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Original Research

Studies on the identification of tomato rot fungi and physiological changes of tomato fruits infected with post-harvest fungi

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ABSTRACT:

Objectives: To detect post-harvest fungal attack on rotted tomato fruits and to determine different physiological changes in the contents of infected tomatoes.

Material and methods: This study was carried out on various rotted tomato fruits collected from the different markets of Sajer City. All specimens collected were transported immediately to the microbiological laboratory for identification of fungi and then to physiological laboratory to detect different physiological parameters for the contents of infected tomatoes.

Results: *A. flavus* and *A. fumigatus* were the most dominant fungi prevalent in the rotten tomato samples. These species were respectively recovered from 66.66% and 71.66% of the samples matching 21.17% and 23.14% of the total count of fungi. *F. moniliforme*, *F. solani*, *M. hiemalis, P. notatum* were moderately encountered (20%-26.66% of samples) whereas *P. chrysogenum*, *P. corylophilum* and *P. citrinum* were of low incidence (8.3% for each). *A. alternata* and *A. tenuissima* both of which appeared in low incidence (13.3% of sample for each). Physiological parameters like changes in (dry weight, protein content, pectin content, total sugar, reducing sugar and non reducing sugar content, ash, calcium content, phosphorus content and ascorbic acid content) from tomato were estimated. The maximum decrease in dry weight was reported because of the presence of *A. fumigatus*, *A. flavus*, *Alternaria alternate*, *A. niger* and *Alternaria tenuissima.* The maximum loss of protein contents were occurred by *A. fumigatus* and *A. flavus*. The maximum loss of pectin contents were observed under the action of *Aspergillus flavus*, *A. fumigatus*, *Fusarium moniliforme*, *Alternaria alternata*, *A. tenuissima*, *A. niger* and *F. solani*. The maximum decreasing of total sugar was reported by *Fusarium moniliforme*, *F. solani*, *F. equiseti*, *F. oxysporum*, *Aspergillus flavus* and *A. niger*. The maximum depletion of ash was seen due to *Alternaria alternate, A. tenuissima, Aspergillus flavus* and *Fusarium moniliforme*. The maximum decreasing of calcium was found to be in the sample infected by *Alternaria alternata*, *A. tenuissima*, *Aspergillus flavus* and *F. equiseti*. *F. moniliforme* and *A. alternata* were responsible for the maximum depletion of phosphorus content. *Fusarium moniliforme*, *A. alternata, F. solani*, *Mucor hiemalis*, *M. racemosus*, *A. flavus, A. niger* and *Penicillium notatum* caused maximum decrease in the ascorbic acid contents.

Keywords:
Post-harvest fungi, Deterioration, Physiological changes, Tomatoes fruits.

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is widely grown vegetable crop of the world, belonging to the family Solanaceae and ranks second in importance among vegetables. Tomato is also known as "love apple" (Rao, 2005). It is originally native of tropical America from Peruvian and Mexican regions (Thompson and Kelly, 1957).

Tomato cultivation has become increasingly popular since the mid-nineteenth century because of its varied climatic tolerance and high nutritive value. The major tomato growing countries are China, USA, Italy, Turkey, India, Egypt, Brazil, Iran and Mexico (Kumar, 2011). Tomato is one of the most imperative vegetable crops for human utilization (Grandillo *et al*., 1999) Tomatoes can be devoured by various ways. The fresh fruits are eaten as sandwiches, salads and as salsa while the cooked ones are eaten as pastes, jelly, sauces, soups, juices and beverages (Alam *et al*., 2007; Beckles, 2012). Tomatoes give a wide assortment of nutrients and numerous health related advantages to the body. Tomatoes comprise generally of water, sugar, vitamin A and C, protein and higher measures of lycopene, which is considered as a sort of carotenoid with antioxidant properties (Arab and Steck, 2000) that assume a vital job in lessening the frequency of some chronic diseases (Basu and Imrhan, 2007) like malignancy and numerous other cardiovascular disorders. (Freeman and Reimers, 2011). Juice of the fruit is a mild aperients, a promoter of gastric secretions and blood purifier. It is also considered as good antiseptic for the intestine.

The microbial decay of tomatoes causes decrease in the market values and dietary characteristics, and sometimes rendered the friuts non-fit for utilization. This is because of the contaminations with mycotoxins (Muhammad *et al*., 2004). In the of developing nations, tomato fruits are frequently found in containers and on benches for the planned clients, consequently presenting them to opportunistic microbial infections particularly mycotoxigenic fungi (Baiyewu *et al*., 2007). Microbial fruit infections could happen amid development of crops, harvesting, post-harvest handling, storage, transportation and bundling and circulation at different channels and selling outlets of which microorganisms and growths are pervasive (Barth *et al*., 2009; Fung, 2009; Akinyele and Akinkunmi, 2012). Fresh tomato fruits with about 80% water content, low pH, profoundly rich supplements and sugars, serves as a good medium for microbial development (Singh and Sharma, 2007). Research has likewise demonstrated that post-harvest loss of fruits because of microbial diseases.

Research on post-harvest problems of tomatoes is receiving great attention in many countries including the USA, the UK, the Netherlands, Australia, China, Nigeria and others (Snowdon, 1990). In USA, showed the post- harvest decay problems and are usually due to the severity of the disease in the filed and to the inoculums levels associated with the fruit before harvest (Eckert and Ogawa, 1988). Amid pathogenesis different parasites and microbes not just distort or cause rot to various natural products yet in addition the post-infectional biochemical changes decrease their nourishment and market esteems significantly (Mehrotra *et al*., 1998; Arun 1993). The microorganism often responsible for post-harvest disease are *Botrytis cinerea*, *Alternaria alternate*, *Phytophthora parasitica, Erwinia carotovora*, *Rhizopus stolonifer*, *Mucor* sp, *Fusarium* sp, *Phytophthora infestans*, *Rhizoctonia solani* and *Aspergillus* sp (Oladiran and Iwu, 1993). Nutritional value of the fruits mainly depends on their quality and quantity of sugars, vitamins and other essential substances. Fruits are considered as the best sources of sugars, amino acids, organic acids, vitamins and other nutrients (Mehrotra *et al*., 1998). Considering the fact, physiological changes of tomato under the influence of postharvest fungi were studied.

MATERIALS AND METHODS

Collection of tomato samples

One hundred of mouldy tomato fruits were randomly collected from the different markets in Sajer City. The weight of each sample was nearly 250g.Samples were separately kept inside clean plastic bags, transferred to the laboratory and stored in a refrigerator until mycological and physiological analysis.

Isolation and identification of fungi

The direct plating technique described by (Pitt and Hocking, 1985) was employed. Four small pieces from the margin of lesions of each sample were directly inoculated on pre-poured plates of glucose-Czapek's agar medium (Pitt and Hocking, 1985). The cultures were incubated at 28ºC for 5 to 7 days. The resulting colonies were isolated, purified and identified (Pitt and Hocking, 1985).

Different physiological changes of rotten tomato fruits were determinate by standard physiological method as the following

Determination of dry matter content

For determination dry matter content, l00 g of sample was taken in a clean dry pre-weighed tray and is kept in oven for 48 hours or more at 95±5°C, till constant weight. Weight of the dried sample was calculated as percent dry matter.

Determination of protein

This was carried out using the Lowry's technique. The optical density of each of the sample was taken at 600 nm with the Jenway 6051 Colorimeter. Serial dilutions of egg albumin powder (Sigma) were treated in the same manner and used to plot a standard graph. The unknown value of protein in each test sample was extrapolated from the standard graph (Lowry *et al*., 1951).

Determination of pectin

Samples (50 g) were placed in 2.5 L boiling water and 8 mL HCl was added to give a pH of 2.2± 0.1, followed by addition of 20 g paper pulp filter aid. The mixture was heated at 95–100°C for 30 min. with constant stirring, after which the mixture was filtered and the residue was washed once with 500 mL boiling water. The filtrate was cooled before adding to 1.5 volumes 95% ethanol containing 2 mL/L HCl. The mixture was slowly stirred and left to stand for 30 min. The residue was collected and dried at 60°C overnight (McCready, 1970).

Determination of total sugar and reducing sugar

Total sugar was determined by spectrophotometric method i.e. anthrone method (Dubois *et al*., 1956), reducing sugar was determined by spectrophotometric method i.e. DNS method (Miller, 1959)

Determination of non reducing sugar

The percentage of non-reducing sugars was calculated by subtracting the value of the percentage of reducing sugars from that of total sugars.

Determination of ash

The residue after incineration of sample at 550 – 600°C is known as ash. For this purpose the samples were subjected to a high temperature up to 600°C and then the ash content is determined. During ignition to such a high temperature all organic compounds decompose and pass off in the form of gases, while the material elements remain in the form of ash. For this the procedure is followed by (AOAC, 1970; Oser, 1979) two gram of tomato fruit was placed in a previously weighed crucible and it was subjected for heating on hot plate till the sample was sufficiently turned black in about 30 min. Then it was placed in the muffle furnace, pre-heated to 600°C for two hours with automatic control. Crucible were transferred directly to desiccators, cooled and weighed immediately. Weight of the ash was obtained per 2 g of sample and the ash content was calculated.

Determination of calcium

An aliquot (25 mL) of the ash portion of the

acid solution was diluted to 150 mL with distilled water. Few drops of methyl red was included and the blend was neutralised with ammonia (NH_3) till the pink colour changes to yellow. The solution was warmed until the point that it bubbles and 10 mL ammonium oxalate solution was added and boiled for few min. Glacial acetic acid was then included till particularly pink shading returned. The mixture was kept aside for 12 to 24 h at the room temperature. At the point when the precipitate at calcium oxalate settled down, it was sieved through Whatman's filter paper No. 42. The precipitate was washed a few times with distilled water, to make it free from acid. It was then transferred in a small beaker by piercing a hole in the filter paper and by pouring over it around 15 mL 2N H_2SO_4. This is warmed to above 40°C and titrated against 0.01N $KMnO_4$ solution until the point when the first drop gives the solution a pink tinge enduring for no less than 30 sec. The measure of calcium was determined utilizing a equation. 1 mL of $KMnO_4$=0.2004 mg of Ca. The percent calcium on DM basis was then determined based on the amount of sample utilized for ashing, the volume to which acid solution of ash is diluted and the volume of the aliquot taken for the precipitation of the calcium. The methodology of estimation of calcium was done following (Mungikar, 1999).

Determination of phosphorus

The estimation of phosphorus is done by the strategy given by Oser (1979). 0.5 mL of acid soluble part of ash was taken in a test tube. Dilute it to a volume of 10 mL with distilled water. At the same time taken a blank containing 10 mL of distilled refined water. 1 mL molybdate solution was added to each test tube and blended, and afterwards 0.4 mL ANSA reagent was included and again blended. It was permitted to stand for 5 min and the Optical Density (O.D.) was seen at 660 nm utilizing colorimeter by setting it to zero with the clear. The O.D. of standard phosphorus solution was set up by setting up a standard chart containing 0 to1 mL standard phosphorus solutions in a series of test tubes. The amount of phosphorus in an aliquot was determined with the assistance of standard graph and the phosphorus content in the fruit pulp mash was determined considering its sum taken for ashing, volume of acid soluble ash and amount of aliquot utilized for the reaction.

Determination of ascorbic acid

Ascorbic acid (Vitamin C) content was assessed by standard titration technique. 5 mL of standard solution of standard Ascorbic acid (100 mg/mL) was pipetted out into a conical flask, and 10 mL of 0.4% oxalic acid was taken and it was titrated with dye. After that 2 g sample was extracted in 0.4% oxalic acid and volume was completed to 100 mL by 0.4% oxalic acid. From the solution 5 mL of test was pipetted out into conical flask and titrated with dye. End point was pink colour. Finally amount of vitamin C in mg/100mL pulp was evaluated by utilizing following equation.

Amount of ascorbic acid mg/100ml pulp = 0.5mg/V_1 mL x V_2 mL/5 mL x 100 mL/wt. of sample x 100.

Where, V_1 mL = volume of Standard Ascorbic acid.

V_2 mL = volume of samples ascorbic acid. (Jagota and Dani, 1982).

RESULTS

Twenty two fungal species attributed to ten genera were isolated from 100 samples of mouldy tomato fruits which were collected from different localities in Sajer's markets.

Aspergillus was the genus most frequently found on 88.33% of tomato fruits accounting for 58.95% of total fungal population. It was represented by four species of which *A. flavus* and *A. fumigates* were the most dominant. These species were respectively recovered from 66.66% and 71.66% of the samples matching 21.17% and 23.14% of total count of fungi. *A. niger* was recovered from 43.33% representing 8.99% of total fungi. *A. terreus* appeared in low

Table 1. Physiological changes (dry weight, protein content and pectin content) in tomato fruit due to post harvest fungi

S. No	Fungi	Dry weight (g/100 mL)	Protein (g/100 mL)	Pectin (g/100mL)
1	*Aspergillus flavus*	3.2	1.4	1.2
2	*A. fumigatus*	3	1.3	1.3
3	*A. niger*	3.4	1.5	1.4
4	*A. terreus*	4	1.6	1.8
5	*Fusarium moniliforme*	4.8	1.9	1.3
6	*F. solani*	4.9	1.9	1.4
7	*F. equiseti*	5	1.9	1.5
8	*F. oxysporum*	5	1.9	1.5
9	*Mucor hiemalis*	3.7	1.6	1.6
10	*M. circinelloides*	3.9	1.7	1.7
11	*M. racemosus*	4	1.7	1.7
12	*Penicillium notatum*	4.7	1.8	1.6
13	*P. chrysogenum*	4.7	1.8	1.7
14	*P. corylophilum*	5.8	-	1.6
15	*P. citrinum*	5.8	-	1.8
16	*Alternaria alternata*	3.2	1.6	1.3
17	*A.tenuissima*	3.5	1.7	1.4
18	*Acremonium* sp	5.8	-	1.8
19	*Geotrichum* sp	5.7	-	1.8
20	*Rhizopus* sp	5.7	-	1.7
21	*Trichothecium* sp	5.9	-	1.8
22	Control	6	2	1.9

incidence (11.66%) as well as in low counts (2.41% of fungal count).

Fusarium (4 species), *Mucor* (3 species) and *Pencillium* (4 species) were of moderate incidence on tomato fruits. These genera appeared on 43.33%, 28.33% and 43.33% of the samples accounting for 11.79%, 6.55% and 7. 64% of total fungal count. Of these genera, *F. moniliforme*, *F. solani*, *M. hiemalis, P. notatum* were moderately encountered (20%-26.66% of samples) whereas *P. chryrogenum*, *P. corylophilum* and *P. citrinum* were of low incidence (8.3% for each).

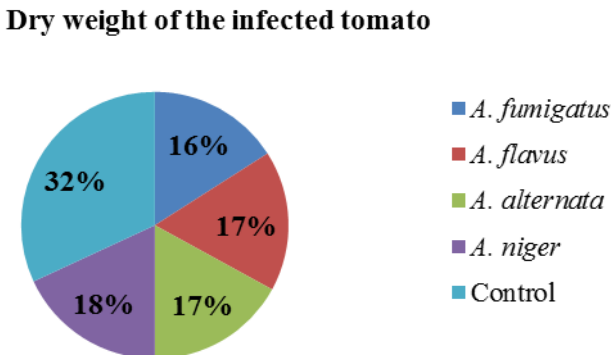

Figure 1. Maximum decrease in the of dry weight of infected tomatoes with different fungal species in comparison to the healthy fruit (control)

The genus of *Alternaria* was less incident and recovered from 26.6% of tomato samples matching 7.64% of total fungal count. It was represented by *A. alternate* and *A. tenuissima*, both of which appeared in low incidence (13.3% of sample for each). The remaining genera and species were of rare frequency of occurrence on tested tomato fruits. They include some species belonging to *Acremonium*, *Geotrichum, Rhizopus* and *Trichothecium* in addition to budding yeast.

Different physiological changes were occurred for the contents of tomato under the influence of

Table 2. Different physiological changes (ash, calcium and phosphorus) in tomato fruit due to post harvest fungi

S. No	Fungi	Ash (mg/100 mL)	Calcium (mg/100 mL)	Phosphorus (mg/100 mL)
1	*Aspergillus flavus*	240	6	11
2	*A. fumigatus*	250	8	10
3	*A. niger*	250	7	13
4	*A. terreus*	290	9	18
5	*Fusarium moniliforme*	245	8	8
6	*F. solani*	255	7	10
7	*F. equiseti*	270	6	11
8	*F. oxysporum*	275	10	11
9	*Mucor hiemalis*	255	9	12
10	*M. circinelloides*	260	10	13
11	*M. racemosus*	265	10	13
12	*Penicillium notatum*	265	6	14
13	*P. chrysogenum*	270	7	15
14	*P. corylophilum*	275	8	17
15	*P. citrinum*	270	8	16
16	*Alternaria alternata*	220	5	9
17	*A. tenuissima*	230	6	10
18	*Acremonium* sp	290	10	18
19	*Geotrichum* sp	285	10	17
20	*Rhizopus* sp	250	9	15
21	*Trichothecium* sp	285	10	17
22	Control	300	11	19

postharvest fungi. It was observed that all dry weight of infected tomatoes were decreased under the action of isolated fungi (Figure 1). The maximum decreased was achieved under the action of *A. fumigatus*, *A. flavus*, *Alternaria alternata*, *A.niger* and *Alternaria tenuissima* and these dry weight of tomatoes were (3, 3.2, 3.3, 3.4 and 3.5, respectively). The protein content of each infected tomato fruit were decreased under the action of different fungi except *P. corylophilum, P. citrinum, Acremonium* sp, *Geotrichum* sp, *Rhizopus* sp and *Trichothecium* sp have no effect on protein content of tomato fruits (Figure 2). The maximum loss of protein

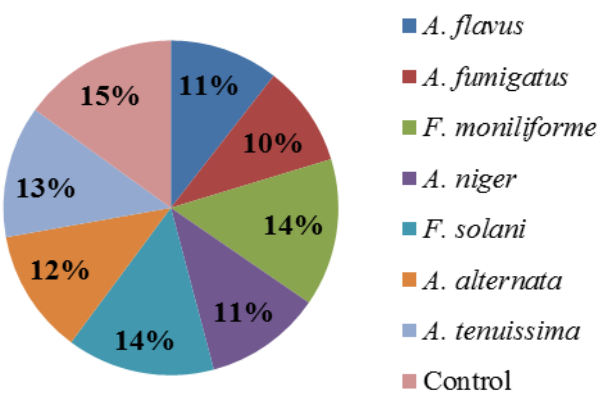

Figure 2. Maximum decreasing in protein content of infected tomatoes with different fungal species in comparison to the healthy fruit (control)

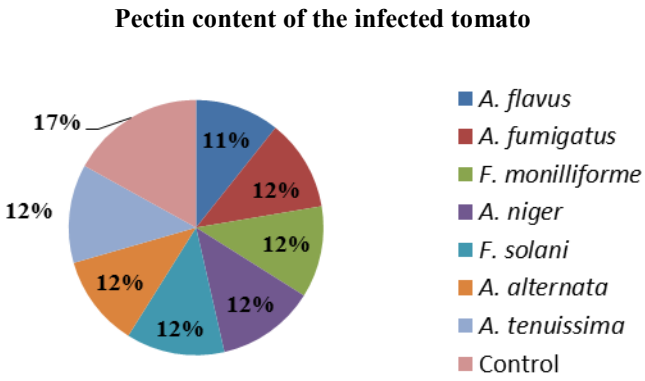

Figure 3. Maximum decrease in the pectin content of infected tomatoes with different fungal species in comparison to the healthy fruit (control)

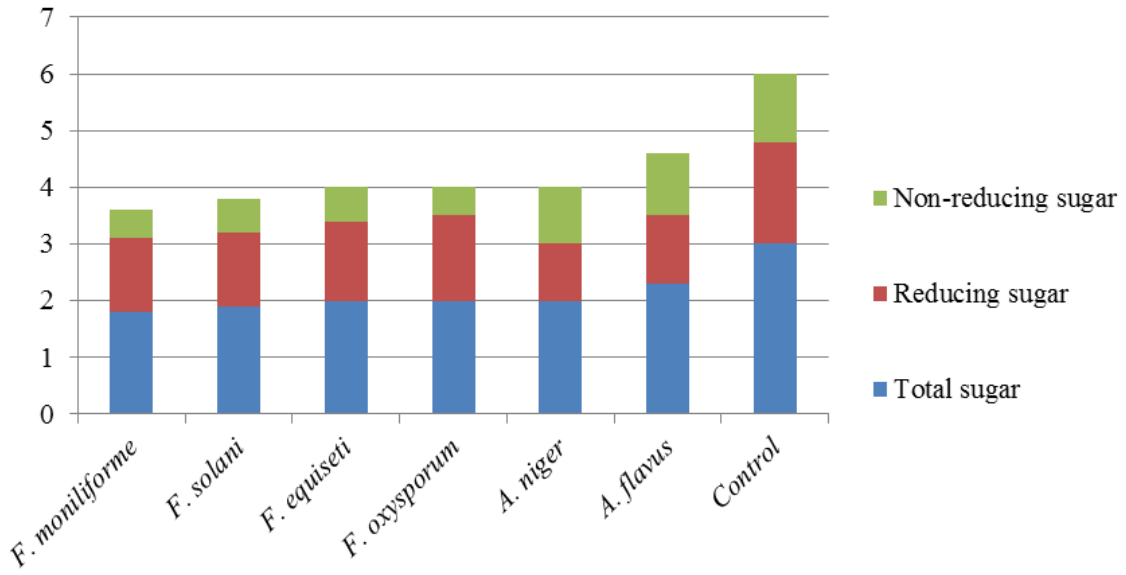

Figure 4. Maximum decrease in the total sugar, reducing sugar and non-reducing sugar of infected tomatoes with different fungal species in comparison to the healthy fruit (control)

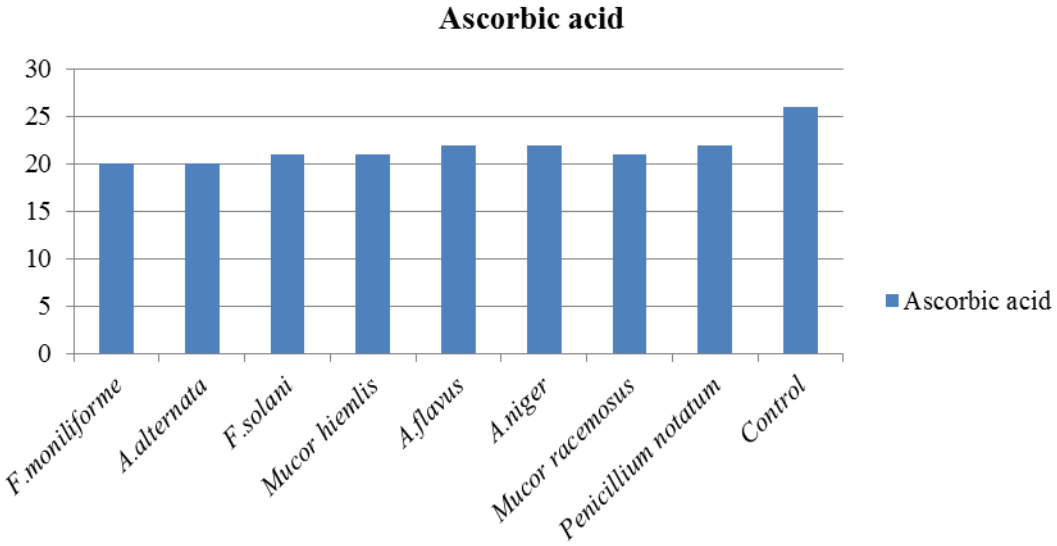

Figure 5. Maximum decrease in ascorbic acid content of tomato infected with different fungi

contents was occurred by *Aspergillus fumigatus* and *A. flavus*. In our analysis, all fungi deteriorate pectin contents of tomato fruits (Figure 3). The maximum loss of pectin contents was observed by *Aspergillus flavus*, *A. fumigatus, Fusarium moniliforme, Alternaria alternata, A. tenuissima, A. niger* and *F. solani* (Table 1).

The results showed that the total sugar of all infected tomato fruits were decreased by different deteriorated fungi. The maximum decreasing of total sugar were achieved by *Fusarium moniliforme, F. solani, F. equiseti, F. oxysporum, A. niger* and *Aspergillus flavus*. It was found that all fungi reduced the reducing sugar in all tomato fruits. The maximum depletion of reducing sugar due to *Aspergillus niger, Alternaria alternata, Aspergillus flavus, Fusarium moniliforme, F. solani* and *A. tenuissima*. The maximum decreasing of non-reducing sugar was achieved by *A. tenuissima*, *A. alternata*, *F. moniliforme*, *F. oxysporium*, *F. solani* and *F. oxysporium* (Figure 4).

The results revealed that the ash content of tomato fruits was depleted by different species of fungi. The maximum depletion of ash were achieved by *Alternaria alternata, A. tenuissima, Aspergillus flavus* and *Fusarium moniliforme*. The calcium content was slightly decreased under the effect of pathogenic fungi. The maximum decreasing was achieved by *Alternaria alternata*, *A. tenuuissima*, *Aspergillus flavus* and *F. equiseti*. The results revealed that all fungi reduced the phosphorus content of tomato fruits. *Fusarium moniliforme* and *Alternaria alternata* were responsible for maximum depletion of phosphorus content (Table 2). All fungi showed decrease in ascorbic acid content. *Fusarium moniliforme*, *Alternaria alternata, F. solani*, *Mucor hiemalis*, *Aspergillus flavus, A. niger*, *Mucor racemosus* and *Penicillium notatum* caused maximum decrease of ascorbic content (Figure 5).

DISCUSSION

Ten fungal genera were isolated from tomato fruits include *Aspergillus, Fusarium, Mucor, Penicillium, Alternaria, Acremonium, Geotrichum, Rhizopus*, *Trichothecium* and yeast. These pathogenic genera showing that these pathogens could develop and survive in tomato fruits. These pathogens were considered as the causal agents of post-harvest rot of tomatoes in Sajer city. This is because of the way that tomatoes contain a few nutrients fundamental for the development of pathogenic microorganisms. The deterioration of the fruits amid post-harvest storage is because of infection by these microbes which may have picked up entry through stomata openings, growth cracks or surface injuries (Fiske and Subbarow, 1925). These pathogens additionally picked up entry through various wounds caused by rough dealing poor road and storerooms (Wills *et al*., 1981).

Aspergillus was the most common genus of tomato fruit and accounting for 58.95% of total fungal population. *A. flavus* and *A. fumigatus* were the most dominant species. These results agree with the previous study which found that *A. flavus* and *A. niger* were the most common deteriorated fungi of tomato fruits (Liu and Ma, 1983)

Species of *Fusarium*, *Mucor* and *Pencillium* were of moderate incidence on tomato fruits. Of these species, *F. moniliforme*, *F. solani*, *M. hiemalis, P. notatum* were moderately encountered (20%- 26.66% of samples) whereas *P. chrysogenum*, *P. corylophilum* and *P. citrinum* were of low incidence (8.3% for each).

A. alternata and *A.tenuissima* were appeared in low incidence (13.3% of sample for each). The remaining genera and species were of rare frequency of occurrence on tested tomato fruits. They include some species belonging to *Acremonium*, *Geotrichum, Rhizopus, Trichothecium* in addition to budding yeast. These findings are in close agreement and harmony with the previous reports, since tomatoes were observed to be contaminated with *Alternaria alternata, Aspergillus niger, Geotrichum candidum, Phoma destructiva, Rhizopus stolonifer, Trichothecium roseum, Alternaria solani, Colletotrichum lycopersici, Rhizopus nigricans* and *Mucor racemosus* consistently (2013-2016). *Cladosporium fulvum, Sclerotium rolfsii, Myrothecium roridum and Penicillium italicum* were not found. Most elevated recurrence happened in *Alternaria alternata* (16.51%), trailed by *Alternaria solani* (12.43%*), Geotrichum candidum* (10.66%), *Aspergillus niger* (8.82%) and *Colletotrichum lycopersici* (7.53%). Most minimal recurrence happened in *Sclerotium rolfsii*, *Mucor racemosus, Penicillium italicum* and *Cladosporium fulvum* (Kobina and Ebenezer, 2012). *Aspergillus niger* and *Fusarium oxysporum* on tomato fruit were reported in wet conditions (Sajad *et al*., 2017). *F. equiseti*, *F. chlamydosporum*, *Alternaria solani*, *Geotrichum candidum*, *Acremonium recifei*, *Aspergillus flavus* and *A. niger* were responsible for 30 per cent losses of tomato fruits due to different rots (Safiuddin *et al*., 2012).

Studies on post-harvest diseases of tomato at vegetable market and Anand amid 2007 to 2008 showed the occuerence of five pathogenic fungi that cause decay, *Alternaria* (19.7%), *Rhizopus* (4.59%), *Aspergillus* (3.44%), *Penicillium* (2.6%) and *Fusarium* rot (2.2%) respectively (Haque and Khan, 2010).

Seven species of fungi were consistently obtained from the rotted fruits of tomato i.e. *A. alternata, Cladosporium oxysporum*, *F. pallidoroseum*, *F. equiseti, Rhizopus stolonifer*, *Sclerotium rolfsii* and *Geotrichum candidum*. These six genera of fungi were responsible for causing different rots and the prevalence varied from 4 to 9 percent (Penchal *et al*., 2005).

This study reported the post-infectional changes pertaining to physiological aspects caused due to major post-harvest mycobial rot pathogens in tomato fruits. The results revealed significant decrease in different physiological parameter of rotted tomato fruits as compared to healthy fruits (control).

The results revealed that all dry weight of the infected tomatoes were decreased under the action of all isolated fungi (Figure 1). The maximum decreased was achieved by *A. fumigatus*, *A. flavus*, *Alternaria alternata*, *A. niger* and *Alternaria tenuissima.* These results were nearly closed to the results of (Sharma and Choudhary, 2004) since the dry weight of all infected tomatoes were decreased.

The protein content of each infected tomato fruit were decreased under the action of different fungi (Figure 2). The maximum loss of protein content was occurred by *Aspergillus fumigatus* and *A. flavus.* These results were nearly close to the results of Ghadsingh and Mandge (2012) who reported that protein content of tomato was decreased by *A. flavus*.

In other study, protein content in tomato was found to be hampered due to *Phytophthora parasitica* while *Rhizopus stolonifer* showed minimum decrease in protein content of tomato (Sanyaolu, 2006).

It was observed that all fungi deteriorate the pectin contents of tomato fruits (Figure 3). The maximum loss of pectin contents was observed by *Aspergillus flavus*, *A. fumigatus, Fusarium moniliforme, Alternaria alternata, A. tenuissima, A. niger* and *F. solani.* These results were in agreement with the report of Gulab and Ashok (2012) who investigated on the papaya fruits. The maximum loss of pectin contents was observed by *Fusarium moniliforme*, *Curvularia lunata*, *Fusarium moniliforme* and *Rhizopus stolonifer.*

The results showed that the total sugar of all infected tomato fruits were decreased by different deteriorated fungi (Figure 4). The maximum decreasing of total sugar were achieved by *Fusarium moniliforme, F. solani, F. equiseti, F. oxysporum, A. niger* and *Aspergillus flavus*. It was found that all fungi reduced the reducing sugar in all tomato fruits. The maximum depletion of reducing sugar was due to *Aspergillus niger, Alternaria alternata, Aspergillus flavus, Fusarium moniliforme, F. solani* and *A. tenuissima.* These results were nearly close to the results recorded by Sawant and Gawai (2011) who found that *Rhizopus stolonifer, Aspergillus flavus*, *A. niger*, *Penicillium digitatum*, *Curvularia lunata* and *Fusarium moniliforme* were responsible for the decrease in total sugar and in reducing sugar content of tomato fruit. Ghadsingh and Mandge (2012) observed other trend of results in tomato fruit infected with *Alternaria solani, Colletotrichum* sp, *Aspergillus niger* and *Phytophthora parasitica* revealing 2.7, 2.5, 2.1 and 1.8 per cent decrease in total sugar, respectively as compared to the control (3.00%).

The results revealed that the ash content of tomato fruits was depleted by different species of fungi. The maximum depletion of ash were achieved by *Alternaria alternata, A. tenuissima, Aspergillus flavus* and *Fusarium moniliforme*. The calcium content was slightly decreased under the effect of deteriorated fungi. The maximum decreasing was achieved by *Alternaria alternata*, *A. tenuissima*, *Aspergillus flavus* and

F. equiseti. Sanyaolu (2016) found in their study that *A. niger* showed a similar trend in its deteriorative effect on calcium content of tomato fruit. The mean value obtained showed calcium in the tomato sample was significantly lower (P=0.05) in the infected sample at day three (9.50 ± 0.05^{a}) and five (10.30 ± 0.18^{a}) compared with the control sample (12.30 ± 1.06^{b}).

The results revealed that all fungi reduced the phosphorus content of tomato fruit. *Fusarium moniliforme* and *Alternaria alternata* were responsible for maximum depletion of phosphorus content. The phosphorus content of pawpaw fruits infected with both *Penicillium digitatum* and *Fusarium oxysporum* decreased compared with phosphorus content of healthy fruits (Oke and Banjoko, 1991).

All fungi showed decrease in ascorbic acid content. *Fusarium moniliforme*, *Alternaria alternata, F. solani*, *Mucor hiemalis*, *Aspergillus flavus, A. niger*, *Mucor racemosus* and *Penicillium notatum* caused maximum decrease of ascorbic content. The results of present investigation were corroborate with the results obtained by Ogaraku *et al*. (2010) who did his examinations on the storage and rot of tomatoes and vitamin C content in fruits vaccinated with *Aspergillus niger, Aspergillus flavus, Alternaria alternata, Alternaria solani* and *Fusarium oxysporium*. The outcomes demonstrated that the infected fruits contains 2.2 mg/100 g vitamin C while the healthy tomato fruits contains 2.51 mg/100g vitamin C. Sharma *et al*. (2011) also reported a significant loss in ascorbic acid content in tomato fruits which were infected by the post-infectional changes post-harvest mycobial rot pathogens *viz. Alternaria alternata, Botryodiplodia theobromae, G. candidum, Penicillium digitatum and P. italicum* as compare to uninoculated healthy fruits.

Similar to the present investigations, the depletion in ascorbic acid content was observed in tomato fruits inoculated with *F. equiseti, F. chlamydosporium, Geotrichum candidum* and *Aspergillus* sp, when compared with control fruits. (Oladiran and Lwu, 1992).

CONCLUSION

Most of the post-harvest fungi cause different harmful effect of infected tomato fruits by decreasing different essential contents of tomato fruits which reduces their value and human consumption.

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