Determination of Fungi Associated with Potato Spoilage: A Review Paper

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ABSTRACT

Food security is the most important and valuable sector in the world. As such this work reviewed the most challenging problems associated with potato production. Fungi associated with spoilage of Irish potato tubers were investigated and isolated. The following fungi; *Alternata alternaria, Aspergillus candidus, A. fumigatoides, A. nidulans, A. niger, A. oryzae, A. terreus, Aureobasidium pullulans, Botrytis cinerea, Chaetomium globosum, Cladosporium herbarum, Currularia lunata, Fusarium moniliforme, F. oxysporium, F. roseolum, F. solani-tuberosi, Mortierella wolfii, Mucor pusillus, Myceliopthora thermophila, R. stolonifer, Rhizophus oryzae, Pennicilium chrysogenum, Paecilmyces variotii, Rhizopus nigricans, Scopulariopsis brevicaulis, Syncephalastrum racemosum, Trichothecium roseum and Ulacladium chartarum* were isolated from rotted tubers. Rhizopus stolonifer has the highest percentage occurrence followed by *Aspergillus niger* and *Alternaria alternata* has the least percentage frequency.

The pathogenicity test revealed that *R. stolonifer* is the most virulent followed by *F. oxysporum* while *M. racemosus* is the least virulent fungus. The use of good storage facilities, adequate control measures and improved Irish potato varieties should be encouraged in order to reduce spoilage of stored Irish potato tubers.

By so doing food security in the world will not only Nigeria and sub-Saharan Africa will be a forgotten issue.

Keywords: Potato tubers, fungi, storage, rots, markets, prevention, challenging, security

INTRODUCTION

Background of the Study

Irish potato is an edible tuber from the *Solanum tuberosum* plant, which is actually native to South America, not Ireland as many people think. Irish potatoes are named after Ireland because; they are closely associated with the Irish potato famine, a historical famine caused by a mold infection of the Irish potato crop.

Irish potato is a complete food that is rich in carbohydrate, protein and vitamins contents. It also contains some minerals such as potassium, phosphorus, iron and magnesium. It has about 70% water. It is characterized by its large brown oblong shape. It is green in colour when not matured and yellowish brown when matured. It grows best in climates where cool nights alternate with warm day especially during the period of tuber formation. For time immemorial Irish potato was restricted to the highland tropics and was confined to less privileged economic groups, especially the expatriates. Nigeria, Kenya and highland India are of particular interest as the potato was widely accepted as a subsistence crop as well as cash crop. In view of its nutrient and water contents, potato is easily colonised by microorganisms especially when the skin is physically damaged due to harvesting faults which occurs under humid condition (Donna, 2008).

Postharvest decays of fruits, vegetables and tubers account for significant level of postharvest losses. It is estimated that about 20-25% of the harvested fruit, vegetable and tubers are decayed by pathogens during postharvest handling even in developed countries (El-Gaouth *et al.*, 2004; Droby, 2006; Singh and Sharma, 2007). In developing countries, postharvest losses are often more severe due to inadequate storage and transportation facilities. Synthetic fungicides are primarily used to control postharvest diseases of fruits, vegetables and tubers (El-Gaouth *et al.*, 2004; Korsten, 2006; Singh and Sharma, 2007; Zhu, 2006).

Wheeler (1979) reported many storage diseases of tuber rots caused by *Rhizopus spp*; it causes soft rot of fleshy parts which spread rapidly at lower temperature. The most common post-harvest storage diseases as reported by (Ameinyo and Ataga 2006) include *Rhizopus* soft rot (*Rhizopus stolonifer*) bacteria soft rot (*Erwinia chrysentheli*), fusarium surface rot (*Fusarium oxysporum*) and black rot (*Ceratocystis fimbriata*).

Harvested tubers are vulnerable to attack by microorganisms because of their moisture content and rich nutrient due to harvest, packing and transportation. Injuries of various kinds facilitate the entry of certain pathogens. Some of the pathogens produce extracellular enzymes and start degenerative process in advance of the fungal hypae or bacterial cells of the attacking pathogens. As a result of infection, the market and nutritive value of the tubers are reduced, either due to its ugly appearance or the changes in the stored products of the tubers (Oyewale, 2006).

Cultivation of Irish Potato

Irish potato originated from the Andes highland of South America, Bolivia and Peru. It later spreads to Europe in 16th century. It was introduced to Africa in 19th century (Mih and Atiri, 2011). Potato has high nutritive value and the tuber contain Carbohydrate 14.2%, Protein 4.7%, Ash 5%, Fat 0.7%, Fibre 0.8%, Vitamin 69%, Calcium 1%, Iron 14%, Magnesium 6%, Phosphorus 8%, Potassium 9% and Sodium 6%. Postharvest decays of fruits, vegetables and tubers account for significant level of postharvest losses. It is estimated that about 20-25% of the harvested fruit, vegetable and tubers are decayed by pathogens during postharvest handling even in developed countries (El-

Gaouth *et al.*, 2004; Droby, 2006; Singh and Sharma, 2007). In developing countries, postharvest losses are often more severe due to inadequate storage and transportation facilities. Synthetic fungicides are primarily used to control postharvest diseases of fruits, vegetables and tubers (El-Gaouth *et al.*, 2004; Korsten, 2006; Singh and Sharma, 2007; Zhu, 2006). The numerous diseases which occur in transit and storage result mainly from the activity of fungi and bacteria.

Fungi range in form and size from unicellular

yeasts to large mushrooms and puffballs.
Yeasts are unicellular, do not have flagella and

reproduce asexually by budding or transverse

fission or
sexually by spore formation. Multicellular forms such as moulds have long,
branched, threadlike filaments called hyphae, wh ich aggregate together to form a tangled *Myceliu m.*

Fungi Associated with Spoilage of Potatoes

The potato disease dry rot is caused by the *Fusarium spp*., fungi that are normally dormant in soil as well as on the surface of the potato tuber. *Fusarium spp.* enters the growth cracks (or other site of injury from harvesting) where spores are distributed. Once the fungi begin to grow within the tuber tissue, dry rot lesions occur along the points of injury, Ibrahim, M. et al (2014). Symptoms of dry rot include a brown, firm, sunken flesh with wrinkled surfaces and brown or white protuberances (Yanta and Tong, 2006).

Another organism, *Pythium ultimum*, the cause of "leak", invades tuber tissue through wounds (generally from harvest) causing rot during transport or in storage, Korsten, L.,(2006). Symptoms of leak include oozing tubers, pink thin flesh and mushy rot. *Fusarium oxysporum*, *Fusarium trichothecioides* and *Fusarium radicicola* to cause potato tuber rot under different condition of temperature and humidity.

A white mould commonly found on potatoes from the soil-borne fungus formed hardened black surfaces on potato plants. The fungus produces lesions on area of the potato vine that will result in infection, killing the tissue of the vine above the lesion.

Factors that Influence Spoilage of Irish potato

Many factors must be evaluated for each specific food when making decisions on whether it needs time/temperature control for safety. These can be divided into intrinsic and extrinsic factors. Intrinsic factors are those that are characteristic of the food itself, extrinsic factors refers to the environmental factors surrounding the foods. The need for time/temperature control is primarily determine by the potential for contamination with pathogenic microorganisms.

The high incidence of rot of potato encountered in most part of the world could be attributed to prevailing climatic factors and storage conditions (Nora, J. Miller, and P. Nolte. 2006). It could also be attributed to handling procedures during harvest, transit, marketing and storage places.

Moisture Content

Microorganisms need water in an available form to grow in food products. The control of the moisture content in foods is one of the oldest exploited preservation strategies. Food microbiologists generally described the water requirement of microorganisms in terms of the water activity (a_w) of the food or environment. Water activity is defined as the ratio of water vapour pressure of the food substrate to the

vapour pressure of pure water at the same temperature.

Most fresh foods, such as fresh meat, vegetables and fruits, have a_w values that are close to the optimum growth level of most microorganism (0.97 – 0.99).

pH and Acidity

An increase in the acidity of foods, either through fermentation or the addition of weak acids, has been used as a preservation method since ancient times. In their state, most foods such as meat, fish and vegetables are slightly acidic while most fruits are moderately acidic. A few foods such as egg white are alkaline. pH is a function of the hydrogen ion concentration in the food. pH = log10 (H^+).

It is well known that groups of microorganisms have pH optimum, minimum and maximum for growth in foods. As with other factors, pH usually interacts with other parameters in the food to inhibit growth. Such factors include water activity ($a_{w)}$, salt, temperature, redox potential, and preservatives to inhibit growth of pathogens and other organisms.

Many pathogens can survive in foods at pH levels below their growth minima. It has been reported that *Clostridium botulinum* was able to produce toxin as low as pH 4.2, but these experiments were conducted with high inoculum levels (103-104 CFU/g up to 106 CFU/g), in soy peptone, and with the presence of Bacillus spp. (Smelt and others 1982). The panel did not consider these results to be relevant to the foods under consideration in this report. It should also be noted that changes in pH can transform a food into one which can support growth of pathogens, Pastor, F.J. and J. Guarro. (2008).

Symptoms of Potato Spoilage

Infection occurs through lenticel and wounds sustained either during harvest or in transit from farm land to storage facility, Ameinyo, C. A. and Ataga, A. E. (2006).

Symptoms are usually manifested and observed on the skin surface of the potato tubers by forming different types of lesions.

Infected tubers have rough, cracked skin with scab – like spots. In severe infection, the tuber skin is covered with rough black welts.

Initial infection reveals reddish brown spot on the surface of the tubers which with time, if left untreated it expand and become corky and necrotic and infect others gradually.

Detection of Potato Spoilage

Detection of potato spoilage involves two methods; simple and scientific methods.

Simple method refers to the physical observation of the potato tubers.

Formation of spots with characteristics black, yellowish, reddish brown coloration accompanying softness the tubers is the first sign of the spoilage, Guarro, J. (2013).

If not detected early the infected tuber develops unpleasant smell.

Scientific method of detection is group into three;

Direct detection

Polymerase Chain Reaction based on fidelity of DNA hybridization and replication. PCR was initially used for highly specific detection of diseases caused by bacteria and viruses. Now it has been used for detection of plant pathogens, El-Ghaouth, A., Wilson, C.L., Wisniewski, M.E., 2004

Fluorescence in-situ Hybridisation (FISH), a molecular detection technique that target genes from plant samples

- Enzyme linked immunosorbent assay, also molecular in nature for detecting diseases based on antibodies and colour change in the assay

Immunofluorescence, a microscopy based optical technique used for analyses of microbiological samples. The technique detect pathogens infection in plants tissue, Odebunmi, E. O., Oluwaniyi, O.O., Sand, A.M.,Kolade, B. O. (2007).

Immunofluorescence is also used in combination with FISH which detects *Solanum dulcamara*, a causative agent of Crown rot in potato.

Indirect detection

Thermography, allows imaging the differences in surface temperature of plants leaves and tubers and canopies, a promising tool to monitor the heterogeneity in the infection of soil borne pathogens

Fluorescence imaging, used to analyse pathogen infections based on changes in the photosynthetic apparatus and photosynthetic electron transport reactions

- **Hyperspectral technique,** used in plant phenotyping and crop disease identification in large scale agriculture.
- **Gas chromatography,** involves the profiling of the volatile organic compounds which indicates the type of stress experienced by plants

Microscopic detection

This method includes wet mounts, Gram stains and conventional histopathology provides clues suggesting the presence of fungi, Donna, A. (2008).

Blankophor or calcofluor mixed with 10 to 20 per cent potassium hydroxide (KOH) stains fungal cell walls and improve its detections.

How to treat and prevent potato spoilage before and after infection

1. After harvest or purchase sort out the unhealthy ones (those with injuries and or bruise), as these would facilitate the spread and infection of the healthy ones
2. Keep the healthy ones you sorted in a dry and cool store
3. Try as much as possible to keep the temperature of the store cool (but not moist store)
4. Keep a periodic check of the store for any spoilage signs. Remove any infected potato to avoid transmission to the healthy ones. That is every few weeks it is wise to check your potatoes briefly for "problem" signs. One rotten potato can infect the others around it, so getting rid of bad potatoes before they have a chance to spread is vital.
5. Use of hot water treatment at different temperatures.
6. Physical damage to potato tubers should be avoided as it serve the entry points of pathogens into the tubers
7. Cure those with minor injuries or cut by;

a. Arranging the potatoes on bed of papers in cool but dry place and
b. Raising the storage temperature slightly to 50^{o}C-60^{o}C and leave it this way for about two weeks for the injured skin to thickened, but under regular check

Knowing the ins and outs of proper potato storage is essential for getting the most value out of your vegetables, whether you buy them at the supermarket or grow them yourself.

Having known the nutritional value and causes of spoilage and some of these microbes (fungi)

can equally harm human beings if consumed raw or improperly cooked, it is therefore recommended that farmers as well as consumers are well enlightened on how to manage and store potato produce after harvest.

Farmers shall as well practice good sanitary measure and also use resistant varieties in order to prevent potato infestation, Ameinyo, C. A. and Ataga, A. E. (2006).

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