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Phytopathogenic Activities on Postharvest Vegetable Fruit Crops a Case Study in Nigeria

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Abstract: The activities of plant pathogens on postharvest fruits/vegetable have been a problem to mankind. In a nation like Nigeria where food is not meeting the needs of the increasing population, there is an increasing urgency to understand the activities of these microorganisms so as to control them in order to make fresh food supply available at all seasons of the year. Poor handling can result in development of entry points for moulds and bacteria, increased water loss and increased respiration rate. Fungi and bacterial diseases are spread by microscopic spores which are distributed in the air and soil and via decaying plant material. Infection after harvest can occur at any time. It is usually the result of harvesting or handling injuries. The main objective of this review is to find out the microorganisms (pathogens) that infect the food crops after harvest and their effect on food losses. It has been established in this review that these pathogens thrive well in humid environment and are spread during harvesting and poor handling techniques as it is the case with fungi and bacteria when nutrients are available.
Keywords: phytopathogens, food loss, postharvest, pathogenicity, mycotoxins, isolation

INTRODUCTION

The term phytopathogen include any physical, chemical or biological factor able to induce disease in plants but it is usually referred to microbial organism that benefits from an interaction with a plant and has a negative effect on that plant. Phytopathology (also plant pathology) is the scientific study of diseases in plant caused by infectious organisms and environmental conditions [1]. Organisms that cause infectious diseases include fungi, oomycetes, bacteria, viruses, viroids, phytoplasmas, protozoa, nematodes and parasitic plants.

Plant diseases cause major economic losses for farmers worldwide. The food and Agricultural organization estimates indeed that pest and diseases are responsible for about 25% of crop loss. To solve this issue, new methods are needed to detect diseases and pests early such as novel sensors that detect plant odours and spectroscopy and biophotonics that are able to diagnostic plant health and metabolism, Martinelli *et al.;* in 2014 [2]. Fruits and vegetables are of great commercial and nutritional value. They are important sources of vitamins and essential minerals, thus, essential components of the human diet that helps keep a good and normal health. Vegetable production forms a substantial percentage of the major food crops (about 25%) cultivated in the considerable section of the population [3].

Fruits and vegetables in their fresh forms contain high percentage of water. They are living and hence, carry out their physiological function of respiration thereby absorbing and releasing gasses and other materials from and to their environment. These activities lead to their deterioration in storage and transit which is more rapid under conditions of high temperature and humidity [4]. One factor that imparts negatively on the economic value of fruits is that they have a short shelf-life. This is as a result of many factors, prominent among which is the activity of Pathogens, Ewekeye *et al.;* in 2013 [5]. They are susceptible to pathogenic attack due to their low pH, high moisture content and nutrient composition. These make them rot and unfit for consumption due to the production of mycotoxins. Their presence in these food produce also constitute health risks. Eni *et al.;* in 2010 [6] reported that fruits and vegetables are exposed to contamination by microbes through contact with soil, dust and water and by handling at harvest or during post-harvest processing. This makes them harbor a wide range of microorganisms including plant and human pathogens. Differences in microbial profiles of diverse fruits and vegetables could be due to varying factors including resident micro-flora in the soil, application of non-resident micro-flora through animal manures, sewage or irrigation water, transportation and handling by individual retailers [7].

PHYTOPATHOGENIC ACTIVITIES ON FRUITS

In Nigeria, a visit to most markets revealed that between 15% and 40% of fruit displayed for sale showed symptoms of microbial infection and were sold at lower prices and were usually preferred by low income earners [8]. Gupta and Pathak (1986) [9] reported that *Aspergillus niger, Asergillus flavus, Rhizopus niger, Curvalaria lanata, Rhizopus oryzae* and *Fusiarium moniliforme* were responsible for post-harvest losses of pawpaw in South Western Nigeria. Oke and Banjoko (1991) [10] have also reported *Penicilium digitatum* and *Fusiarium oxysiporium* on pawpaw. This agrees with Ewekeye, *et al.;* in 2013 [5] that *Rhizopus stolonifer, Aspergillus flavus, A. niger, mucor* sp, *Penicillium* sp. and *Fusiarium accuminatum* were isolated from diseased pawpaw fruits and when inoculated into healthy fruits, all organisms were found to initiate disease symptoms as found on the diseased pawpaw fruits.

After three to five days, total rotting of the fruits occurred and as spot developed, some became sunken which turned to brown or black and oozed out a foul odour and milky latex. One of the diseased pawpaws (from Iyana-Iba market) was characterized by water soaked spot which is caused by Fusiarium accuminatum has also been reported by Pathak (1976) [11] and Barkai-Golan (1981) [12]. However, some of the pawpaw fruits found in this market have been perched by birds and destroyed by insects which reduced the quality of fruit and also create openings for Pathogen entry. For pineapple, Ewekeye *et al.;* in 2013 [5] reported that *Aspergillus flavus, Phytopthora* spp were isolated from Queen and Cayene varieties of *Ananas comosus* and this agrees with the work of Akinmusire (2011) [13] who also isolated *Aspergillus flavus* and *Phytopthora* sp from *Ananas comosus*. Pathogenicity tests showed that the pathogens isolated affected both species of *Ananas comosus.* Upon repeated isolation from the different species of the fruits at different times from the same markets the same pathogens were majorly recorded to be consistent. However, *Penicillium* sp, *Aspergillus flavus, A. niger, Fusiarium subglutinans, Nigrospora* sp, *Phytopthora* sp, *Hendersonula toruloidea and Rhizopus* sp were isolated from both varieties of pineapple (Queen and Cayene varieties) imported from Benin Republic and Nigeria.

In citrus fruits, post-harvest losses and decay can be traced to infections that occur either between flowering and fruit maturity or during harvesting and subsequent handling and storage; the Pre harvest infections are mainly caused by fungal pathogens such as Phytopthora sp, Colletotrichum glocosporiodes [14, 15]. Ifeanyi (1995) [16] also reported that fungi such as yeast and mould are mainly associated with the diseased and deteriorated citrus fruits. However, Tafinta *et al.;* in 2013 [17] reported that *A. Fumigatus, A. niger, A. flavus* and *R. stolonifer* and some yeasts were found in the spoilt sweet orange fruits sold in Sokoto State and this agrees with Ifeanyi (1995) [16] and Bello (2010) [18] who both isolated seven different fungal genera from different fruits including sweet orange fruits and when these isolates were aseptically inoculated into healthy susceptible fruits, the characteristic symptoms originally observed were also noticed and thus confirmed as the causal organism of fruits decay [8, 19] Such fungi that cause spoilage are considered toxigenic or pathogenic and are potentially harmful to human and animals [8].

Iwuagwu *et al.;* in 2014 [20] repoted that Rhizopus spp caused a high degree of spoilage in tomato fruits, the reason being obvious. This pathogen thrives well in very humid environment and the high moisture content tomato fruits provided a suitable condition for its growth [21, 22] affirmed the fact that biological, microbiological, chemical and biochemical causes of loss are primarily due to the place and method of storage and the time lag between purchase and selling [23]. Micro organisms (e.g. fungi and bacteria) cause damage to stored foods. They usually directly consume small amount of the food but they damage the food to the point that it becomes unacceptable because of rotting or other defects. Toxic substances elaborated by moulds known as mycotoxin cause some food to be condemned and hence lost. The best known mycotoxin is aflatoxin (a liver carcinogen) which is produced by the mould *Aspergillus flavus*. Another mycotoxin which is found in some processed apple and pear products is patulin, which is formed in the apple by rotting organisms such as *Penicillium* expansum which infect fresh apples before they are processed [24].

ACTIVITIES ON VEGETABLES

After harvest, different organisms have been isolated from carrot diseases ranging from *Pythium* sp [25], *Thielaviopsis basicola* [26], *Fusiarium* sp. [27], *and Alternaria* sp [28]. Ewekeye *et al.;* in 2013 [5] reported that *Mucor* sp, *Rhizopus* sp and *Aspergillus niger* were isolated from samples collected from Iyana-Iba market; *Mucor* sp, *Rhizopus* sp and *Alternaria* sp form Okoko market; *Rhizopus* sp, *Aspergillus* flavus, *A. fumigatus* and *Fusiarium* sp from Agboju market. The result of the pathogenicity test revealed that all the fungi originally isolated from diseased carrots induce similar disease symptoms when inoculated on healthy carrots. The variations on the isolates obtained from different researchers may be connected to the fact that different varieties of carrots may be used as well all different experimental procedures [29].

In the work done by Iwuagwu *et al.;* in 2014 [20], the report shows that *Hemithosporuim* sp had 57% disease frequencies in *Telfaria* spp while *Curvularia* spp had 38% disease. *Celosia* spp with the highest rot pathogens showed 46% Fusiarium spp disease frequency, 32% of *Aspergillus* spp and 12% *Cladosporium* spp where as in *Amaranthus* spp and

Okra only fungal pathogens *Fusiarium moniliforme* and *Fusiarium* spp had disease frequencies of 49% and 24 % respectively. The reason for this could be because fungi are quite ubiquitous. Its high prevalence could have resulted from the fact that the seeds from which the vegetables were grown were not treated before sowing into the nursery. The fungi which are highly prevalent in the southern Agricultural zone of Nigeria [30] must have resulted from seeds which were transferred to the leaves during the growing in the field.

Poor handling can result in development of entry points for moulds and bacteria, increased water loss and increased respiration rate [31]. Fungi and bacterial diseases are spread by microscopic spores which are distributed in the air and soil and via decaying plant material. Infection after harvest can occur at any time. It is usually the result of harvesting or handling injuries. Adebayo and Diyaulo in 2003 [32] reported that fungi especially moulds are important pathogens of fruits and vegetable particularly under tropical and subtropical conditions. The importance of storage rate includes reduction in the value [33]. Other important consequence often over looked, is mycotoxin contamination of the affected materials [34].

Black mould disease caused by *Aspergillus niger* var *Tieghem* (An) is a limiting factor in onion production worldwide [35], *Aspergillus niger* also primarily reported to survive between onion crops as a soil saphrophyte (on decaying matter) in or on onion bulbs or on cull onions in field or storage and being ubiquitous in occurrence it attacks/infects bulbs of onions in field/storage whenever they find injured tissues by producing various enzymes or toxins [36]. The fungicides are known to be highly effective in controlling various postharvest diseases of vegetables. Although effective, their continued or repeated applications may disrupt equilibrium of ecosystems leading to dramatic diseases outbreaks, widespread development of pathogens resistant to one or more chemicals, toxicity to non-target organisms and environmental problems [37].

Fungal contamination of onion bulbs especially black moulds constitute a menace in the production and storage of onion particularly in the tropics. Apart from toxins productions, presence of moulds in onion bulbs eventually leads to disease development, deterioration and reduction in market value. A Niger shows as the casual organism of black mould rot of onion as shown in pathogenicity test. The primary symptom was black discoloration of tissues, infected bulbs showed blackening at the neck, streaks or spot of black colour appeared on or beneath the first and second outer scale. In advance stage of infection, the entire bulb appears black and becomes shriveled [38].

ACTIVITIES ON OTHR FOOD CROPS

African annual postharvest losses due to inefficiencies across the agricultural value chain on cereals and legumes have been estimated to be as high as 14% of the total crop harvested, 15-20% for oil seeds and pulse, 15-30% for roots and tubers and 30-40% for perishable products such as harvested fruits and vegetables [39, 40]. Many fungal diseases have been affecting the production of Irish potatoes but the most challenging are the post-harvest diseases. Bootn (1974) [41], reported that these losses were as a result of physical, physiological or pathogenical factors or a combination of the three factors especially when there are mechanical injuries due to physical factors. Abiodun and Olamide (2007) [42] observed that Rhizopus oryzae was among the organism implicated for causing rot in Solanum tuberosum tuber, whereas Ewekeye *et al.;* in 2013 [5] isolated seven fungi from the tuber and they were: *Aspergillus niger*, *A. flavus*, *A. fumigatus*, *Rhizopus* sp., *Mucor* sp., *Curvularia* sp. and a yet to be identified organism. He further reported that all the fungal isolates from pathogenicity test caused rot on healthy tubers. This observation is consistent with a previous work of Amadioha and Adisa (1993) [43] that these organisms among others were responsible for tuber rot in Irish potatoes.

Post-harvest food loses occur during harvesting and handling due to grain shattering, spillage during transport and biodeterioration at all steps in the postharvest chain. The principal agents of biodeterioration could be moulds, insects, rodents and birds. Also, losses of roots and tubers can be physiological (caused by the effect of environmental conditions), pathological (caused by the attack of pathogens such as fungi, bacteria, insects) [44]. Exposition to extreme temperatures (high, low) during pre and postharvest and rough handling does not only reduce the value of the crop through damage created in appearance, it also leads to invasions of pathogens causing decay of the attacked crop in the storage [45].

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