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Research Article

First Report of Post-Harvest Rots of Strawberry Fruits (*Fragaria ananassa* Duch.) in Plateau State, Nigeria

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ABSTRACT

Strawberry (*Fragaria ananassa* Duch.) is emerging as an economically important commercial fruit crop in Plateau State of Nigeria. Strawberries like most fruits is prone to fungal spoilage, and are particularly perishable, especially after harvest, even if they are apparently healthy at the time of harvest. This study was undertaken to isolate and identify the fungi associated with contamination of strawberry fruits commonly sold in Jos metropolis, Plateau State. Pure fungal isolates were identified by tissue isolation and single-spore isolation using standard microbiological methods. Data collected were analyzed using simple descriptive statistics (frequency and mean) and analysis of variance. Twelve (12) fungal isolates (*Aspergillus flavus, Aspergillus fumigatus, Aspergillus niger, Collectotrichum gloeosporioides, Schizosaccharomyces pombe, Penicillium meriotylum, Mucor* spp, *Geotrichum candidum, Botrytis cinerea, Fusarium* spp, *Alternaria alternata* and *Rhizopus stolonifer*) were identified. Most of the fungi species were identified with varying percentage prevalence across the markets; *Collectotrichum gloeosporioides* had the highest 18 (15.0%) frequency of occurrence followed by *Fusarium* spp 15 (12.5%) and *Botrytis cinerea* 13 (12.8%) while *R. stolonifera* had the least 4 (3.33%). However, there was no significant difference ($P<0.05$) in the fungal load of the various markets studied. The main strawberry pathogens associated with the strawberry fruit rots in this study are of economical and public health significance. This is the first ever detailed study of its kind on the status of the prevalence of strawberry disease and its distribution on this relatively new crop in Jos, Plateau. Some strains of *Aspergillus* and *Fusarium* have been reported to produce potent mycotoxins that can be harmful to human beings and animals. Thus, management strategy must be taken through improved technology-based preservation methods that target keeping the quality of strawberry fruit from farms, handling and transportation to storage.

Key word: Strawberry (*Fragaria ananassa*), Fungi, Anthracnose, Prevalence, Mycotoxin occurrence, Plateau State.

Introduction

Fruits and vegetables are very important and have high dietary and nutritional qualities (Barth *et al.*, 2009). The importance of fruits in human nutrition cannot be overestimated as it provides essential growth factors such as vitamins and minerals necessary for proper body metabolism (Lewis, 2002; Al-Hindi *et al.*, 2011; Giampieri *et al.*, 2012).

Strawberry (*Fragaria ananassa* Duch.) is an important economic fruit crop in the world (Zhang *et al.*, 2014). It is a herbaceous perennial plant with short stems (crowns) and densely spaced leaves in the genus *Fragaria* and in the family Rosaceae. Strawberry is highly adaptable, widely cultivated, and extensively distributed (Bordelon, 2001; Simpson, 2018). The fruit crop is appreciated in the food industry for its high content of bioactive compounds, such as vitamin C and phenolic constituents with antioxidant capacity (Hu *et al*., 2012; Barrufet *et al.*, 2013; Giampieri *et al.*, 2014). Strawberry is usually consumed fresh or processed into juices. They are unique with highly desirable taste, flavor, and excellent source of vitamins, potassium, fiber and sugars (Sharma and Sharma, 2004).

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As compared to other berry fruits, strawberries contain a higher percentage of vitamin C, phenolics and flavonoids (Hakkinen and Torronen, 2000).

Planting scale of strawberry has been expanded rapidly, because it is a cash crop with a short production cycle, high effectiveness, and high efficiency (Li *et al*., 2004). The average annual planting area is 2.5 $\times 10^5$ hm^2, and the average annual yield is 4.5 × 108^t (Singh *et al*., 2008; FAOSTAT 2013). Europe has the greatest strawberry production, followed by the America and, in descending order: Asia, Africa, and Oceania. China is the most important country for strawberry production in Asia (Šamec *et al*. 2016). The United States leads the world in strawberry production, and California accounts for the highest commercial production of this berry crop, followed by Florida and Oregon (Boriss *et al.*, 2010; Klopotek *et al.*, 2005; Hipol *et al*., 2014; Meyers *et al*., 2003, Mishra *et al*., 2014). The total world production of strawberries reached up to 8,337,099 tons (Tan *et al.,* 2003; FAO 2007; FAOSTAT 2019). The United States produces almost 20% of the world crop and leads the world in production per unit area. The farm gate economic value of strawberries has been between $2.3 billion and $2.8 billion during the past 3 years (Tan *et al.*, 2003; USDA, 2016).

In the Northern part of Nigeria, strawberry farming is mostly done in the Northern part of Plateau State. A cup of strawberries provides 55 calories and vitamin C content is more than the recommended human daily requirement (Salami *et al.,* 2010). Strawberry fruits production has improved the diet of the local people, whose diet generally consisted of starch staples lacking essential vitamin and minerals and are beneficial to the human diet as a source of macro- and micronutrients, vitamins and health promoting antioxidants (Basu *et al*., 2014; Giampieri *et al*., 2015).

Despite these benefits, strawberry like most fruits, are prone to fungal spoilage, are particularly perishable, especially after harvest, when even if they are apparently healthy at the time of harvest, they can undergo spoilage in a short while. The main causes of decay of strawberry fruit during storage and shelf life are the development of rots that are caused by a range of fungi (Behrouz *et al*., 2006; Poling, 2008; Lv *et al*., 2010; Fang *et al.*, 2012; Hu *et al*., 2012).

In developing countries, postharvest losses are often more severe due to inadequate storage and transportation facilities. Fungal fruits infection may occur during the growing season, harvesting, handling, transport and post-harvest storage and marketing conditions, or after purchasing by the consumer. Fruits contain high levels of sugars and nutrients element and their low pH values make them particularly desirable to fungal decayed (Singh and Sharma, 2007).

The chemical composition and nutritive value of this fruit crop is often influenced by a number of pathogenic microorganisms. It is also estimated that about 20% of all fruits and vegetables produced are lost each year due to spoilage (Barth *et al*., 2009; Droby, 2006). However, blind large-scale plantings, extensive management modes, climate change, farming system alterations, the disordered introduction of strawberry varieties, the misappropriation, and misuse of chemical pesticides, have resulted in increasingly serious strawberry diseases and the continuous emergence of new diseases (Mari *et al*., 2009; Zhang *et al*., 2010a, b; Walker e*t al*., 2011; Nadim *et al.,* 2014).

These fruits were usually displayed on benches and in baskets for prospective customers in the open markets until sold, thereby exposing them to further microbial infection beside those associated with the fruit surface and those from adjacent infected fruits (Chukwuka *et al*., 2010; Baiyewu *et al*., 2007; Akintobi *et al*., 2011).

Strawberry cultivation in Nigeria is still an untapped goldmine despite its huge acceptance as a fruit in the country, and farming is mostly done in Plateau State due to the state's cold climate but that does not mean it can't be grown in other parts of the country.

Fruit rot diseases of strawberry are serious problems for strawberry producers in many areas of the world and are particularly severe and enhanced by worm temperate and frequent rains during the harvest season. In addition, under the conditions of low temperature, high humidity, and insufficiency light, the fungus showed a high virulence toward its host, leading to a large disease incidence. Rot diseases caused by fungal pathogens provoke severe losses of agricultural and horticultural crops every year and are particularly severe where diseases are often enhanced by warm temperatures and frequent rains during the harvest season (Salman, 2005; Parveen *et al.*, 2016).

The postharvest disease known as soft rot, black rot, leak, Rhizopus rot, or Mucor rot can be devastating, as the relative etiological fungi can spread rapidly from

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one infected fruit to the next, healthy, fruit, which can result in extensive breakdown of the commodity. The casual agents belong to the genus *Rhizopus*, which is usually *R. stolonifer*, and to the genus *Mucor* (Snowdon, 1990; Salman, 2005).

During postharvest handling, strawberry fruit have high susceptibility to mechanical damage, and thus they need to be handled with care, to avoid damage that can create an entry point for the decay-causing fungi (Aliasgarian *et al.*, 2013).

Anthracnose: The disease anthracnose is caused by fungi belonging to the genus *Colletotrichum*, and especially by *Colletotrichum acutatum*, which is a quarantine pathogen in some European countries (Poling, 2008). Magnoli *et al.* (2003), Sharma and Kulshrestha, (2015), Micheal and Omer (2016) also reported that Anthracnose is an important disease of strawberry that can affect foliage, runners, crowns, and fruit. The disease is caused by several species of fungi in the genus *Colletotrichum.* The main disease symptoms are firm, round, brown lesions on fruit surfaces, which with advanced infections have salmon-colored conidial masses that cover the center of the lesions. The infected fruit eventually dries up and becomes 'mummified' (Maas 1998). The fungi can lie quiescent inside the host tissue for a period, and thus in some cases the infection only becomes visible after harvest. However, during storage, the fungi can only sporadically spread to the nearby fruit (Timmer *et al.*, 1998; Agrios, 2005; Embaby and Abd-Ellatif, 2013).

The strawberry diseases have been recorded in other countries like China, Florida, Korea and are mainly root rot, gray mold, soft rot, powdery mildew, anthracnose, leaf spot, and brown spot (Behrouz *et al*., 2006; Poling, 2008; Lv *et al*., 2010; Fang *et al.*, 2012; Sylla *et al*., 2013; Asad-Uz-Zaman *et al*., 2015; Campos-Requena *et al*., 2015; Lachhab *et al.*, 2015; Sharma and Kulshrestha, 2015). Botrytis fruit rot, caused by *Botrytis cinerea*, which is the main causal agent of gray mold; the most important fruit rot on strawberries world-wide and also the many other pathogens that can cause postharvest spoilage (Xiao *et al*., 1999; Mohammadi *et al*., 2015; Sabrina *et al*., 2017). Others including *Rhizopus stolonifer, Mucor* spp., *Colletotrichum* spp., and *Penicillium* spp. are the most important preharvest diseases of strawberry in Florida (Legard *et al*., 1997a, b).

In Plateau State, Nigeria, no fungal diseases of strawberry have been reported. To the best of my knowledge, this is the first report about strawberry fruits rots caused by fungal pathogens in Plateau State and North Central Nigeria. In addition, there are limited or no available reports on postharvest diseases of strawberries that are cultivated or grown in Nigeria, except few reports on the imported fruits. It is important to identify fungal contaminants in fresh fruits because some molds can grow and produce mycotoxins on this commodity (Tournas and Katsoudas 2005). It is therefore, very important to detect and identify the fungal pathogens associated with the fruit rots of the strawberry sold in some markets in Jos, Plateau State. This will further enhance proper strategy to control pre- and post-harvest diseases caused by these fungal pathogens, management handling and processing or any other mode of plant protection is required to control the economic loss.

Materials and Methods

Study Area

The study/sampling areas were Farin gada, Terminus, Vom and Kuru markets, all in Jos Metropolis in Plateau State, Nigeria. Scientific research was conducted in the Department of Science Laboratory Technology Central laboratory, University of Jos.

Sample Collection

A total of four hundred and eighty (480) samples of diseased strawberry fruits were randomly purchased, one hundred and twenty (120) each from Terminus market (TM), Farin-Gada market (FM), Vom market (VM) and Kuru market (KM). The samples were transported immediately to the Department of Biochemistry Laboratory of the University of Jos in sterile paper bags for standard microbiological analysis. The samples were collected between the Months of February and March around the period which the fruit is in season and readily available in the study area in 2022 and in 2023.

Preparation of Culture Media

The media used was Potato Dextrose Ager (PDA) (Oxoid-Exp: Oct, 2020) and Strawberry Fruit Agar (Prepared), a general-purpose medium for yeast and molds was supplement with 4ml of chloramphenicol (antibiotic) to inhibit bacterial growth. The media was prepared according to the manufacturer instruction. 19.5g of PDA was weighed on a weighing balance and

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transferred into conical flask 20ml of sterile distilled water was poured into it and swirled for the powder ager to dissolve and 30ml of sterile distilled water was added into it making 50ml of sterile distilled water. The solution was properly covered with cotton wool and aluminum foil paper and was brought to boil in order to dissolve completely, then was autoclaved at 121^0 C for 15 minutes and cool to 45ºC. At 47ºC, 4ml of chloramphenicol was added aseptically; it was transferred into sterile petri plates and allowed to solidify.

Preparation of Strawberry Fruit Agar Medium

Strawberry fruit agar was prepared for the sub-culturing of the molds and any possible yeasts characterization firstly by washing the healthy Strawberry fruits with sterile distilled water and sterilized with 70% ethanol. After which the clean pulp was blended with water in a blender into a fine paste. The blended Strawberry fruit pulp was poured into conical flasks and steamed at 100^0C in the autoclave, upon cooling the mixture was sifted using muslin cloth and filtered. Agar agar (2% wt/v) was added to the filtered strawberry fruit extract and autoclaved at 121^0C for 15minutes.

Identification and Characterisation of Fungi Associated with the Diseased fruit Samples

The rotten parts of the infected fruits were also picked using sterile swab sticks and were used to seed PDA plates and spread out by streaking. The inoculating loop was flamed after each streaking in order to allow for the reduction in population and growth of distinct colonies on plates as well as for easy identification. The workbench was disinfected with 70% ethanol. PDA plates were incubated on the workbench at room temperature (25-28ºC) for 1-5 days while strawberry plates were incubated making use of the incubator at 26^0C for 3-7 days. Pure isolates were obtained by selecting discrete colonies and having them sub-cultured onto petri-dishes containing freshly prepared PDA medium. The fungal isolates were sub cultured onto PDA plates using a 2mm Cork borer. The count of the fungal growth on the plates was carried out based on the origin of germination of the organisms that grows on the plates and recorded accordingly based on macroscopic observation. The yeasts were identified using the simple gram stain.

The fungal growths that appeared were primarily identified using cultural and morphological features according to the method of Domsch *et al*. (1993) and Barnett and Hunter (1998). Two drops of lactophenol cotton blue reagent was placed on a clean, grease-free glass slide. A small tuft of the fungus was obtained using sterile inoculating needle and transferred to the glass slide. A cover slip was placed over the preparation and examined under the microscope using magnification of ×400. The Fungal structures of importance like mycelium: Coloured or Non-coloured, Septate or non-septate hyphae, Spores: types of asexual, nature of spores and the presence of special structures: such as stolon, rhizoids and foot cells were observed.

Statistical Analysis

Data was analyzed using SPSS and One-Way Analysis of Variance (ANOVA). The P-value <0.05 were considered statistically significant.

Results

The results of the cultural, and morphological characteristics of the isolated fungi found in all strawberry fruits sampled from the markets of Jos Metropolis include fungal species are as stated in Table 1.

The characteristic symptoms, types of rots and associated fungal isolates of the diseased strawberry fruits are also shown in Table 1.

Twelve (12) fungi isolates were implicated with the infected strawberry fruits from the four markets surveyed. Viz: *Aspergillus flavus*, *Schizosaccharomyces pombe*, *Aspergillus fumigatus*, *Aspergillus niger*, *Collectotrichum gloeosporioides*, *Mucor* spp, *Penicillium meriotylum*, *Geotrichum candidum*, *Botrytis cinerea*, *Fusarium* spp, *Alternaria alternata* and *Rhizopus stolonifer*.

Botrytis cinerea infection on strawberry fruit 14 Days after inoculation is as shown in Plate 1.

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Table 1: Characteristic symptoms, types of rots and associated fungal isolates of diseased strawberry fruits in Jos Metropolis

Symptom/appearance of diseased strawberry fruits	Types of Rot	Types of fungi isolated From the infected strawberry fruits
Whitish macerated growth covering the bark/skin of the strawberry fruits. Watery leakage causes an unsightly mess and is characterized by a soft and watery rot appearance that quickly causes the collapse of the entire fruit but leaves the cuticle intact.	Botrytis/Gray mold	*Rhizopus* sp, *Botrytis cinerea, Mucor* sp. and *Penicillium* sp.
Wet oozing white fluid covering some parts of the fruit tissues and macerations.	White/Soft Rot	*Mucor sp, Rhizopus* sp, *P. meriotylum, Botrytis* spp.
Strawberry tissue covered with greenish mycelia, funny yellowish brown and Greyish-black tissues with internal raminification. Soft rot water-soaked appearance, brown lesions	Anthacnose	*Aspergillus niger, A. flavus, Penicillium* sp, *Botrytis cinerea, Rhizopus stolonifer* and *Collectotrichum gloeosporioides*
Dark brownish-black fruits. On the fruit surface, white hyphae appeared in the early stage, and a white layer of mold formed in the late stage.	Brown/Black Rot	*Aspergillus* sp, *Fusarium* sp, *Alternaria alternata,*

Plate 1: *Botrytis cinerea* infection on strawberry fruit 14 Days after inoculation

Results of the frequency of occurrence (%) and distribution of fungal isolates from Strawberry in the four (4) markets in Jos is as shown in Table 2. While the Occurrence (%) of each fungus in all the markets studied in Jos Metropolis is shown in Figure 1. The strawberry fruit agar supported the growth of similar microorganisms with *Collectotrichum gloeosporioides* being the most isolated fungi genera with 18(15.0%) frequency of occurrence of isolated fungi in relation to location in Farin-Gada market and across the four markets followed by *Fusarium* spp 15 (12.5%), *Botrytis cinerea* 13(12.8%) while *R. stolonifera* had the least mean frequency of 4(3.33%).

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Table 2: Frequency of occurrence (%) and distribution of fungal isolates from Strawberry in Markets of Jos Metropolis

Fungal Isolate	Market				Total No. of isolates in the 4 markets
	Farin-Gada	Terminus	Vom	Kuru	
S. pombe	8(6.67)	9(7.50)	11(9.17)	13(10.8)	**41**
A. flavus	9(7.50)	10(8.33)	8(6.67)	10(8.33)	**37**
A. fumigatus	9(7.50)	11(9.17)	9(7.50)	9(7.50)	**38**
A. niger	8(6.67)	12(10.0)	10(8.33)	13(10.8)	**43**
C. gloeosporioides	18(15.0)	14(11.7)	16(13.3)	10(8.33)	**58**
Penicillium spp.	9(7.50)	11(9.17)	8(6.67)	9(7.50)	**37**
R. stolonifer	4(3.33)	7(5.83)	6(5.00)	5(4.17)	**22**
Mucor spp.	9(7.50)	8(6.67)	9(7.50)	7(5.83)	**33**
Penicillium spp.	8(6.67)	8(6.67)	8(6.67)	10(8.33)	**34**
B. cinerea	13(10.8)	10(8.33)	11(9.17)	12(10.0)	**46**
Fusarium spp	15(12.5)	12(10.0)	14(11.7)	12(10.0)	**53**
G. candidum	10(8.33)	8(6.67)	10(8.33)	10(8.33)	**38**
Total	**120**	**120**	**120**	**120**	**480**

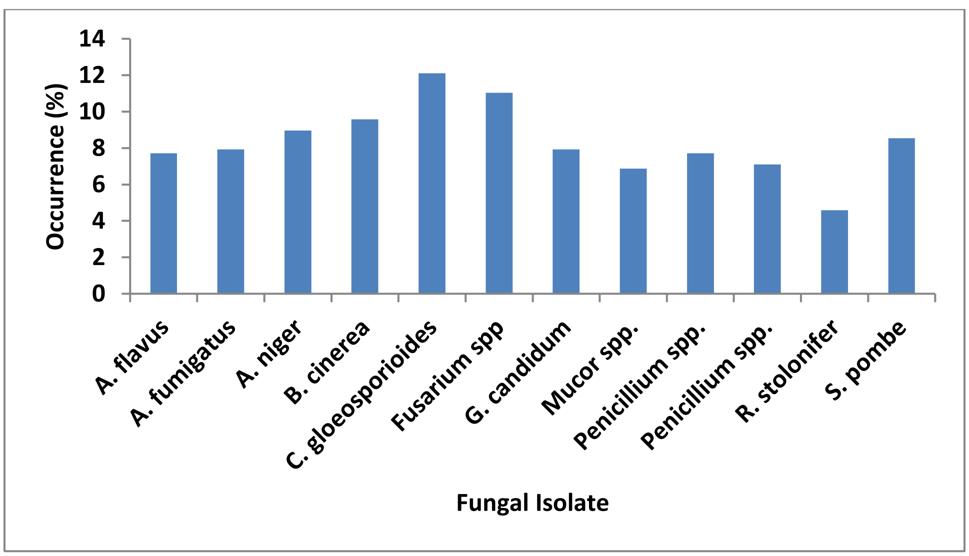

Fig. 1: Occurrence (%) of fungal isolates from Strawberry in Markets of Jos Metropolis

Meanwhile, there is no significant difference (P<0.05) in fungal isolates of strawberry fruits across the four markets (Farin-Gada, Terminus, Vom and Kuru markets) (Table 2). On the other hand, the occurrence of each fungal isolate in all four markets showed that, *Collectotrichum gloeosporioides* also had the highest occurrence of 12.1% followed by *Fusarium* spp (11.04%), and *Botrytis cinerea* (9.58%). While *R. stolonifera* had the least occurrence of 4.58%.

Discussion

This study revealed the fungi associated with some rot diseases in strawberry fruits in Plateau State. The isolation and prevalence of these suspected agents of the strawberry fruit spoilage fungi organisms from the four locations depicts that they are of public health importance molds in Plateau State. This study agreed with the report by Sabrina *et al*. (2017), Feliziani and Romanazzi (2016), Akinmusire (2011), Nadim *et al.* (2014) and Liu *et al*. (2011) who in their separate works on postharvest decay of strawberry fruit: etiology, epidemiology, and disease management in Italy, reported that the major pathogens responsible for postharvest decay of strawberry fruits are *Botrytis cinerea*, followed by *Rhizopus stolonifer*, *Mucor* spp., *Colletotrichum* spp., *Penicillium* spp., and these were all identified in this study.

This study shows that there was no significant difference in the fungal counts from the four study sites where the samples were collected. It also showed an increase in the percentage frequency of occurrence of these organisms in the study locations. These could be as a result of latent infections in the field that becomes active following harvest or could be as a result of cross contamination during harvest cleaning, storage and distribution as reported by Nunes *et al.* (1995) and Boer *et al.* (2009).

In this study, the growth rate of the isolated fungi associated with the strawberry fruit rots increased with the length of time during the inoculation. This effect is typical for strawberry, and the incidence of decay can increase quickly, especially toward the end of the storage period (Wilcox and Seem 1994; Talbot and Chau, 1991).
Most of the diseased fruits samples collected showed some skin damages which may be inflicted on produce at the time of harvest. This may also have caused the major infections or rots observed, since most of the spoilage microorganisms invade the produce through such damaged tissues.

Rhizopus can enter the fruit tissue only through wounds and cannot penetrate uninjured fruit surfaces. Thus, the disease rate was high when the pathogen infected wounded tissue, indicating it was a weak pathogen. Therefore, wounding that occurs during harvesting, transporting, or postharvest handling plays an important role in the development of the disease.
It is therefore necessary and important that both the farmer who harvests the fruits into bags for transportation, the marketers and consumers take necessary and appropriate precautions in preventing contamination and eating of contaminated fruits. This will however reduce the risk of mycotoxins associated with fungi contamination which are deleterious to human health (Baiyewu *et al*., 2007; Chukwuka *et al*., 2010).

Furthermore, most of the fruits sold by vendors were displayed in open containers, Wheel barrows, plastic food packs and tables beside the roads and markets. Thus, the reason for the high prevalence of the infection observed. Several researchers have reported that poor sanitary practices, transportation, packaging and storage systems can worsen infection through cross-contamination and contact infection of the produce (Aliasgarian *et al.*, 2013**)**. The magnitude of the symptoms of the induced disease is a reflection of the extent of colonization.

Researches have shown that the recent disruption of the global food supplies is predominantly due to post-harvest losses associated with microbes (Chukwuka *et al*., 2010). In line with the assertions of Krige *et al.* (2006) and Chukwuka *et al*. (2010), since fruits were usually infected by pathogenic organisms, to be effective, production, preparation and preservation of food such as fruit salads must be carried out as rapidly and hygienically as possible using good quality equipment, produce and materials (Onuegbu, 2002; Villa-Rojas *et al.*, 2011). Poling (2008), Brown (2000) and Djami-Tchatchou *et al*. (2012) reported that *Colletotrichum gloeosporioides* causes the disease commonly known as anthracnose on a wide range of plants in tropical, subtropical, and temperate regions. The results from this study have shown that strawberry fruits sold in Jos, Plateau State Nigeria, suffered spoilage as a result of fungal infections caused by these pathogenic fungi.

This study agreed with Sosa-Alvarez *et al*., (1995) and Legard, *et al*. (1997a, b). Garrido *et al.* (2011) reported that the most economically impactful pathogens of strawberry are fungi, which can infect all parts of the plant and cause severe damage or death. Saber *et al.* (2003) reported that *Aspergillus niger* is associated with the rotting of strawberry fruit at postharvest stage. This was also corroborated by Sutton (1998), Legard *et al*. (2000a, b) and Boer *et al*. (2009) who all reported that the main fungal species that cause post-harvest rot in strawberry are *Botrytis cenerea* and *Rhizopus stolonifer*.

Generally, spoiling fungi are considered toxigenic or pathogenic as they were being isolated in this study. In this study, toxigenic fungi were also identified. This agreed with Al-Hindi *et al*. (2011) who reported that toxigenic fungi like *Aspergillus* spp and *Fusarium* spp were associated with spoiling fruits. This agreed with the work by Tournas and Katsoudas (2005) who reported these fungi in a study on Mould and yeast flora in fresh berries, grapes and citrus fruits.
The fungi isolated in this study have been reported to produce secondary metabolites in plants tissues. These secondary metabolites are potentially harmful to humans and animals (Eaton and Groopman, 1994; Baiyewu *et al.,* 2007). A good example is Aflatoxin which has been associated in cancer of the liver (heptatoma), aflatoxicosis and also with acute hepatitis in humans, especially in the developing world (Eaton and Groopman, 1994; Muhammad *et al*., 2004; Baiyewu *et al.,* 2007). Some strains of *Aspergillus* and *Fusarium* were isolated from strawberry fruits and are well known for the production of the naturally-occurring aflatoxins mainly B1 and B2 (Muhammad *et al*., 2004). *Aspergillus* spp. were widespread among all examined spoilage fruits.

The occurrence of fungal spoilage of fruits and vegetables is also recognized as a source of potential health hazard to man and animals due to their production of mycotoxin compounds which are capable of causing, infections, allergies and mycotoxicoses in man following ingestion or inhalation (Tournas and Stack, 2001; Monso, 2004).
Aspergillus spp. are known to produce several toxic metabolites, such as malformins, naphthopyrones (Pitt and Hocking, 1997) and they can produce Ochratoxins (OTA), a mycotoxin which is a very important toxin worldwide because of the hazard it poses to human and animal health (Peraica *et al*., 1999; Petzinger and Weidenbach, 2002). Thus, extra care should be taken during personnel handling of these fruits during harvesting, cleaning, sorting, packaging, transport and storage (Al-Hindi *et al*., 2011).

In conclusion, this study has provided useful information on fungi associated with strawberry fruits rots from Farin-Gada, Terminus, Kuru and Vom markets in Plateau state, Nigeria. Thus, this is the first report of a strawberry fruits' rots diseases caused by these fungi species. Hence, necessary precaution in preventing contamination of this crop by these fungi will enhance the microbial quality of the produce.
Considering the fact that the isolated fungi found on the strawberry fruit could change the nutritive value of these fruits, some of the fungi isolates were mycotoxigenic in nature. Economic loss of the strawberry fruit's rots is caused by improper handling practices, marketing and lack or inadequate storage facilities. High prevalence of some of these fungi demand that appropriate control measures against infection, should be employed if farmers/sellers/ vendors expect good performance of their produce. Adequate microbiological knowledge and handling practices of the Strawberry crop would therefore help minimize wastes due to deterioration and unacceptability.

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