species*, *Aspergillus flavus*, *Botryodiplodia theobromae* and *Rhizopus stolonifera* are responsible for post-harvest decay rot of sweet potato tubers, they produce various types of mycotoxins and enzymes (Okoye *et al.*, 2024). Paul *et al.* (2020), carried out research on occurrence of sweet potato wilt and surface rot disease in Korea, and reported that *Aspergillus flavus*, *Botryodiplodia theobromae*, *Fusarium oxysporium*, and *Aspergillus niger* cause black rot, wilt rots, and delayed in germination and other important humans' diseases such as pneumonia.

Postharvest deterioration of sweet potato

Food spoilage is a metabolic process where food product becomes inedible to ingest by the consumers due to the reduction in the food quality (Shofoluwe *et al.*, 2024). The spoilage of food can be cause by microbes, rodents, insect or pest. Sweet potatoes are affected by a number of diseases, both fungal and bacterial (Clark *et al.*, 2013). The common fungi observed that causes the postharvest diseases include *Ceratocystis fimbriata* which causes black rot, *Aspergillus niger* which causes dry rot, *Fusarium oxysporium* which cause surface rot, foot rot cause by *Plenodomus destruens*, soft rot cause by *Rhizopus stolonifer* and *Rhizopus oryzae*, blue mold cause by *Penicillium* spp., Java black rot cause by *Botryodiplodia theobromae*, circular spot cause by *Sclerotium rolfsii*, charcoal rot cause by *Macrophomina phaseolina* and storage rot by *Mucor* sp., (Paul *et al.*, 2020; Sugri *et al.*, 2020). Dania and Thomas (2019) due to the fact that the crop is sensitive to drought at the tuber initiation stage 50-60 days after waterlogging, which causes tuber rots and reduction in the growth of the stored crops when aeration is poor (Shofoluwe *et al.*, 2024).

High post-harvest spoilage and poor post-harvest handling leads to uneven quality of the sweet potato and results in contamination by fungi respectively (Agu *et al.*, 2016). It is estimated that in the tropics each year between 25 % and 40 % of stored agricultural products are lost because of

inadequate farm and village-level storage (Agu *et al.*, 2015). Quantitative and qualitative losses or a combination of both arising from post-harvest storage results from physical, physiological, or pathological factors or various combinations of these factors (Ogbo and Agu 2014). After harvesting, sweet potato roots are perishable products and are subject to high losses during transportation, storage and selling. The skin of the sweet potato root is damaged easily during harvest and post-harvest handling (Hegde *et al.*, 2012). In addition, its high water content makes storage difficult and vulnerable to microbial attacks, resulting in high losses. Normally the fungi causing rot in sweet potato are lesion pathogens (Agu *et al.*, 2016).

Two new postharvest disease pathogens, *A. wentii* and *P. rotoruae*, were isolated in the storage roots of sweet potato. *A. wentii* caused black mold or dry rot disease, and *P. rotoruae* caused blue mold disease (Paul *et al.*, 2021). The rots include; Black rot (*Ceratocystis fimbriata*), Dry rot (*Aspergillus niger*, *Aspergillus fumigates*), Fusarium root and stem rot (*Fusarium solani.*), Foot rot (*Plenodomus destruens*), Soft rot (*Rhizopus stolonifer*), and Blue mold rot (*Penicillium* spp) (Agu *et al.*, 2015). Noticeable changes occurring are desiccation of several layers of the outermost parenchymal cells exposed to air on wounding. It has been shown that beneath the dissociated cells is a subsequent deposition of a polymeric material in the parenchymal cells (Agu *et al.*, 2016). Traditional storage method which include leaving tubers on open floor and burying in the ground, has recorded heavy losses owing to sprouting, rodent destructions, and insect and microbial damage (Hegde *et al.*, 2012). Although sweet potato is comparatively easy to grow and has high consumer acceptability, its post-harvest has been dealt with rarely in the past.

Mold disease is also a common postharvest disease caused by *Penicillium* spp. including *P. oxalicum* and *P. citrinum* (Zhang *et al.*, 2018). *Aspergillus niger* is found to be responsible for most of the sweet potatoes spoilage during storage as reported by Abdulrahman, *et al.* (2018). Agu *et al.* (2015) identified *Fusarium rosens*, *Rhizopus stolonifer*, *Aspergillus fumigatus*, *Penicillium*, and *Aspergillus niger* species were responsible for postharvest rot of sweet potato tubers. Agu *et al.* (2016) reported that *Rhizopus stolonifer* is the most frequently isolated fungus from spoiled sweet potato tubers in South western, Nigeria. Agu *et al.* (2015) further reported that fungi constitute a menace in storage rots of many agricultural commodities, and observed that *Aspergillus niger* and *Rhizopus stolonifer* were the most frequently isolated fungus from spoiled sweet potato tubers in Anambra State.

Factors that influence deterioration of sweet potato

Yeast and moulds generally can grow at a wide range of temperatures from 5 to 35°C (Paul *et al.*, 2018). Postharvest rot of sweet potato tubers may be due to its low pH, moisture content and nutritional compositions which make it susceptible to infection by fungi. The chain of deterioration could also be attributed to handling procedures during harvest, transit, marketing and storage places (Alum, and Umeh 2020). Colonization of the tubers by fungi will lead to reduction in consumption materials, market value and production of mycotoxins. Consumption of excess mycotoxins can cause illness or death (Agu *et al.*, 2015). The effect of fungi spoilage on the potato tubers led to hydrolysis of starch in the tubers leading to the elaboration of a lot of simple sugars for carbon and energy sources and subsequent colonization by post-harvest rots of sweet potato tubers.

Low pH, moisture content, and nutritional composition influence susceptible to infection by fungi (Okoye *et al.*, 2024). Variation in incidence and severity of Sweet Potato infection could be partly attributed to climatic and soil conditions which could have affected disease development. Cool humid weather conditions have been reported to favor leaf spot development and foliar destruction (Ilindu, 2013). Disease development could further have been affected by plant defense mechanisms, which differ by species and environmental patterns (Sseruwu *et al.*, 2016). Disease incidence may have also been influenced by the specific sweet potato variety cultivated (Sseruwu *et al.*, 2016). Pathogen factors such as virulence, dispersal rate, and farm practices such as sources of sweet potato vine and variety planted also influenced disease incidence and severity (Sseruwu *et al.*, 2016).

The pathogenic fungi can cause allergies in susceptible individuals. Under a controlled environment, sweet potato roots can be stored for several months. Curing potato for 8 days at 15o and 95o RH will allow extended storage of up to 5 months at 4 °C and 95 % to 98 % RH (Hegde *et al.*, 2012).

Management of fungal deterioration

The shelf-life and safety of fresh-cut products can be significantly improved by reducing the initial microbial load and continuous refrigeration during processing and storage. To mitigate these losses, implementing improved storage practices, such as controlled humidity and temperature, and introducing post-harvest management strategies could enhance sweet potato quality, ensuring a more sustainable supply chain and economic resilience for traders (Hafiz *et al.*, 2023). Curing allows injured roots marked by high water content to heal (Alum, and Umeh 2020). In respect to the health benefits of sweet potatoes, novel methods should be developed by the farmers, agriculturist and entomologist to curb the microbial spoilage of sweet potatoes. Farmers should apply integrated pest control to reduce infestation and infection of sweet potatoes which will help to increase yield and enhance the economic growth development ((Sseruwu *et al.*, 2016)). Moreover, sweet potatoes should be stored in a ventilated area and retailer should avoid mishandling of sweet potatoes in order to reduce the microbial load. The high cost of synthetic chemicals is very predominant for the control of disease, apart from this it also has hazardous effect on the environment and are also toxigenic to man and animal. The negatives effects of this chemical lead to the search for an alternative means which is easily feasible, degradable and safe to man and the environment.

Conclusion

This review shows that *Aspergillus*, *Fusarium* and *Rhizopus* sp. are the major fungi that causes spoilage of the sweet potatoes at storage reducing the post-harvest quality despite its nutritive value and economic importance. The information from this review showed enhance disease control that can curb the spoilage of sweet potatoes by fungi during storage thereby increasing the productivity yield.

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