Research Article

Incidence of Post-Harvest Fungal Rot of Some Vegetables in Swabi, Khyber Pakhtunkhwa Pakistan

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Abstract | The major global concern of the developing countries is to fulfill the basic need of food to mankind as more than one-third of the food is lost due to various kinds of diseases and many other effects like post-harvest loss by different fungi. The danger of post-harvest disease influences the way most horticultural crops are handled. Hence, the proper identification of the causal pathogen is important before appropriate treatment can be made to control the pathogens. Therefore, In the present study, *Alternaria alternata*, *Alternaria*, *Rhizopus*, *Mucor*, *Aspergillus niger*, *Aspergillus flavus*, *Cladosporium*, *Botrytis cinerea*, *Fusarium moniliforme*, *Drechslera*, *Penicillium*, and *Geotrichum candidum* were identified among various vegetables including potato, carrot, okra, eggplant, turnip, cucumber, round gourd, cauliflower, and chilli. These losses result in about a 30% reduction in the yield of these vegetables. By reducing the post-harvest losses, it could be possible to overcome the need of food as the world population is in dare need of research relating to crop sustainability.

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Introduction

Food insecurity is the ultimate result of income and poverty (Tacoli, 2019) which also results in malnutrition and hence affects the world's population (Godfray *et al*., 2010). Therefore, due to less consumption of fruits and vegetables, mortality is among the top risk factors (Ezzati *et al*., 2002). Vegetables are the living parts of plant and contain about 65 to 95% of water (Can *et al*., 1988). In Pakistan about 36 varieties of vegetables are cultivated on large scale and these vegetable provides a prerequisite for health because they supply the essential nutrients to the body needed for a balanced diet (Gulfam *et al*., 2020). Moreover, they play an important role in the diet of mostly lower income families.

Most of the countries in last few decades focused on the improvement of agricultural production to overcome the increasing food demand (Kumar and Kalita, 2017). During post-harvest operations, about one third of the food produced is at risk or totally lost globally (Gustavsson *et al*., 2011). Whereas the term food loss is defined as that the food goes unconsumed even it was available (Buzby *et al*., 2015). Post-harvest loss can be explained as degradation in volume, value and nutrition (Chitranshi *et al*., 2020). Considerable amount of food is gone in post-harvest (Faiz *et al*., 2020). Moreover, the fungi and nematodes are also posing a serious threat to our crops (Parveen *et al*.,

2020). Fungi is considered to be among the imperative pathogens of plants resulting in huge losses (Gonzalez *et al*., 2011; Hamon *et al*., 2011). Due to pest and pathogen attack on vegetable and fruits, Pakistan is no more the fifth larger exporter of the world; among all other pathogens the diseases caused by fungus are more lethal (Hussain and Usman, 2019).

In this context the most common fungi like *Alternaria alternata*, *Alternaria solani*, *Aspergillus niger*, *Aspergillus flavus*, *Fusarium solani*, *Pencillium* spp and *Rhizopus stolonifer* responsible for post-harvest lost in vegetables were studied in Khyber Pakhtunkhwa especially in Swabi. Post-harvest losses of vegetables occur due to improper harvesting, transportation storage and distribution. The post-harvest losses can be minimizing by adopting necessary culture techniques such as careful handling, packing and the use of appropriate chemicals at pre and post-harvest stages. The current study about reduction in post harvest losses could be helpful for sustainable crop productions.

Materials and Methods

Sample collection

Sample of different rotted vegetables like Cucumber, (*Cucumis sativus*) Cauliflower, *(Brassica oleracea*) Eggplant, (*Solanum melongena*) Okra, *(Hibiscus esculentus)* Potato, (*Solanum tuberosum*), Chili (*Capsicum annum*), Turnip (*Brassica rapa*), Carrot (*Daucus carrota*) and Round gourd (*Praecitrullus fistulos*) were collected in different season from different market of District Swabi including Tordher and Marghuz. These areas were located in Khyber Pakhtunkhwa province of Pakistan.

Sample preparation

Rotted vegetables were brought to laboratory in sterile polythene bags. Small pieces (five in number) were cut with sharp razor each of about 1 cm and transfer into Potato Dextrose Agar (PDA) plates containing penicillin (10000 units\L) and streptomycin (0.2 g\L) and then incubated for 5 days at room temperature. After 5 to 7 days' pathogens were identified on the basis of their color, colony structure, growth of pathogens, spores and mycelium structure (Reddy *et al*., 2014).

Experimental work

These cultures then purified by "single spore isolation method" these pure cultures were maintained on PDA slants for further study. Pure cultures were obtained by observing the following characteristics like, colony characteristics, biochemical properties, morphology, staining reaction etc.

Results and Discussion

Different types of rotting vegetables such as Cucumber (*Cucumis sativus*), Cauliflower *(Brassica oleracea*), Eggplant *(Solanum melongena*), Potato (*Solanum tuberosum)*, Okra (*Hibiscus esculentus*), Carrot (*Daucus carota)*, Chili (*Capsicum annum*), Turnip *(Brassica rapa)*, Round gourd *(Praecitrulus fistulosa*) were collected from two markets of Swabi including Tordher and Marghuz. In this study carrot (*Daucus carota)* was infected *by Aspergillus flavus, Geotrichum candidum, Rhizopus stolonifer and Alternaria alternata* (Table 1; Figure 1) and Cucumber (*Cucumis sativus)* was infected by *Alternaria alternata, Rhizopus, Alternaria solani, Botrytis cinerea, Aspergillus niger, Pencillium, Fusarium moniloforme* (Table 1; Figure 2), Eggplant (*Solanum melongena*) was affected by *Aspergillus flavus, Aspergillus niger, Cladosporium, Alternaria alternata and Rhizopus* (Table 1; Figure 3), Chili was infected by *Alternaria solani*, *Aspergillus terreus*, Mucur, *Botrytis cinerea* (Table 1; Figure 4). The microscopic structure of *Rhizopus* causing disease in Cucumber, Turnip and Round gourd was also shown (Figure 5) and the structure of *Alternaria alternata* causing disease in Cauliflower, Eggplant and Round gourd were observed (Figure 6). Potato (*Solanum tuberosum*) was identified to be infected by *Aspergillus niger, Cladosporium, Fusarium moniliforme and Alternaria solani*, Ladyfinger (*Hibiscus esculentus)* was spoiled by *Aspergillus flavus, Aspergillus niger, Cladosporium and Drechselera* (Table 1; Figure 7) and Cauliflower (*Brassica oleracea)* was infected by *Pencillium, Botrytis cinerea, Alternaria alternata, Aspergillus flavus, and Alternaria solani* pathogens (Table 1; Figure 8).

Post-harvest losses among fruits and vegetables may occur at any time while handling as the management related to postharvest done to maximize the storage value and quality of vegetables and most of the genera found involved acting as pathogens like Geotrichum, Aspergillus, *Penicillium, Alternaria, Fusarium, Phomopis*etc (Adaskaveg *et al*., 2002; Rahul *et al*., 2015).

Table 1: *Identification of pathogens and disease caused by these pathogens on vegetables.*

S. No.	Common names	Botanical names	Pathogens	Location
1	Cauliflower	*Brassica oleraceae*	*Pencillium, Botrytis cinerea, Aspergillus flavus, Alternaria alternata, Alternaria solani*	Tordher
2	Cucumber	*Cucumis sativus*	*Aspergillus flavus, Pencillium, Rhizopus, Aspergillus niger, Fusarium moniliforme*	
3	Ladyfinger	*Hibiscus esculentus*	*Aspergillus flavus, Drechselera, Aspergillus niger, Cladosporium*	
4	Eggplant	*Solanum melongena*	*Aspergillus flavus, Aspergillusniger, Cladosporium, Alternaria alternate*	
5	Potato	*Solanum tuberosum*	*Fusarium moniliforme, Cladosporium, Aspergillus niger*	
6	Carrot	*Daucus carota*	*Alternaria alternata, Aspergillus flavus, Rhizopus stolonifer, Geotrichum candidum*	
7	Capsicum	*Capsicum annuum*	*Alternaria, Aspergillus flavus, Mucur, Botrytis cinerea*	
8	Turnip	*Brassica rapa*	*Alternaria solani, Rhizopus*	
9	Round gourd	*Praecitrullus fistulosa*	*Rhizopus, Alternaria solani*	
10	Cauliflower	*Brassica oleraceae*	*Pencillium, Botrytis, Aspergillus flavus, Alternaria alternata, Alternaria solani,*	Marghuz
11	Cucumber	*Cucumis sativus*	*Aspergillus flavus, Botrytis cinerea, Rhizopus*	
12	Ladyfinger	*Hibiscus esculentus*	*Aspergillus flavus, Drechselera Aspergillus niger, Cladosporium*	
13	Eggplant	*Solanum melongena*	*Aspergillus flavus, Aspergillus niger, Cladosporium, Alternaria alternate*	
14	Potato	*Solanum tuberosum*	*Alternaria solani ,Fusarium moniliforme, Cladosporium Aspergillus niger*	
15	Carrot	*Daucus carrota*	*Aspergillus flavus, Rhizopus stolonifer*	
16	Capsicum	*Capsicum annuum*	*Alternaria solani, Aspergillusterreus, Mucur, Botrytis cinerea,*	
17	Turnip	*Brassica Rapa*	*Alternaria solani, Rhizopus*	
18	Round gourd	*Praecitrullus fistulosa*	*Rhizopus, Alternaria solani, Alternaria alternate*	

Figure 1: *Alternaria alternata showing symptoms on Carrot.*

Figure 2: *Fusarium moniliforme identified on Cucumber.*

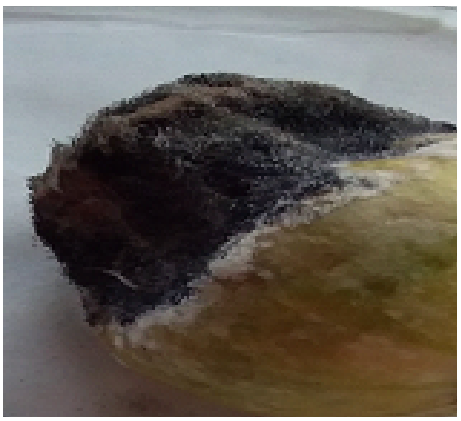

Figure 3: *Rhizopus showing disease symptoms on Round Gourd.*

Figure 4: *Botrytis cinerea identified on Chili.*

Figure 5: *Microscopic structure of Rhizopus to cause disease on Cucumber, Turnip and Round gourd*

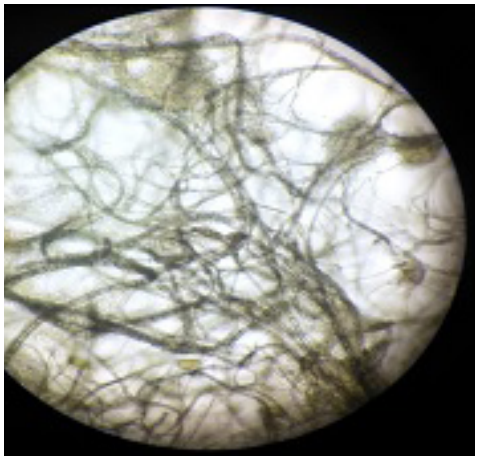

Figure 6: *Microscopic structure of Alternaria alternata to cause disease on Cauliflower, Eggplant and Round gourd.*

Figure 7: *Microscopic structure of Drechselera to cause disease on Ladyfinger.*

Figure 8: *Microscopic structure of Alternaria solani to cause disease on Round gourd, Potato and Cauliflower.*

In this study *Alternaria alternata, Rhizopus, Alternaria solani, Botrytis cinerea, Aspergilus niger, Pencillium, Fusarium moniloforme* were found to be associated with Cucumber whereas Fatima *et al.* (2009) worked on the same vegetable and identified *Cladosporium, Cladosporioides, Fusarium solani, Geotrichum candidum.* The Cauliflower (*Brassica oleracea)* was infected by *Pencillium, Botrytis cinerea, Alternaria alternata, Aspergillus flavus, and Alternaria solani* pathogens and according to Enyiukwu *et al.* (2014), species of *Aspergillus, Fusarium, Colletotrichum, Pencillium, and Rhizopus* are the pathogen that participates in post-harvest rots of horticultural products. The Eggplant (*Solanum melongena*) was infected by *Aspergillus flavus, Aspergillus niger, Cladosporium, Alternaria alternata and Rhizopus* while Hausbeck *et al.* (2008) studied eggplant *(Solanum melongena*) and tomato (*Lycopersicon esculentum*) and observed that *Phytophthora capsici* was the infectious cause. The Potato (*Solanum tuberosum*) was infected by *Alternaria niger, Cladosporium, Fusarium moniliforme and Alternaria solani*. Whereas Species of *Alternaria, Fusarium, Pencillium, Aspergillus, Geotrichum as well as Botrytis* have been reported as common post-harvest fungi (Splittstoesser, 1987; Adaskaveg *et al.*, 2002). The Okra (*Hibiscus esculentus)* was spoiled by *Aspergillusflavus, Aspergillus niger, Cladosporium and Drechselera.* The Carrot (*Daucus carota)* was infected *by Aspergillus flavus, Geotrichum candidum, Rhizopus stolonifer, and Alternaria alternata.*

Conclusions and Recommendations

It is very important to identify the post-harvest fungal pathogens that are responsible to cause diseases in vegetables and ultimately reduce the yield which can decrease the economy of Pakistan. It is much important to develop the awareness and biocontrol agent to overcome the diseases of fungi.

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Novelty Statement

In post-harvest losses that species of fungi is vary in different areas due to environmental factor while in the area of Swabi Khyber-Pakhtunkhwa it was first time reported that different vegetables have become

destroyed due to less awareness, lacking of diagnostic measurement and precaution of its post-harvest losses.

Author's Contribution

GP: Conceived and designed the experiments.
NM: Analyzed the data.
GP, NM, NB and SI: Wrote the paper.

List of abbreviation

KP: Khyber PakhtunKhwa; PDA: Potato Dextros Agar; Spp: Species; GP: GulnazParveen; NM: Naila Mukhtar; NB: Nain Bukhari; SI: ShamailaIrum

Availability of data and materials

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors have declared no conflict of interest.

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