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PREVALENCE OF POST-HARVEST ROT OF VEGETABLES AND FRUITS IN KARACHI, PAKISTAN

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Abstract

Post-harvest diseases caused by bacteria, yeast and fungi develops on fruits and other plant products between harvesting and consumption. The threat of post-harvest disease influences the way most horticultural crops are handled. Therefore the accurate identification of the causal pathogen is essential before appropriate treatment can be made to control the pathogens. In the present study a number of fungi viz., *Alternaria alternata, A. citri, Aspergillus niger, A. flavus, Aspergillus* sp., *Cladosporium cladosporioides, Drechslera australeinsis, Fusarium solani, Fusarium* sp., *Geotrichum candidum, Penicillium* spp., *Phytophthora capsici* and *Rhizopus stolonifer* responsible for post-harvest deterioration of fresh fruits and vegetables were isolated and identified.

Introduction

Post-harvest diseases destroy 10-30% of the total yield of crops and in some perishable crops especially in developing countries, they destroy more than 30% of the crop yield (Agrios, 2005; Kader, 2002). Fruits and vegetables are highly perishable products, the quality is affected by post-harvest handling, transportation, storage and marketing. The improper handling, packaging, storage and transportation may result in decay and production of microorganisms, which become activated because of the changing physiological state of the fruits and vegetables (Wilson *et al*., 1991). Fruit, due to their low pH, higher moisture content and nutrient composition are very susceptible to attack by pathogenic fungi, which in addition to causing rots may also make them unfit for consumption by producing mycotoxins (Philips, 1984; Moss, 2002, Stinson *et al.* 1981). International agencies that monitor world food resources have acknowledged that one of the most feasible options for meeting future food needs is reduction of post-harvest losses (Kelman, 1984). Careful post-harvest handling is the major but often neglected step towards offering a greater volume of nutritious food to planet and to prevent loss between harvesting and consumption. Fungi are the most important and prevalent pathogens, infecting a wide range of host plants and causing destructive and economically important losses of most fresh fruits and vegetables during storage and transportation (Sommer, 1985).

Crop losses due to the soilborne fungus like oomycete *Phytophthora capsici* (Leonian) have been well documented (Hausbeck & Lamour, 2004, Erwin & Ribeiro, 1996). *Phytophthora capsici* affects a wide range of solanaceous and cucurbit hosts worldwide (Erwin & Ribeiro, 1996; Hawng & Kim, 1995). The first reported occurrence of *P. capsici* on a cucurbit crop in USA occurred in 1937, when a 3.2-ha field of cucumbers became diseased resulting in 100% of the fruit rotting (Kreutzer, 1937). By 1940, *P. capsici* had also been described on eggplant, honeydew melon fruit, summer squash, and tomato fruit (Kreutzer & Bryant 1946; Wiant, 1940). Satour & Butler (1967) reported that 45 species of cultivated plants and weeds, representing 14 families of flowering plants susceptible to *P.*

capsici. Under warm (25-30^{o}C) and wet condition, *P. capsici* caused root and crown infection resulting in wilting (Hausbeck & Lamour, 2004). *Phytophthora capsici* has been reported as a serious threat to chili production in Pakistan (Naz *et al*., 2007, Saleem *et al*., 1999). The present work describes the role of *P. capsici*, along-with other fungi in post-harvest rot of fresh fruits and vegetables from Karachi, Pakistan.

Materials and Methods

Sample collection: Fresh fruits like, apple (*Malus pumila* Mill.), grapes (*Vitis vinifera* L.), guava (*Psidium guajava* L.), mango (*Mangifera indica* L.), melon (*Cucumis melo* L.), lemon (*Citrus limon* (L.) Burman.f.), sweet orange (*Citrus sinensis* Osbeck), papaya (*Carica papaya* L.), pear (*Pyrus communis* L.), pomegranate (*Punica granatum*) and vegetables like taro (*Colocasia esculenta* (L.) Schott), bell pepper (*Capsicum annuum* L.), bitter gourd (*Momordica charantia* L.), bottle gourd (*Lagenaria siceraria* (Molina) Standley), egg plant (*Solanum melongena* L.), carrot (*Daucus carota* L.), common bean (*Phaseolus vulgaris* L.), cucumber (*Cucumis sativus* L.), okra (*Abelmoschus esculentus* (L.) Moench.), pumpkin (*Cucurbita moschata* L.), radish (*Raphanus sativus* L.), round gourd (*Praecitrullus fistulosus* (Stocks) Pangale), sponge gourd (*Luffa aegyptiaca* Mill.), tomato (*Lycopersicon esculentum* Mill.) and turnip (*Brassica rapa*. var. *rapa* (L.) reichb) showing the deterioration and rotting were collected from different markets/ shops of Karachi like Karachi University Campus, Gulshan-e-Iqbal, Gulistan-e-Jouhar, Malir Liaquat Market, Liaquatabad, Gulbahar and Empress Market Saddar. Samples were kept at 4°C until the identification and isolation were made within 48 hours.

Identification of post-harvest fungi: Temporary slides of diseased tissues were made and observed under light microscope. Fungi were identified after reference to Barnett and Hunter (1998), Booth (1971), Dix & Webster (1995), Domsch *et al*., (1980), Dugon (2006), Ellis (1971), Erwin & Ribeiro, (1996) and Nelson *et al*., (1983).

Isolation of fungi from diseased tissues: Somewhat healthy tissues adjacent to diseased tissues were cut with the help of a sharp razor and transferred onto PDA plates containing penicillin (100000 units/L) and streptomycin (0.2 g/L) after surface sterilization with 1% Ca(OCl)2. Plates were incubated for 5 days at 28°C under 12 hours light and dark conditions. Fungi that grew were identified as described above. Whereas *Phytophthora* Selective Medium (PAR), was used for the isolation of *Phytophthora* (Kannwischer & Mitchell, 1978).

Results

Fungi isolated were identified as *Alternaria alternata* (from apple, bell pepper, bitter gourd, bottle gourd, papaya, pear, round gourd, sponge gourd and tomato), *Alternaria citri* (from sweet orange), *Aspergilllus flavus* (from lemon, mango and tomato), *Aspergillus niger* (from lemon, mango, round gourd and tomato), *Aspergillus* sp., (from mango, pear and tomato), *Cladosporium cladosporioides* (from carrot, cucumber and guava), *Drechslera australiensis* (from mango, papaya and tomato), *Fusarium solani* (from melon, papaya, egg plant, cucumber, sponge gourd and tomato), *Fusarium* sp., (from bell pepper, bitter gourd, egg plant, okra, pear and turnip), *Geotrichum candidum* (from apple, egg plant, carrot, cucumber, guava, melon, papaya, pumpkin, radish, sponge gourd and turnip), *Penicillium* sp., (from grapes and pomegranate), *Phytophthora capsici* (from taro, bottle

gourd, eggplant, common bean, sponge gourd and tomato) and *Rhizopus stolonifer* (from tomato and papaya). Post-harvest *Phytophthora* rot of vegetables is being a serious problem in Karachi, Pakistan. Infected fruits initially show water-soaked lesions and eventually shrivel and rot. The fruits turn white, and the interior of the fruits are heavily colonized by the white mycelium of *Phytophthora capsici* (Fig. 1).

Table 1. Fungi isolated from deteriorated fruits and vegetables collected from different market of Karachi.

S. No.	Host		Name of fungi
	Scientific name	Common name	
1.	*Abelmoschus esculentus* (L.) Moench	Okra	*Cladosporium cladosporioides, Geotrichum candidum**
2.	*Brassica rapa* var. *rapa* L.	Turnip	*Cladosporium cladosporioides, Fusarium* sp.*, *Geotrichum candidum*
3.	*Capsicum annum* L.	Bell pepper	*Alternaria alternata**, *Drechslera ausltralinsis, Fusarium solani, Geotrichum candidum*
4.	*Carica, papaya* L.	Papaya	*Alternaria alternata**, *Aspergillus* sp., *Fusarium solani, Geotrichum candidum, Rhizopus stolonifer*
5.	*Citrus* sinensis Osbeck	Sweet orange	*Alternaria citri**, *Aspergillus* sp.
6.	*Citrus limon* (L.) Burm.f.	Lemon	*Aspergillus flavus, Aspergillus niger**, *Geotrichum candidum*
7.	*Colocasia esculenta* (L.) Schott	Taro	*Fusarium solani, Phytophthora capsici**
8.	*Cucumis melo* L.	Melon	*Cladosporium cladosporioides, Fusarium solani, Geotrichum candidum**
9.	*Cucumis sativus* L.	Cucumber	*Cladosporium cladosporioides, Fusarium solani, Geotrichum candidum**
10.	*Cucurbita moschata* L.	Pumpkin	*Cladosporium* sp., *Drechslera australinsis, Fusarium solani, Geotrichum candidum**
11.	*Daucus carota* L.	Carrot	*Cladosporium cladsporioides, Geotrichum candidum**
12.	*Lagenaria siceraria* (Molina) Standl.	Bottle gourd	*Alternaria alternata**, *Fusarium solani, Phytophthora capsici*
13.	*Luffa aegyptiaca* L.	Sponge gourd	*Alternaria alternata, Fusarium solani**, *Geotrichum candidum, Phytophthora capsici*
14.	*Lycopersicon esculentum* Mill.	Tomato	*Alternaria alternata**, *Aspergillus niger, Fusarium solani, Drechslera* sp., *Rhizopus stolonifer, Phytophthora corpsici*
15.	*Malus pumila* Mill.	Apple	*Alternaria alternata**, *Geotrichum candidum*
16.	*Mangifera indica* L.	Mango	*Aspergillus niger**, *Aspergillus* sp.
17.	*Momardica charantia* L.	Bitter gourd	*Alternaria alternata**, *Cladosporium* sp., *Fusarium solani, Geotrichum candidum*
18.	*Phaseolus vulgaris* L.	Common bean	*Fusarium* sp.,* *Geotrichum* sp., *Phytophthora Capsici*
19.	*Praecitrullus fistulosus* (Stocks) Pangalo	Round gourd	*Cladosporium* sp., *Fusarium** sp., *Geotrichum candidum**
20.	*Psidium guajava* L.	Guava	*Alternaria alternata, Drechslera* sp., *Geotrichum candidum**
21.	*Punica granatum* L.	Pomegranate	*Penicillium* sp.*
22.	*Pyrus communis* L.	Pear	*Alternaria alternata, Drechslera* sp, *Geotrichum candidum**
23.	*Raphanus sativus* L.	Radish	*Cladosporium* sp., *Drechslera australiensis, Fusarium solani**
24.	*Solanum melongena* L.	Eggplant	*Fusarium solani, Geotrichum* sp., *Phytophthora capsici**
25.	*Vitis vinifera* L.	Grape	*Penicillium* sp.*

* = Major fungus

Fig. 1. Eggplant fruit showing colonization by *Phytophthora capsici*.

Discussion

Losses caused by post-harvest diseases are greater than generally realized because the value of fresh fruits and vegetables increases several-fold while passing from the field to the consumer (Eckert & Sommer, 1967). Species of *Alternaria, Fusarium, Penicillium, Aspergillus, Geotrichum* as well as to *Botrytis* have been reported as common post-harvest fungi (Splittstoesser, 1987; Adaskaveg *et al.*, 2002). Some of the moulds could produce mycotoxins while grown on fruits (Stinson *et al.*, 1980) even during refrigeration (Tournas & Stack, 2001). Pathogenic fungi, on the other hand, could cause infections or allergies in susceptible individuals (Kurup, 2003). Since pathogenic fungi alone caused 10-30% reduction in the yield of major food and cash crops (Agrios, 2005), several pre and post-harvest technologies have been used to control their decay (Serrano *et al.*, 2005).

In this study, besides common post-harvest fungi, *P. capsici* has also been found involved in post-harvest rot of some vegetables viz., taro (*Colocasia esculenta* (L.) Schott), bottle gourd (*Lagenaria siceraria* (Molina) Standley), egg plant (*Solanum melongena* L.), common bean (*Phaseolus vulgaris* L.), sponge gourd (*Luffa aegyptiaca* Mill.) and tomato (*Lycopersicon esculentum* Mill.). *Phytophthora capsici* ranks as a top threat to production of Cucurbitaceae, Solanaceae and most recently Fabaceae vegetables (Hausbeck *et al.*, 2008). The incidence of damping off, foliar blight and fruit rot on melon, peppers, pumpkins, squashes and watermelon caused by *P. capsici* has dramatically increased in Illinois, USA (Babadoost, 2000ab). Infection of the plants in the field may occur at any time during the growing season. Early infections caused seedling blight and later infections caused foliar blight, stem lesion, vine rot, fruit rot and root and crown rot (Lee *et al.*, 2001; Islam & Babadoost, 2002). Presence of *P. capsici* in fresh vegetables of Karachi markets indicates that the fungus is present in the fields from where the vegetables are coming. The pathogen infects fruits during prolonged periods of

heavy rainfall and high humidity, especially when plants are over-crowded or over-fertilized with nitrogen (Shannon, 1989). Fruit rot can occur from the time of fruit set until harvest (Babadoost, 2000a). In Karachi, spraying of water on vegetables during marketing may provide an excellent opportunity for spread of *Phytophthora* rot. It is impossible and uneconomical to completely eliminate post-harvest losses, it is possible and desirable to reduce them by 50%. Minimizing post-harvest losses of food that has already been produced is more sustainable and environmentally sound than increasing production areas to compensate for these losses (Kader, 2002).

References

Adaskaveg, J.E., H. Forster, N.F. Sommer. 2002. Principles of post-harvest pathology and management of decays of edible horticultural crops. In: *Post-harvest Technology of Horticultural Crops,* (Eds.): A.A. Kader. Vol. 3311. University of California Publication, California, Pp. 163-195.

Agrios, G.N. 2005. *Plant Pathology,* Academic Press, New York.

Babadoost, M. 2000a. Outbreak of *Phytophthora* foliar blight and fruit rot in processing pumpkin fields in Illinois. *Plant Disease*, 84: 1345.

Babadoost, M. 2000b. Incidence and impact of *Phytophthora* diseases on Illinois. *Proc. ISHS Orchard and SIU Hort. Day* 2000. pp. 22-25.

Barnett, H.L. and B.B. Hunter. 1998. *Illustrated Genera of Imperfect Fungi*. 4th ed. APS Press, St. Paul, Minnesota. pp. 218.

Booth, C. 1971. *The Genus Fusarium*. Commonwealth Mycological Institute, Kew, Surrey, England, pp. 237.

Dix, N.J. and J. Webster. 1995. *Fungal Ecology*. Chapman and Hall, London.

Domsch, K.H., W. Gams and T.H. Anderson. 1980. *Compendium of Soil Fungi*. Vol. 1. Academic Press New York. pp. 859.

Dugan, F.M. 2006. *The Identification of Fungi: An Illustrated Introduction With Keys Glossary and Guide to Literature*. APS. Press, St. Paul. Minnesota, USA. pp. 176.

Eckert, J.W. and N.F. Sommer. 1967. Control of diseases of fruits and vegetables by post-harvest treatment. *Ann. Rev. Plant Pathol*., 5: 391-432.

Ellis, B. 1971. *Dematiaceous Hyphomycetes*. Commonwealth Mycological Institute, Kew, Surrey, England. pp. 608.

Erwin, D.C. and O.K. Ribeiro. 1996. *Phytophthora Diseases Worldwide*. American Phytopathological Society, St. Paul, MN.

Hausbeck, M.K. and K.H. Lamour. 2004. *Phytophthora capsici* on vegetable crops: research progress and management challenges. *Plant Disease,* 88: 1292-1303.

Hausbeck, M.K., A.P. Keinath, C.S. Kousik and M.E. Matheron. 2008. Managing *Phytophthora* disease with fungicides. *Phytopathology,* APS Centennial celebration in Minneapolis, MN. July 26, 2008.

Hwang, B.K. and C.H. Kim. 1995. *Phytophthora* blight of pepper and its control in Korea. *Plant Disease,* 79: 221-227.

Islam, S.Z. and M. Babadoost. 2002. Effect of red light treatment of seedlings of pepper, pumpkin and tomato on occurrence of *Phytophthora* damping-off. *Hort Science,* 37: 678-681.

Kader, A.A. (Tech. Ed.). 2002. *Post-harvest Technology of Horticultural Crops*. University of California, Agriculture and Natural Resources. Pub. 3311.

Kannwischer, M.E. and D.J. Mitchell. 1978. The influence of a fungicide on the epidemiology of black shank of tobacco. *Phytopathology*, 68: 1760-1765.

Kelman, A. 1984. Post-harvest pathology of fruits and vegetables. pp 1-3. In: *Post-harvest Losses in Perishable Crops*. (Ed.): H.E. Moline. University of California Agricultural Experimental Station Bulletin.

Kreutzer, W.A. 1937. A *Phytophthora* rot of cucumber fruit. *Phytopathology*, 27: 955.

Kreutzer, W.A. and L.R. Bryant. 1946. Certain aspects of the epiphytology and control of tomato fruit rot caused by *Phytophthora capsici* Leonian. *Phytopathology,* 36: 329-339.

Kurup, V.P. 2003. Fungal allergens, *Curr. Allergy Asthma Rep*., 3: 416-423.

Lee, B.K., B.S. Kim, S.W. Chang and B.K. Hwany. 2001. Aggressiveness of isolates of *Phytophthora capsici* from pumpkin and pepper. *Plant Disease,* 85: 797-800.

Moss, M.O. 2002. Mycotoxin review. 1. *Aspergillus* and *Penicillium*. *Mycologist*, 16: 116-119.

Naz, I., M. Ahmad, S. Alam, M. Tahir and F. Raziq. 2007. Control of root and collar rot disease, a serious threat to chillies production in NWFP [Pakistan]. *Sarhad J. Agric.*, 23: 451-453.

Nelson, P.E., T.A. Toussoun and W.F.O. Marasas. 1983. *Fusarium Species. An Illustrated Manual for Identification*. The Pennsylvania State University Press, University Park and London, Pp. 193.

Phillips, D.J. 1984. Mycotoxins as a post-harvest problem. Pp. 50-54. In: *Post-harvest Pathology of Fruits and Vegetables: Post-harvest Losses in Perishable Crops.* (Ed.): H.E. Moline. Agricultural Experimental Station, University of California, Berkeley Publications, NE.

Saleem, A., K. Hameed, F.F. Jamil and M. Ansar. 1999. Screening of *Capsicum* germplasm against *Phytophthora capsici*. *Pak. J. Biol. Sci.*, 2: 459-461.

Satour, M. M. and E.E. Butler. 1967. A root and crown rot of tomato caused by *Phytophthora capsici* and *P. parasitica*. *Phytopathology,* 57: 510-515.

Serrano, M., D. Martinez-Romero, S. Castillo, F. Guillen and D. Valero. 2005. The use of the natural antifungal compounds improves the beneficial effect of MAP in sweet cherry storage. *Innovative Food Science and Emerging Technologies*, 6: 115-123.

Shannon, E. 1989. *Chili Disease Control.* Cooperative Extension Service guide. H-219. New Mexico State University, Las Cruces, NM.

Sommer, N.F. 1985. Strategies for control of post-harvest disease of selected commodities. In: *Post-harvest Technology of Horticultural Crops.* University of California Press, pp. 83-98.

Splittstoesser, D.F. 1987. Fruits and fruit products. pp. 101-128. In: *Food and Beverage Mycology.* (Ed.): L. Beuchat. Van Nostrand Reinhold, New York .

Stinson, E.E., D.D. Bills, S.F. Osman, J. Siciliano, M.J. Ceponis and E.G. Heisler. 1980. Mycotoxin production by *Alternaria* species grown on apples, tomatoes, and blue berries. *J. Agric. Food Chem*., 28: 960-963.

Stinson, E.E., S.F. Osman, E.G. Heisler, J. Siciliano and D.D. Bills. 1981. Mycotoxin production in whole tomatoes, apples, oranges and lemons, *J. Agric. Food Chem.*, 29: 790-792.

Tournas, V.H. and M.E. Stack. 2001. Production of alternariol and alternariol methyl ether by *Alternaria alternata* grown on fruits at various temperatures, *J. Food Prot*., 64: 528-532.

Wiant, J.S. 1940. A rot of winter queen watermelons caused by *Phytophthora capsici*. *J. Agric. Res.*, 60: 73-88.

Wilson, C.L., M.E. Wisniewski, C.L. Biles, R. McLaughlin, E. Chalutz and S. Droby. 1991. Biological control of post-harvest diseases of fruits and vegetables: alternative to synthetic fungicides. *Crop Prot*., 10: 172-177.

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