POST HARVEST LOSSES IN APPLE AND BANANA DURING TRANSPORT AND STORAGE

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Total losses in the apples transported from Quetta, Swat and Murree to Faisalabad market during the months of August, September and November were found to be 23, 20 25 percent respectively. In apples kept under the conditions of cold storage for 22 weeks losses were found to be 28 percent. The fungi isolated from rotten apples were *Aspergillus niger, A. fumigatus, Alternaria tenuis, A. tenuissima, Cladosporiums herbarum, Helminthosporium tetramera, Mucor racemosus, Penicillium expansum, Pencillium italicum* and *Rhizopus nigricans*. The pathogenecity test revealed that *Alternaria tenuis, Aspergillus niger* and *Rhizopus nigricans* were pathogenic to both injury inoculated and non injured inoculated apple fruits. Total losses in banana transported from Nawabshah, Mirpur Khas and Hyderabad to Faisalabad market in the months of December, February and March amounted to 37, 39 and 43 percent respectively. The fungi isolated from rotten banana were *Aspergillus fumigatus, Alternaria tenuis , Botryodiplodia theobromae, Colletotrichum musae, and Verticillium theobromae*. All these fungi expect *A. fumigatus* were found to be pathogenic both to injury and non injury inoculated banana fruits.
Keywords: Post harvest losses, apple, banana, fungal rots, transport, storage.

INTRODUCTION

Apples and banana are transported from localities of production to far off places for marketing and consumption. Both fruit being succulent are liable to damage and deterioration during harvesting, transportation, marketing, storage and consumption, if not properly handled. Their damage and deterioration may result due to physical injuries, enzymatic action by the attack of microorganisms or combination of both these factors. Injuries and damage to fruits may in turn result in loss of moisture due to faster surface evaporation. Injured fruits are attacked by microorganisms (fungi, bacteria) and become diseased. The diseased fruits respire at much faster rates than intact healthy fruits (Agrios, 1997). Faster fruit respiration and their faster metabolic activity results in senescence and storage decay or rots. This paper reports on the extent of post harvest losses occurring to apple and banana fruits from harvest to consumption and the fungi associated with their decay and rots prior to their consumption.

MATERIALS AND METHODS

The determination/estimation of post harvest losses of apple and banana were undertaken on the basis of interviews with owners of gardens, pre-harvest contractors, commission agents, whole sale agents, retailers and house wives. In order to substantiate the statements of these people and to have more reliable estimates, the gardens were visited and processes of harvesting, handling, grading, packing, transportation, whole selling, retailing and consumption (at homes) were observed carefully and data regarding losses of apple and banana at different stages were recorded separately. The produces of Quetta, Swat and Murree that were later transported to Faisalabad market, were selected for the estimation of losses in apple and the produces of Nawabshah, Mirpur Khas and Hyderabad that were later transported to Faisalabad market, were selected for determination of losses in banana. Three samples of each fruit, consisting of 100 fruit per sample were collected from different fruit heaps in the gardens of the above mentioned places, mixed and were passed through all the stages of marketing. The data on the extent of losses were thus determined at the time of harvesting, whole selling, retailing and in household consumption. The losses at harvesting included picking of unripe, over ripped fruits and fruit deteriorated/damaged during handling. The losses at the stage of wholesale market to vendor's shop or sale point on animal driven cart, included damage on account of pressing of the fruit by the customers, damage during storage and damage due to overnight storage and exposure to sun and unfavorable conditions. The losses in house held consumption included deterioration of fruits while carrying them in baskets, polythene or paper bags before actual consumption.

A lot of apples transported after harvesting from Quetta to Faisalabad was kept in a cold storage for 22 weeks (November to April) and then marketed for selling. The post harvest losses for this lot were consequently determined.

The specimens of deteriorated apple and banana were collected from fruit lots in cold storage, with whole-sellers, retailers etc at Faisalabad and were brought to laboratory. The fungi responsible for their decay or rots were isolated on sterilized PDA (potato starch, 20g; dextroxe 20g, agar agar 20g and distilled water 1000ml) poured in 90mm petriplates, purified, and these were identified and maintained on PDA for pathogenicity tests.

For pathogenicity test of the fungal isolates, three sets of ten healthy fruits of apple and banana each were taken, washed, air dried, surface sterilized with 0.1 percent $HgCl_2$ solution for 2 minutes, rinsed twice in sterilized water. One set of fruit was injury inoculated, the other set was inoculated without injury while the third set was non inoculated to serve as control. The three sets of fruits were kept at 25± 2°C for 7 days and were examined for decay or rot development.

RESULTS AND DISCUSSION

Losses in apple

Table 2. Post harvest losses in apple at various stages from producers to consumers

Table 1. Post harvest losses in apple at various stages from producers to consumers

Apple transported		Percent loss during				
From	To	Harvesting	Whole sale marketing	Retail marketing	House hold consumption	Total
Quetta	Faisalabad	8	4	6	5	23
Swat	Faisalabad	7	3	6	4	20
Murree	Faisalabad	9	2	8	6	25
Quetta Kept in cold storage (Nov.–Apr.)	Faisalabad	8	9	7	4	28

The post harvest losses in apple at various stages from producer i.e. growers to consumers are given in Table 1. The apples transported from Quetta to Faisalabad suffered from 8, 4, 6 and 5 percent losses during harvesting, whole sale marketing, retail marketing and house held consumption respectively. The apples transported from Swat to Faisalabad suffered from 7, 3, 6 and 4 percent losses during harvesting, whole sale marketing, retail marketing and house held consumption respectively while the apples transported from Muree to Faisalabad suffered from 9, 2, 8 and 6 percent losses during harvesting whole sale marketing, retail marketing and house held consumption respectively. Thus lots of apples transported from Quetta, Swat, Muree suffered from total loss of 23, 20 and 25 percent respectively. The 23 percent loss of Quetta apples was due to 11, 2, 5 and 5 percent injured, unriped, over ripped and rotten or

diseased fruits respectively (Table, 2). The 20 percent loss of apples transported from Swat included 7,3,6 and 4 percent loss due to injured, unripped, over riped and diseased i.e. rotten fruits respectively, while the 25percent loss in apples transported from Murree included 9, 2, 8 and 6 percent injured, unripped, over ripped and diseased fruits respectively.

The apple lot transported from Quetta to Faisalabad and then kept in the cold storage suffered from 8, 9, 7, and 4 percent losses during the harvesting, wholesale marketing, retail marketing and house held consumption (Table 1). The total post harvest losses of this lot which amounted to 28 percent was due to 11, 2, 7, and 8 percent injured, un ripped, over ripped and rotted apple fruit (Table 2). The increase in post harvest loss of this lot was due to increase in injured fruit and fruits rotted in cold storage.

Isolation of fungi from diseased (rotten) apples and their pathogenicity test

The fungi isolated from rotten apple fruits were *Alternaria tenuis, Alternaria tenuissima, Aspergillus fumigatus, Aspergillus niger, Cladosporium herbarum, Helminthosporium tetramera, Mucor racemosus, Penicillium expansum, Penicillium lilacinum and Rhizopus nigricans*. The results of their pathogenicity test (Table 3) revealed that *Alternaria tenuis, Aspergillus niger* and *Rhizopus nigricans* were found pathogenic to both injured and uninjured apple fruits. *Alternaria tenuissima, Aspergillus fumigatus* and *Penicillium expansum* caused rottening of injured fruits only. *Cladosporium herbarum*, *Helminthosporium tetramera*, Mucor race-moses and *Penicilluim lilacinum* did not cause rottening of both injury and non injury inoculated apple fruits. No rottening or decay occurred in uninjured uninoculated apple fruits.

Table 3. Percent infection of inoculated and uninoculated apple fruit by various fungi (Pathogenicity test)

Fungus isolate	Percent fruit rots		
	Non injured uninoculated	Uninjured inoculated	Injured inoculated
Alternaria tenuis	0	20	100
Alternaria tenuissima	0	0	100
Aspergillus fumigatus	0	0	70
Aspergillus niger	0	30	100
Cladosporium rerbarum	0	0	0
Helminthosporium tetramera	0	0	0
Mucor racemoses	0	0	0
Penicillium expansum	0	0	100
Penicillium lilacinum	0	0	0
Rhizopus nigricans	0	10	100

Losses in banana

Table 4. Post harvest losses in banana at various stages from producers to consumers

Banana transported		Percent loss during				
From	To	Harvesting	Whole sale marketing	Retail marketing	House hold consumption	Total
Nawabshah	Faisalabad	6	13	10	8	37
Mirpurkhas	Faisalabad	5	14	11	9	39
Hyderabad	Faisalabad	7	15	12	9	43

The post harvest losses in banana at various stages from production to consumption are given in Table 4. The banana transported from Nawab Shah to Faisalabad suffered from 6, 13, 10 and 8 per loss during

harvesting wholesale marketing, retail marketing and house held consumption respectively. The banana transported from Mirpur Khas to Faisalabad suffered from 5, 14, 11 and 9 percent loss during harvesting, whole sale marketing retail marketing and house held consumption respectively while the banana transported from Hyderabad to Faisalabad suffered from 7, 15, 12 and 9 percent loss during harvesting, whole sale marketing, retail marketing and house held consumption. Thus apple lots transported from Nawab Shah, Mirpur Khas and Hyderabad suffered from total loss of 37, 39 and 43 percent respectively. The 37 percent loss of banana transported from Nawab Shah was due to 14, 3, 12 and 8 percent injured, unripped, over-ripped and diseased (rotten) fruits respectively (Table 5). The 39 percent loss of banana transported from Mirpur Khas was due to 13,3,14 and 9 percent injured, unripe, over riped and diseased fruit respectively while 43 percent loss of banana transported from Hyderabad included 12,4,16 and 11 percent injured, unripe, over ripped and diseased fruits respectively.

The fungi isolated from rotten banana fruits were *Aspergillus fumigatus, Alternaria tenuis, Botryodiplodia theobromae, Colletotrichum musae, Collclotrichum* gleosporiodes*, Fusarium moniliformae* and *Verticillium theobramae*. The results of their Pathogenecity test (Table 6) revealed that all the above fungi except *Aspergillus fumigatus* were pathogenic in causing decay or rot of both injury and non injury inoculated banana fruits.

Table 5. Post harvest losses in banana at various stages from producers to consumers

Banana transported		Percent loss due to				
From	To	Injured	Unripe	Overripe	Diseased	Total
Nawabshah	Faisalabad	14	3	12	8	37
Mirpurkhas	Faisalabad	13	3	14	9	39
Hyderabad	Faisalabad	12	4	16	11	43

Table 6. Percent infection of inoculated and uninoculated banana fruits by various fungi (Pathogenicity test)

Fungus isolate	Percent Banana Fruit Rot		
	Uninjured Uninoculated	Uninjured Inoculated	Injured Inoculated
Aspergillus fumigatus	0	0	0
Alternaria tenuis	0	20	100
Botryodiplodia theobromae	0	10	90
Colletotrichum musae	0	10	100
Colletotrichum gleosporiodes	0	10	100
Fusarium moniliformae	0	60	100
Verticillium theobromae	0	80	100

RESULTS AND DISCUSSION

Several fungi all over the world cause considerable post harvest losses in apple and banana, during storage and transportation. More than 90 fungal species have been reported to cause decay of apples during storage (Jones and Aldwinckle, 1991). The relative importance of each pathogen depends upon the climate and storage conditions. The pathogens infect apple fruits through wounds or lentical in the growing season or after harvesting (Biggs, 1995, Roberts, 1994) and aggravate the losses during the storage (Sholberg and Haag, 1996). The post harvest losses in apple can be minimized to a great extent by avoiding mechanical damage to fruits, their proper storage under modified & controlled atmosphere and by pre and post harvest treatment of fruits (Janisie-wicz, 1988; Janisiewicz *et al*., 1994., Robert, 1994). The control of post harvest pathogens relies on the use of synthetic fungicides but the development of fungicide resistant strains and the public demand not to use health hazards chemicals diverted attention towards the search for alternative control strategies (Janisiewicz, *et al*., 1994, Wilson *et al*., 1993). The

use of yeasts and bacterial strains to control post harvest rots of fruit by pathogenic fungi has been extensively studied and there are several examples of successful biologically control of decay of fruits (Janisiewicz and Bors, 1995; Roberts, 1990, 1994). The biological control of post harvest decay by the use of microorganisms is relatively less effective as compared to synthetic fungicides (Sholberg *et al*., 1995). However, their effectiveness can be enhanced by the use of combination of microorganisms and mixture of antagonistic strains that have successfully been used for the control of post harvest decay of fruits (Falconi and Mendgen, 1994; Janisiewicz, 1988; Janisiewicz and Bors, 1995) Since infection of fruit by post harvest pathogens often occurs in the field prior to harvest, it is advisable and advantageous to apply antagonists before harvest. This is also of interest because regulations in some countries do not permit post harvest fungicidal treatment of apples.

Banana is popular fruit among its consumers and due to its relatively small size and characteristic flavor it has got a high export potential. A short storage or shelf life is the major problem associated with its export over long distance. During storage banana fruits deteriorate through the activity of decay causing microorganisms and their activity is favored by the changing physiological state of the fruit (Adisa, 1983; Slabaugh and Grove, 1982). The post harvest losses in banana are due to mechanical injuries, improper storage and post harvest decay by microorganisms. Systemic fungicides of benzimidazole group such as benlate (benomyl) have been used on banana for the effective control of post harvest diseases (Rani and Vir, 1983; Eckert and Ogawa, 1985; Al Zaemy el al., 1993; Illeperuma *et al*., 2000), but now there are increasing public demands for fresh banana that are not fungicide treated after their harvest. Non fungicidal control of post harvest diseases of banana has been attempted by Perera and Karunaratne (2001) and studies on the use of modified atmosphere packing (Illeperuma *et al*., 2000) and cold atmosphere storage (Saranawda and Wijeratnam, 1994) have been conducted in order to extend the storage life of banana and to minimize the use of fungicides. Modified atmosphere storage, created by lowering the oxygen concentration and increasing carbon dioxide concentration prolong the storage life of bananas (Satyan *et al*., 1992; Illeperuma *et al*., 2000). The essential oils of cinnamon and clove have been reported to be sources of antifungal compounds (Arras, 1988, Montes and Carvajal, 1998., Ranasinghe *et al*., 2005). The use of low density polyethylene packaging prevents the evaporation of the volatile compounds of oils and helps to create a high carbon dioxide and low oxygen environment which further retards the growth of pathogen. An integrated strategy to control post harvest decay of banana by combining essential oils with modified atmosphere packaging has been suggested by Ranasinghe *et al*., (2005), which extends storage life of banana upto 21 days in a cold room and 14 days at 28±2C without affecting the organoleptic and physiochemical properties.

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