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Pathogens associated with tomato Post-harvest losses in Mwea, Kenya

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Abstract
Tomato post-harvest pathogens are a threat to the harvested tomatoes. Tomato fruit attract more micro-organisms because of it being succulent, highly rich in nutrients and sugars that are medium for microbial growth. The pathogens destroy tomato fruits reducing the quantity of consumable fruits and at the same time lowering the profit made from the sales of the tomato fruits. Consumption of contaminated fruits results to food poisoning. Isolation and identification of pathogens causing tomato fruit rot is necessary in order to create awareness and reduce the risks of infections arising from handling and consumption of contaminated tomato fruits. The objective of this study was to isolate and identify pathogens that cause tomato fruit rots in Mwea Kenya and test the susceptibility of tomato cultivars to the rots. In this study infected tomato samples were collected from farms and markets in Mwea. Disease causing micro-organisms that were suspected to cause the post-harvest damage were isolated, identified and re-inoculated to wounded surface sterilized fresh harvested ripe tomato fruits to establish pathogenicity. Two common tomato cultivars (Kilele F1 and Roma V.F) grown in Mwea were tested for susceptibility to the common post-harvest tomato pathogens in the area. Data was analysed using SPSS frequency, percent and chi-square test statistics. Six pathogens were isolated from infected tomato samples and they varied significantly ($p<0.001$) with *Furasium* spp. being the most prevalent (30%). Damage caused by the pathogens on tomato fruits also varied significantly ($p<0.001$) with *Rhizopus* spp. causing (100%) rot. The susceptibility of the tomato cultivars to the test pathogens differed significantly ($p<0.045$) with Kilele F1 being the most susceptible. These findings will be of importance in making the farmers and consumers aware of pathogens causing tomato rots and cultivars that are susceptible to rots.

Keywords: Bacteria, Fungi, Tomato, Pathogenicity, Post-harvest

1. Introduction
Tomato (*Lycopersicon esculentum* Mill.) is a climbing, annual fruit vegetable crop which originated from South America and was introduced to Europe in the 16th Century and later to East Africa by colonial settlers in the early 1900 (Wamache, 2005) [47]. In Kenya tomato production accounts for 14% of the total vegetables and 6.72 % of the total horticultural crops (Ochilo *et al*., 2019) [39]. Major tomato producing Counties in Kenya with their production proportions are: Kirinyaga (Mwea area) 14%, Migori (9%), Narok (7), Kajiado (6%), Meru (4.8%), and Kiambu (4.4%) among others (HCDA 2016). Kenya is among the Africa's leading producer of tomato and is ranked 6th in Africa with a total production of 410,033 tones (Ochilo *et al*., 2019) [39]. Tomato fruit is rich in minerals, vitamins, proteins and dietary fibre (Wogu and Ofuase, 2014) [49]. Apart from nutrition, the fruit is also used as medicine, human system cleanser, flavouring ingredient and a detoxifying agent (Abhinaba, 2009) [3]. In addition to its nutritive value, the fruit has a good taste and increased production has increased its availability and affordability to consumers (Behravesh *et al*., 2012) [10].

Tomato production has many challenges which include climatic conditions such as rainfall and whether patterns, pests and diseases (Onuorah and Orji, 2015) [21]. The tomato fruit is highly perishable because of its high moisture content and low pH. The fruits are also attacked by a wide range of fungal and bacterial pathogens which occur in all parts of the world. Infestation of tomato fruit by micro-organisms lowers its market value, nutritional value and the fruit becomes unfit for consumption. Consumption of contaminated fruits results to food poisoning (Muhammad *et al*., 2004) [35]. The attack by the pathogens is mostly through physical injuries, physical deterioration of the fruits due to long storage, packing and distribution at various channels and selling outlets where the pathogens are prevalent (Akinyele and Akinkunmi, 2012) [5]. In a few cases pathogens are able to penetrate healthy tissues of the fruit causing spoilage (Kader, 1992) [28].

Fruits collect micro-organisms from the farms and in the open market places where they are exposed in open benches and open baskets (Baiyewu *et al*., 2007) [12].

The tomato fruit attract more micro-organisms because of it being succulent, highly rich in nutrients and sugars that are medium for microbial growth (Singh and Sharma, 2007) [43]. Microbial spoilage of fruits is known as rot and it is characterized by loss of texture, changes in colour and sometimes with odor (Trias *et al*., 2008) [50]. Moss (2002) [36] reported that its nutrient composition attracts pathogenic fungi and bacteria which cause rots on fruits making them unfit for consumption because fungi produce mycotoxins.

The shelf life and quality of fruits may be determined by environmental factors such as rainfall, temperature and soil type (Bachmann and Earles, 2000) [9]. The biological and physical damages during harvesting and transport coupled with large amounts of water and soft endocarp of the fruit makes the fruit more susceptible to spoilage by fungi (Onuoral and Orji, 2015) [21]. Rots on fruits and damage during transit may be reduced through harvesting fruits prior to softening and full maturity, but the fruit quality is usually lowered (Lytoychenko *et al*., 2009) [34]. Survey conducted by Aworth (1985) [6] showed that 20-50% of tomato fruits harvested for human consumption are lost through microbial spoilage. Pathogenic fungi have been reported to cause allergies and other infections (Cao and Forrer, 2001) [15]. For example, *Aspergillus* spp produces mycotoxins which are harmful to animals and human beings by causing mytocoxicosis when ingested or inhaled (Afsah-Hejri *et al*., 2013) [1]. Some of the tomatoes when consumed raw, the presence of the micro-organisms cause diseases such as gastroenteritis, meningitis and diarrhoea (Beuchat, 2006) [13]. These pathogens destroy tomato fruits therefore reducing the quantity of consumable fruits and at the same time lowering the profit made from the sales of the tomato fruits.

Isolation and identification of pathogens that are associated with rots of tomato fruit is gaining focus in the current research (Akinyele and Akinkunmi, 2012) [5]. This is necessary in order to create awareness and reduce the risks of infections arising from handling and consumption of contaminated tomato fruits. In Benin City of Nigeria, bacteria such as *Bacillus subtilis*, *Salmonella typhi*, *Staphylococcus aureus* and *Proteus mirabilis* were isolated from spoilt tomatoes (Wogu and Ofuase (2014) [49]. Lemma *et al*. (2014) [29] isolated *Alternaria* spp, *Fusarium* spp, *Rhizopus* spp, *Penicillium* spp and *Erwinia carotovora* from rotten tomato samples in Ethiopia. In the United States, *Clostidium* sp., *Bacillus* sp., and *Staphylococcus* sp. were isolated from raw and canned tomatoes (Ajayi, 2013) [4]. According to Etebu *et al*. (2009), the fungal species associated with tomato spoilage were *Aspergillus niger*, *A. phoenicis*, *F. oxysporum*, *F. moniliformis*, *Trichoderma* spp, *A. alternata*, *Mucor* spp, *R. stolonifer*, *Penicillium* spp, *Geotrichum* spp, *Phytophthora* spp. In Kenya the information about types of pathogens associated with tomato fruit rots is scanty. This study therefore aimed at isolating and identifying pathogens responsible for post-harvest rots of tomato fruits in Mwea, Kirinyaga County in Kenya and also determine the susceptibility of the tomato fruit cultivars to the pathogens.

2. Materials and Methods

2.1 Study Site

Farms and market centres in Mwea area were targeted for the survey because of long history of tomato production in the area.

2.2 Sampling of infected fruit samples

Stratified sampling was done to identify the markets and farms where the samples were collected from. Infected tomato fruit samples were identified by physical examination and then collected randomly from the local markets and from the individual farms. One hundred and fifty (150) fruits with various rot symptoms were collected, placed in cool boxes and brought to the Agricultural Science and Technology Departmental Laboratory, Kenyatta University for processing and further analysis.

2.3 Isolation of pathogenic fungi and bacteria from rotting fruits

Fungal and bacterial pathogens were isolated from the fruits using Potato dextrose agar (PDA) and Nutrient agar (NA) respectively. The infected tomato samples were first washed under running tap water, then dipped into 1 % Sodium Hypochlorite to surface sterilize for three minutes and rinsed in three changes of sterilized distilled water. They were then blotted dry using sterilized blotting paper. For fungal isolation, direct plating method was used (Abdullah *et al*., 2002) [2]. A sterilized scalpel was used to cut 3 mm x 3 mm sections of tissue from the tomato moving from the healthy portions to the decayed portion where the pathogens were likely to be more active. The pieces were dried using sterilized blotting paper and the dried tissues directly plated on sterile PDA and then incubated in the laboratory at room temperature (25°C) for 5 days. For bacteria isolation, a sterile loop was used to get some cells of the fruit tissue which were streaked on the NA in petri dishes and colony formation observed after two days. After incubation both fungal and bacterial colonies were observed on the plates, re-isolated and sub-cultured on separate sterile media to obtain pure cultures.

2.4 Identification of Pathogens

Fungal identification was done using morphological characteristics and comparisons using established keys (Barnnet and Hunter, 1999) [11]. Each isolate was subjected to microscopic examination for observation of colony units for morphological features. The identification was based on growth patterns, color of mycelia, vegetative and reproductive structures. For bacteria morphological characteristics such as colony color, gram staining was used and then narrowed down to the use of catalase test using hydrogen peroxide (Schaad *et al*., 2001) [44]. Young cultures (24hrs old) were placed on a clean slide using a loop and a drop of hydrogen peroxide added and observations made. The culture was also used to inoculate sterilized potato slices and rot development observed.

2.5 Pathogenicity Test

Pathogenicity test was carried out according to Koch's Postulates in order to confirm pathogenicity using the techniques described by Okigbo *et al*. (2009). Healthy tomato fruit samples were obtained from farms in Mwea, and brought to Agricultural Science and Technology Laboratory at Kenyatta University. The tomatoes were then washed under running tap water and surface sterilized in 1 % NaoCl for three minutes. Thereafter, they were rinsed in three changes of sterilized distilled water and wiped dry using a sterilized blotting paper.

A sterilized five (5) mm cork borer was used to punch the tomatoes and the discs removed. The same size of the cork borer was used to cut sections of each of the cultures of the isolated fungal pathogens and the discs were used to inoculate the healthy wounded tomatoes (Elmougy *et al*., 2004) [19]. The wound on the inoculated tomatoes was sealed using sterilized transparent adhesive tape. The negative control was also set in the same manner but sterilized PDA was used without fungal cultures. Three tomatoes were placed in each sterile polythene bag as a treatment, replicated four times and stored at room temperature (25°C) in the laboratory. Disease

development was checked after two days. The pathogens were re-isolated and identified as described earlier.
For bacterial isolates a sterile loop that had been dipped into the culture isolate was used to introduce the bacteria into wounded healthy tomatoes. The negative control was also set in the same manner but sterile NA was used without bacterial cultures. Three tomatoes were placed in each sterile polythene bag, replicated four times and stored at room temperature (25ºC) in the laboratory. Disease development was checked after three days. The pathogens were isolated and identified as described earlier.

2.6 Determination of susceptibility of tomato fruits to the isolated pathogens

Two tomato cultivars, (Kilele F1 and Roma V. F), which were the mostly planted by farmers during the study period were selected for further experiments. Sampled fruits of the two cultivars were brought to the Agricultural Science and Technology laboratory at Kenyatta University. The fruit samples were washed under running tap water and surface sterilized in 1 % NaoCl for three minutes, rinsed in three changes of sterilized distilled water and dried using sterilized blotting paper. A cork borer of 5 mm diameter was used to make holes on the fruits. Five (5) mm fungal discs and bacteria colonies respectively were inoculated as described above and the holes covered with sterilized transparent adhesive tape.
Three tomato fruits were inoculated with the same pathogen to constitute a treatment and each treatment replicated four times. The inoculated fruits were placed in sterile polythene papers tied with rubber bands and incubated in the laboratory at room temperature. Susceptibility of the cultivars to disease development was determined by the third day by measuring the diameter of the infected tissue (rot) from each treatment.

2.7. Data Analysis

SPSS frequency and percent was used to analyse the individual pathogen occurrence in the isolates obtained. One way ANOVA was used to determine fruit damage by individual pathogens and means were separated using Students-Newman-Keuls test, α=0.05.

3. Results

3.1 Isolation and identification of potential pathogens associated with post-harvest losses

The pathogens that were isolated and identified were *Fusarium* spp., *Botrytis* spp., *Alternaria* spp., *Geotrichum* spp. *Erwinia* and *Rhizopus* spp. There was a significant difference ($p<0.001$) between the pathogens isolated from the infected tomato samples (Table 1). Among the fungi *Fusarium* spp. was the most prevalent constituting 30 % of the total pathogen isolates. *Rhizopus* spp. took the second position with 22.3 % of the total isolates while *Geotrichum* spp. formed 17.5 % of the total pathogens isolated. *Botrytis* spp., formed 15 %, *Alternaria* spp. 8.5 % of the total isolates while the remaining 6.7 % was made up of *Erwinia* bacteria.

Table 1: Pathogens isolated from infected tomato in Mwea

Pathogens	Frequency	Percent
Erwinia (Bacteria)	4	6.7
Botrytis (fungi)	12	15.0
Alternaria (fungi)	6	8.5
Fusarium (fungi)	24	30.0
Geotrichum (fungi)	14	17.5
Rhizopus (fungi)	17	22.3
Total	77	100.0
p-value		<0.001

3.2 Morphological characteristics of the identified Pathogens

3.2.1 *Geotrichum* spp.

The fungus colony grew in PDA being low, flat, white and leathery with no reverse pigmentation (Fig 1). Hyphae were hyaline septate, branched and broke up into chains of hyaline, smooth, one-celled, subglobose to cylindrical, slimy arthroconidia (ameroconidia) (Fig 1c). The arthroconidia, were quite variable in size, aerial, erect or recumbent, cylindrical, hyaline, unicellular and barrel shaped.

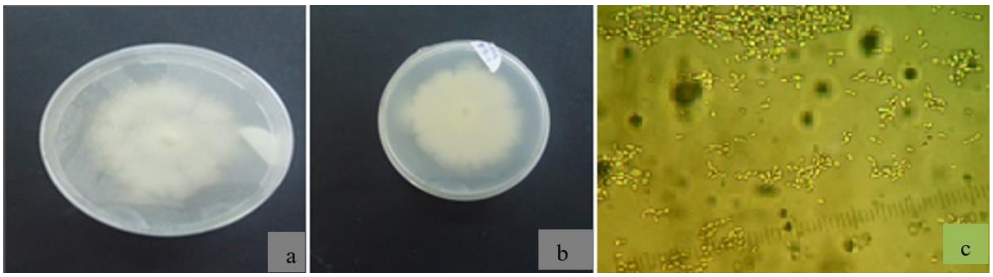

Fig 1: *Geotrichum* spp. colony on PDA; Front (a), Reverse (b) and Arthroconidia(c)

3.2.2 *Fusarium* spp.

Colony was fast growing, mycelia extensive, cottony in culture and pink in color (Fig 2). Conidiophores were variable, slender and simple, or stout, short, branched irregularly or bearing a whorl of phialides, single or grouped into sporodochia; conidia (phialospores) were hyaline, variable, often held in small heads. Macroconidia hyaline, several celled slightly curved or bent at the pointed ends, typically canoe-shaped (Fig 2c).

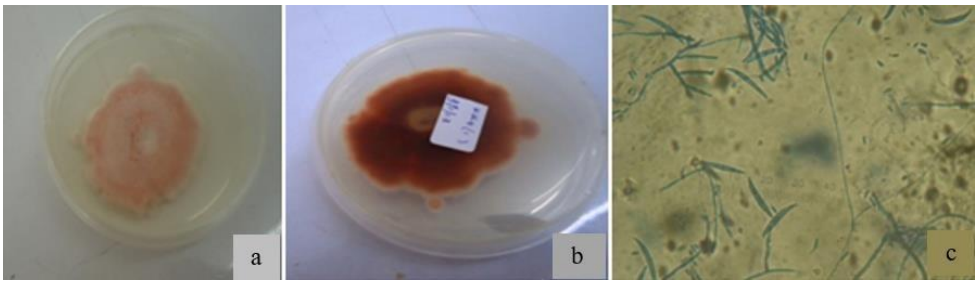

Fig 2: *Fusarium* spp. colony on PDA; Front (a), Reverse (b), macroconidia and Mycelia (c)

3.2.3 *Botrytis* spp.

Fungal colony growing in PDA was woolly, dark grey with a black reverse (Fig 3). The colony was also fast growing but the growth was irregular. Conidiophores were long, slender, pigmented, branched, sometimes near the apex, the apical cells enlarged, bearing clusters of conidia on short sterigmata; conidia (botryoblastospores) ash-colored, gray in mass, 1-celled and ovoid (Fig 3c).

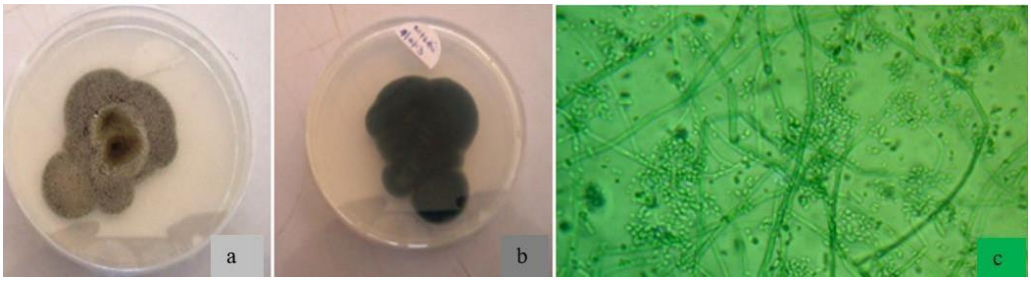

Fig 3: *Botrytis* spp. colony on PDA; Front (a), Reverse (b), microscopic mycelia and conidia (c)

3.2.4 *Alternaria* Spp

On PDA the colony was hairy grey and grey-brown to dark in colour on the reverse (Fig 4). The colony also possessed a texture similar to cotton or velvet. The mycelia were branched and septate and light brown (Fig 4c). The conidiophores were short, simple and were septate. The conidia appeared solitary straight and slightly flexuous oblong or muriform or ellipsoidal or tapering to beak. There were transverse septa in mature conidia and others had longitudinal septa. The conidia varied in beak size, length, septation and width (Fig 4c).

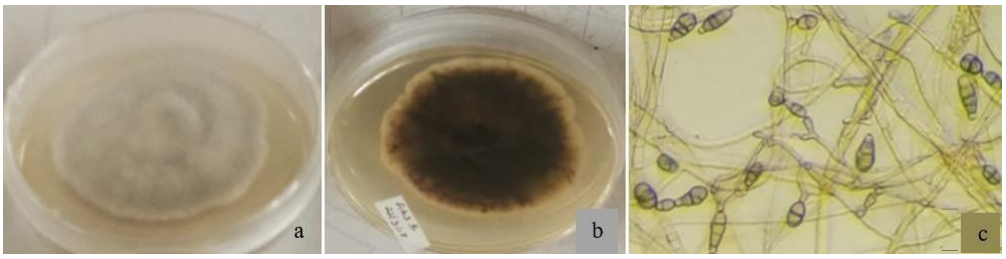

Fig 4: *Alternaria* spp. colony on PDA; Front (a), Reverse (b), Mycelia and Conidia (c)

3.2.5 *Rhizopus* spp.

The fungus grew rampantly filling the petridish with sparse white mycelia within four days. Colony was whitish on the front and brown on the reverse with extensive mycelial growth in culture as it ages (Fig 5). The mycelia was aseptate. Sporangiophores were large with striate walls (Fig 5c). Sporangia were globose to subglobose and blackish-brown at maturity. Columella projected into the sporangium (Fig 5c). Sporangiospores (asexual spores) were irregular in shape and were formed within pinhead like sporangium, which burst to release the spores when mature (Fig 5d).

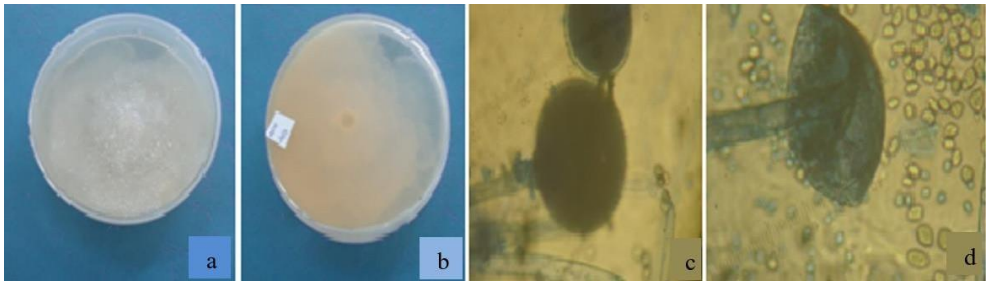

Fig 5: *Rhizopus* spp. colony in PDA; Front (a), Reverse (b), compact sporangium (c) and an open sporangium that has released spores (d)

3.2.6 *Erwinia* spp

It was a flagellated rod, gram-negative bacteria. Colonies growing in NA were circular, convex and creamy white in color (Fig 6a) and when stained, it retained the red colour (Fig 6b). The bacteria was also catalase positive and also induced rotting in potato slices.

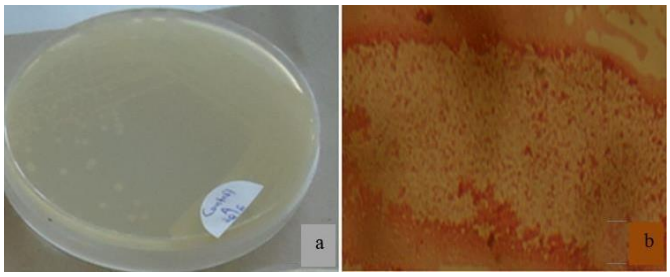

Fig 6: *Erwinia* colonies reverse (a) and *Erwinia* cells

3.3 Pathogenicity Test

The study revealed that the micro-organisms isolated from the infected tomato fruits were pathogenic but the pathogenicity varied between the pathogen species. When inoculated into healthy tomato fruits, *Rhizopus* spp. caused the most rapid (100 %) infection where the inoculated fruits were completely rotten by the end of the third day after inoculation. The fruits were completely disintegrated with extensive mycelial growth forming a dark color covering the fruit skin (Fig 7a). The fruits looked water soaked in appearance and wrinkled with depression. Fruits inoculated with *Fusarium* spp. had water soaked lesions around the inoculated area with some white to pink mycelia (Fig 7b) while fruits inoculated with *Botrytis* spp. showed water soaked lesions with a dark appearance on the inoculated areas (fig 7c). *Geotrichum* spp. caused whitish cheesy like lesions on the inoculated fruits (Fig 7d). On inoculated fruits *Alternaria* spp. caused lesions that looked dark to grayish in colour around the inoculated area (Fig 7e). Moreover, fruits inoculated with *Erwinia* spp. also had water soaked lesions around the inoculated areas (Fig 7f). The pathogens were isolated and identified as described earlier to confirm pathogenicity.

Fig 7: Tomato fruits inoculated with – *Rhizopus* spp. (a), *Fusarium* spp. (b), *Botrytis* spp. (c), *Geotrichum* spp. (d), *Alternaria* spp. (e) a *Erwinia* spp. (f). and a control on the right side of each treatment

3.4 Determination of tomato cultivar damage by the isolated pathogens

All the isolated pathogens caused rots on the tomato fruits but the level of the rots recorded differed significantly between the pathogens and between the two cultivars ($p<0.001$). The study revealed that the most damaging pathogen was *Rhizopus* spp. that caused 100 % rot in both Kilele F1 and Roma V.F which could not be measured. The pathogen disintegrated the entire fruit by the third day. On Kilele F1 *Geotrichum* spp. recorded a higher rot (28.08) while rots caused by *Fusarium* spp., *Erwinia* spp. and *Botrytis* spp. did not differ significantly (Table 2). *Alternaria* spp. recorded the lowest rot. Rots caused by the test pathogens on Roma V. F. varied significantly with *Geotrichum* spp. recording the highest rot diameter followed by *Erwinia* spp, *Fusarium* spp., *Botrytis* spp and *Alternaria* spp. in that order (Table 2). *Geotrichum* spp. was the second most damaging pathogen after *Rhizopus* spp. and it caused more rot on Kilele F1 than on Roma. *Botrytis* spp., and *Fusarium* spp seemed to damage Kilele F1 more than Roma V.F. Damages caused by *Erwinia* spp., and *Alternaria* spp. did not vary significantly between the cultivars. *Alternaria* spp. recorded the lowest rot diameter in the two cultivars meaning that it was less aggressive. Kilele F1 was more susceptible than Roma V.F. There was no rot development observed on the uninoculated fruits (control).

Table 2: Comparison of rot diameter caused by different pathogens on tomato Cultivars (Kilele and Roma)

Pathogens	Kilele (n=12) MeanRD±SD	RomaV.F (n=12) MeanRD±SD	p-value
Botrytis	16.25 ± 3.62^{bD}	13.42 ± 0.79^{dF}	0.001
Geotrichum	28.08 ± 2.61^{aA}	21.25 ± 2.14^{aB}	<0.001
Fusarium	19.33 ± 2.84^{bD}	15.83 ± 1.53^{cE}	0.002
Alternaria	10.58 ± 1.44^{cG}	9.42 ± 1.88^{eG}	0.102
Erwinia	18.25 ± 2.63^{bC}	18.50 ± 3.87^{bC}	0.855
Control	5.00 ± 0.00^{dH}	5.00 ± 0.0^{fH}	-
p-value	<0.001	<0.001	

Mean values followed by the same lower case within the same column are not significantly different and mean values followed by the same upper case within the same row are not significantly different (One way ANOVA, Students-Newman-Keuls test, $\alpha=0.05$).
RD refers to rot diameter and SD (standard deviation)

3.4 Susceptibility of tomato cultivars to selected post-harvest pathogens

The study revealed that all the two cultivars were susceptible to the test pathogens but the susceptibility differed significantly (p=0.045) (Table 4). Kilele F1 was more susceptible than Roma V. F.

Table 4: Cultivar susceptibility to rots

Cultivar	N	MeanRD±SE
Kilele	84	15.69±1.24a
Roma V.F	84	13.79±1.39b
p-value		0.045

Independent t-test showed that the susceptibility of Kilele and Roma V.F differed statistically (p=0.045)

4. Discussion

From this study, the isolated pathogens were *Rhizopus* spp., *Fusarium* spp., *Geotrichum* spp., *Botrytis* spp., *Alternaria* spp. and *Erwinia* spp with *Fusarium* being the most prevalent isolate followed by *Rhizopus* spp. There were more fungal species than the bacteria in the study area. These results corroborates with other researchers who observed that fungi were the major contaminants of tomato fruits (Gosh, 2009; Ibrahim *et al*., 2011; Matthew, 2011; Wogu and Ofuase, 2014) [22, 24, 33, 49]. However, lemma *et al*., (2014) [29] isolated more rot causing bacteria that fungi from tomato fruits. The results of pathogenicity test from this study revealed that all tomato fruits showed symptoms of rot while the un-inoculated control fruits showed no symptoms of rot. However the rate of rot varied significantly between the pathogens with *Rhizopus* spp. being the most virulent pathogen causing the most damage (100 % rot) within three days. *Alternaria* spp. recorded the lowest level of rots.

These results agrees with those of other researchers such as Chuku *et al*. (2008) [17], that showed that *Fusarium* spp., *R. stolonifer* and *Aspergillus* spp. were responsible for soft rot of tomato. Ijato *et al*. (2011) [25] isolated *A. niger, F. oxysporum*, *R. stolonifer* and *G. candidium* from rotten tomato fruits. Similarly, *F. moniliforme, A. niger* and *R. stolonifer* were also isolated from rotten tomato fruits (Onyia *et al*., 2000). In addition, Lemma *et al*. (2014) [29] isolated *Alternaria* spp, *Fusarium* spp, *Rhizopus* spp, *Penicillium* spp and *Erwinia carotovora* from infected tomato samples in Ethiopia. According to Sajad *et al*. (2016) and Cristina *et al*. (2018) [18], *G. Candidum*, *R. stolonifer*, *Alternaria* sp and *Fusarium* sp. were the major pathogens causing tomato fruit rots. Aworth *et al*. (1985) [6] also reported that the major causative agents of post-harvest spoilage of tomatoes are fungi and bacteria. Reports of Mailafia *et al*., (2017) [32], showed that *F. solani* and *R. stolonifer* were among pathogens causing rots on avocadoes, pawpaw, pineapple and tomato fruits. However the findings of this study did not agree with those of Ukeh *et al*. (2012) [51] and Splitstoesser (1987) [45], who reported that the major pathogens causing tomato post-harvest rots were *Mucor piriformis*, *Helminthosporium solani*, *Aspergillus niger* and *Penicillium digitatum*.

Previous literature showed that the decay of fruits during storage was due to the micro-organisms which could have gained entry through cracks, surface injuries due to rough handling, poor road and transport facilities (Wills *et al*., 1981; Liu and Ma, 1983) [48, 31]. According to Kader (2002) [27], the pathogens infect fruits during prolonged periods of rainfall and high humidity, especially when fruits are poorly packed. Reports of Villareal (1980) [46], revealed that a damaged tomato fruit may harbor pathogens that may spread and spoil all tomatoes in a lot. Conditions in the markets such as poor hygiene by the vendors favour fruit contamination and it results to increased post-harvest fruit losses (Mailafia *et al*., 2017) [32].

From the study it was noted that *Rhizopus* spp. caused the most rapid rot (100% infection) within the first three days. This observation agrees with the report of Okoli and Erinle (1990) [40] that showed that *R. stolonifer* caused the most rapid rot on stored tomatoes in Nigeria. Similarly, Chuku (2005) [16], *Rhizopus* recorded the highest rot (80 %) on Avocado and pears in Nigeria. Akinmusire (2011) [8], reported that *Rhizopus* spp. caused more rots on tomatoes. Acoording to this study, *Geotrichum* spp. was the second most damaging pathogen, followed by *Fusarium* spp. and *Erwinia* spp. Ansari *et al*. (2012) [7] also reported the presence of *Fusarium* in tomato fruits under wet conditions. *Fusarium* species produce mycotoxins which are dangerous to human health (Burgess, 1985; Jofee, 1986; Nelson *et al*., 1990) [14, 26, 38]. *G. candidum* causes sour rot on tomato fruits and the pathogen gains entry into the fruit through fruit injuries (Moris, 1982) [37]. In this research there was no *A. niger* isolated as was the case with some researchers who identified the pathogen as the most prevalent (Akinmusire, 2011; Ibrahim *et al*., 2011) [8, 24]. The study also revealed that the rate of tomato fruit damage was more in Kilele F1 than Roma V.F. This could have been brought about by probably their genetic differences.

5. Conclusion and recommendations

It was noted that micro-organisms (fungi and bacteria) caused post-harvest losses on tomato fruits irrespective of the cultivar. In this study *Rhizopus* spp., *Geotrichum* spp., *Erwinia* spp., *Fusarium* spp., *Botrytis* spp. and *Alternaria* spp. were isolated from the infected tomatoes. This showed that the study area had more fungi infecting tomatoes than bacteria. *Rhizopus* spp. proved to be the major cause of rotting in tomatoes while *Alternaria* spp. was found to be the least and this implies that *Alternaria* may not be a major cause to post-harvest losses in tomato. The study indicated that cultivars evaluated (Kilele F1 and Roma V.F) had influence on the post-harvest losses since Kilele F1 was more susceptible than Roma V.F. Farmers should disinfect the tomato fruits after harvesting to reduce chances of infection. This can be done by use of sodium hypochlorite because it less poisonous. Consumers should be advised against consumption of cheap spoilt tomato fruits because the fruits may habour mycotoxins. More studies should be carried out to determine whether seasons correlate with pathogen occurrence. There is need for careful handling of the produce during and after tomato fruits harvesting to avoid injuries that allow penetration of pathogens. Consumers should be made aware of the effects of consuming cheap pathogen contaminated fruits.

6. References

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