INT. J. BIOL. BIOTECHNOL., 5 (1-2): 101-106, 2008.

POST HARVEST LOSSES IN CITRUS FRUIT DURING TRANSPORT

M.B. Ilyas, M. U. Ghazanfar, M.A. Khan, C.A. Khan and M.A,R, Bhatti

Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan

ABSTRACT

The losses of the Feutrell's Early transported from Kallurkot, Bhalwal and Jauharabad to Faisalabad market during the month of November were found to be 16, 17 and 16 percent respectively. The losses in orange transported from Kallurkot, Bhalwal and Jauharabad in the months of December and January accounted for up to 20, 19 and 20 percent, respectively. The losses in case of Kinnow mandarin transported from Kallurkot, Bhalwal and Jauharabad during the months of January and February were found to be 22, 21 and 27 percent respectively. The fungi isolated from citrus fruits (Feutrell's Early, Orange and kinnow mandarin) were *Alternaria citri, A. tunis, A. tenuissima, Aspergilllus flavus, A. fumigatus, A. nigar, Botryodiplodia theobromae, Collectotricum gloeosporiodies, Fusarium solani, Geotrichum candidum, Penicillum digitatum, P. italicum, Phomopsis citri and Rhizopus nigricans,* . The fungi *A. tenuis B. theobromae, C. gloeosporiodies, G. candium, P. digitatum, P. italicum, Phomopsis citri* and *Rhizopus nigric*ans were found pathogenic both on injured and uninjured fruits.

Key words: Post harvest losses, citrus fruits, fungal rot, transport.

INTRODUCTION

Pakistan is one of the leading citrus growing country in south east Asia. Citrus fruits are rich in source of ascorbic acid (vitamin c), sugars and minerals like calcium, phosphorous and iron. Besides this, these are good source of foreign exchange. Citrus fruits are transported from their localities of production to far off places for marketing and consumption. Being succulent these are subjected to post harvest damage and deterioration during harvesting, transit, storage marketing and consumption, if not properly handled. Injuries or damage to the fruit during harvest and transportation results in the loss of moisture due to faster surface evaporation. Injured fruits are also attacked by micro-organisms and become diseased. The diseased fruit respire at much faster rates than healthy fruits (Agrios, 1997). Faster fruit respiration and their faster metabolic activities result in the senescence and storage rots. This paper reports on.

1. Extent of post harvest losses occurring to the citrus fruits such as Feutrell's Early, oranges and kinnow mandarin transported from Kallurkot, Bhalwal and Jauharabad to Faisalabad city.
2. Fungi associated with their decay or rot prior to their consumption.

MATERIALS AND METHODS

The estimates of post harvest losses of citrus fruits (Feutrell's Early, Oranges and Kinnow mandarins) were carried on the basis of the interviews with owners of gardens, post harvest contractors, commission agents, wholesale agents, retailers and house-wives. In order to verify the statements of the people and to have more reliable estimates, the citrus gardens are also visited and operation of the picking of the fruits, their handling grading, packing, transportation to markets, whole selling in the markets, retailing at the shops and consumption at homes are observed carefully and the data regarding losses of Feutrell's Early, Oranges and Kinnow mandarins at different stages were recorded separately. The produces of the citrus fruits harvested at Kallurkot, Bhalwal and Jauharabad and transported to Faisalabad were selected for the post-harvest losses in them. Three samples of each fruit, consisting of 100 fruits per sample were collected from different fruit heaps in the gardens of above mentioned places, mixed and were passed through all stages of marketing. The data on the extent of losses at the time of harvesting included picking of unripe, over ripped, and fruits damaged during handling. The losses at whole selling market include the fruits deteriorated during the transportation and storage before the auction of fruit lot by the commission agent, while losses at retailing included the deterioration of the fruits during transportation, from the whole sale to vendor's shop or sale points on animal driven cart, pressing of the fruit by the customers while storage, overnight storage and exposure to the sun and unfavorable environmental condition. The losses in house hold consumption include deterioration of fruits kept in polythene or paper bags before actual consumption.

The specimen of rotting/ decaying citrus fruits were collected from the fruits lots in the cold storage, with whole sellers, retailers etc. at Faisalabad and were brought to laboratory. The fungi responsible for the their decay or rots were isolated on sterilized PDA(Potato starch 20g, Dextrose 20g, Agar Agar 20g and Distilled water 1000ml) poured in 90 mm diameter Petri plates, purified, identified, and maintained on PDA for pathogenicity test.

For pathogenicity test of the isolated fungi, three sets of ten healthy fruits of each of Feutrell's Early, Orange and Kinnow Mandarin were taken, washed, air dried, surface sterilized with the 0.1 percent $HgCl_2$ solution for two minutes and rinsed twice in sterilized water. One set of each fruit was injury inoculated, the other set of fruits was inoculated without injury while third set was injured and uninoculated to serve as control. The three sets of each type of citrus fruits were kept at 25 ± 2°C for 7 days and then observed for decay and rot development.

RESULTS AND DISCUSSION

A. Losses In Feutrell's Early:

The post harvest losses in Feutrell's early at various stages from producers i.e. harvesting to consumers are given in the Table 1 and 2. The Feutrell's early transported from Kallurkot to Faisalabad suffered from 5, 3, 6, and 2 percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively, while those transported from Bhalwal to Faisalabad suffered from 6, 3, 6 and 2 percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively. . The Feutrell's Early transported from Jauharabad to Faisalabad suffered from 4, 2, 8 and 2 percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively. Thus lots of Feutrell's early transported from Kallurkot, Bhalwal and Jauharabad to Faisalabad suffered from total loss of 16, 17, and 16 percent losses respectively. The 16 percent losses of Feutrell's Early of Kallurkot were due to 9. 1, 1 and 5 percent injured unriped and rotten or diseased fruits respectively (Table 2). The 17 percent losses of Feutrell's Early of Bhalwal were due to 8, 3, 1 and 5 percent injured unriped, over riped and decaying fruit. The 16 percent losses of Feutrell's early of Jauharabad included 8, 2, 0, 6 injured, unriped, overiped and diseased fruits.

The fungi isolated from diseased (rotten) Feutrell's Early were *Alternaria tunuis, A. tenuissima, Aspergilllus fumigatus, Colletotricum gleosporiodies, Penicilium italicum Rhizopous nigricans.* The result of their pathogenicity test (Table 3) revealed *Alternaria tunuis, Colletotricum gleosporioidies* and *Pancillium italicum* were found to be pathogenic to both injured and uninjured fruits of Feutrell's Early. *Aspergillus fumig*atus and *Rhizopus nigricans* caused rottning of injured fruits only. *Alternaria tenuissima* did not cause rotting of the both injured and non injury inoculated fruits of Feutrell's Early.

LOSSES IN ORANGES

The estimated post harvest losses in oranges at various stages from producer i.e. harvesting to consumers are given in the Table 4 and 5. The orange transported from Kallurkot to Faisalabad suffered from 7, 5, 6, and 2 percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively, while oranges transported from Bhalwal to Faisalabad suffered from 6, 4, 6 and 3 percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively. . The lot of oranges transported from Jauharabad to Faisalabad suffered from 9, 4, 5 and 2 percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively. Thus lots of oranges transported from Kallurkot, Bhalwal and Jauharabad to Faisalabad suffered from total loss of 20, 19, and 20 percent respectively. The 20 percent losses of oranges of Kallurkot consisted of 10, 2, 1 and 7 percent injured, unriped and over riped and diseased fruit respectively. The 19 percent losses of oranges of Bhalwal consisted of 8, 2, 2 and 7 percent injured, unriped, over riped and diseased fruit respectively. The 20 percent losses of oranges transported from of Jauharabad included 9, 2, 1and 8 percent injured, unriped, overiped and diseased fruits.

Table 1. Losses in Feutrell's early at various stages from producers to consumers.

Feutrell's Early Transported		**Percent losses during**				
From	**To**	**Harvesting**	**Whole sale marketing**	**Retail marketing**	**House hold**	**Total**
Kallurkot	Faisalabad	5	3	6	2	16
Bhalwal	Faisalabad	6	3	6	2	17
Jauharabad	Faisalabad	8	2	4	2	16

Table 2. Losses in feutrell's early at various stages from producers to consumers.

Fungal isolate	Percent rot of Feutrell's Early		
	Uninjured inoculated	Uninjured inoculated	Injured inoculated
Alternaria tenuis	0	30	60
Altenaria tenissimai	0	0	0
Aspergillus fumigatus	0	0	50
Colletotrichum gleosporides	0	30	65
Penicilium italicum	0	30	65
Rhizopus nigricans	0	0	60

Table 3. Percent infection of inoculated and uninoculated fruits of feutrell's early inoculated by various fungi (pathogenicity test).

Feutrell's early transported		Percent loss due to				
From	To	Injured	Unripe	Over ripe	Diseased	Total
Kallurkot	Faisalabad	9	1	1	5	16
Bhalwal	Faisalabad	8	3	1	5	17
Jauharabad	Faisalabad	8	2	-	6	16

Table 4. Losses in oranges at various stages from producers to consumers.

Orange transported		Percent losses during				
From	To	Harvesting	Whole sale Marketing	Retail Marketing	House Hold	Total
Kallurkot	Faisalabad	7	5	6	2	20
Bhalwal	Faisalabad	6	4	6	3	19
Jauharabad	Faisalabad	9	4	5	2	20

Table 5. Losses in oranges at various stages from producers to consumers.

Orange transported		Percent loss due to				
From	To	Injured	Unripe	Over ripe	Diseased	Total
Kallurkot	Faisalabad	10	2	1	7	20
Bhalwal	Faisalabad	8	2	2	7	19
Jauharabad	Faisalabad	9	2	1	8	20

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

Fungal isolate	Percent rot of Feutrell's Early		
	Uninjured Inoculated	Uninjured Inoculated	Injured Inoculated B. C. D. E. F. G. H. I. J. K. L. M.
Alernaria citri	0	20	100
Alternaria tenuis	0	10	80
Altenaria tenissimai	0	0	60
Aspergillus flavous	0	0	0
Colletotrichum gleosporides	0	0	40
Fusarium solani	0	20	80
Geotrichum candidum	0	0	50
Penicilium digitatum	0	40	100
Penicilium italicum	0	20	80
Rhizopus nigricans	0	0	50

The fungi isolated from diseased (decaying) oranges were *Atlernaria citri, Alternaria tenuis, Altenaria tenuissimai, Aspergillus flavus, Colletotrichum gleosporoides, Fusarium solani, Geotrichum candidum, Penicilium digitatum, Penicilium italicum* and *Rhizopus nigricans* (Table 6). *Alernaria citri, Alternaria tenuis, Fusarium solani, Penicillium digitatum,* and *Penicilium italicum* were found to be pathogenic on injury inoculated and non injury inoculated oranges and caused their rottening. *Altenaria tenissimai Colletotrichum gleosporoides,Aspergillus flavus, Geotrichum candidum,* and *Rhizopus nigricans* were found to be pathogenic on injury inoculated oranges but non pathogenic in non injury inoculated oranges. *Aspergillus flavus* did not cause rotting of both injury and non injury inoculated oranges.

Table 7. Losses in kinnow mandarin at various stages from producers to consumers.

Kinnow mandarin transported		**Percent losses during**				
from	**To**	**Harvesting**	**Whole sale marketing**	**Retail marketing**	**House hold**	**Total**
Kallurkot	Faisalabad	10	4	6	2	22
Bahlwal	Faisalabad	10	3	6	2	21
Jauhrabad	Faisalabad	12	6	7	2	27

Table 8. Losses in kinnow mandarin at various stages from producers to consumers.

Kinnow Mandarin transported		**Percent loss due to**				
From	**to**	**Injured**	**Unripe**	**Over ripe**	**Diseased**	**Total**
Kallurkot	Faisalabad	8	4	1	9	22
Bhalwal	Faisalabad	7	3	1	10	21
Jauharabad	Faisalabad	8	2	5	12	27

Table 9. Percent infection of inoculated and uninoculated fruits of kinnow mandarin by various fungi (pathogenisty test).

Fugal isolate	**Percent rot of futerell early**		
	Uninjured inoculated	**Uninjured inoculated**	**Injured inoculated**
Alternaria tenuis	0	60	100
Altenaria tenuissima	0	0	0
Aspergillus flavus	0	0	0
Aspergillus niger	0	50	100
Botryodiplodia theobromae	0	80	100
Fusarium solani	0	0	0
Geotrichum candidum	0	70	100
Penicilium digitatum	0	80	100
Penicilium italicum	0	80	100
Phomopsis citri	0	50	80
Rhizopus nigricans	0	20	50

LOSSES IN KINNOW MANDARINS

The estimates of post harvest losses of kinnow mandarins at various stages from producers (i.e. harvesting) to consumer are given in the table 7 and 8. the kinnow mandarins transported from Kallurkot to Faisalabad suffered from 10, 4, 6 and 2 percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively, while kinnow mandarins transported from Bhalwal to Faisalabad suffered from 10, 3, 6 and 2 percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively. The lot of kinnow mandarins transported from Jauharabad to Faisalabad suffered from 12, 6, 7 and 2

percent losses during harvesting, whole sale marketing, retail marketing and house hold consumption respectively. Thus lots of kinnow mandarins transported from Kallurkot, Bhalwal and Jauharabad to Faisalabad suffered from total loss of 22, 21 and 27 percent losses respectively. The 22 percent losses of kinnow mandarins of Kallurkot consisted of 8, 4, 1 and 9 percent injured, unriped and over riped and diseased fruit respectively (Table 8), while 21 percent losses of Bhalwal lot consisted of 7, 3, 1 and 10 percent injured, unriped, over riped and diseased fruit respectively. The 27 percent losses of jauharabad lot included 8, 2, 5 and 12 percent injured, unriped, overiped and diseased fruits.

The fungi isolated from diseased (decaying) oranges were *Alternaria tenuis, Altenaria tenuissima, Aspergillus flavus, A. niger, Botryodiplodia theobromae, Fusarium solani, Geotrichum candidum, Penicilium digitatum, Penicillium italicum, Phomopsis citri* and *Rhizopus nigricans*(Table 9). In their pathogenisty test *Alternaria tenuis, A. niger, Botryodiplodia theobromae, Geotrichum candidum, Penicilium digitatum, Penicilium italicum, Phomposis citri* and *Rhizopus nigricans* were found to be pathogenic both on injury and non injury inoculated kinnow fruits, while *Altenaria tenuissimi, Aspergillus flavous* and *Fusarium solani* did not caused rotting of injury or non injury inoculated kinnow fruits.

Post harvest losses in citrus are mainly due to injuries inflicted to fruit surface during harvesting and transportation and decay of fruits in storage and transit due to the attack of microorganisms. Citrus fruits are very susceptible to the attack of pathogenic fungi due to their low pH, higher moisture contents and nutrient composition favoring their growth on or within the fruits and making them unfit for human consumption (Phillips, 1984; Ceponis *et al.* 1984: Moss, 2002). Pre harvest losses or post harvest fungicidal application to control post harvest decay or rots is common strategy. This practice to control post harvest disease can result in carcinogenic, teratogenic effects on consumers and high residual and other side effects on human (lingk, 1991; Unnirshnan and Nath, 2002). Moreover development of fungicide resistant strains within the populations of post harvest decay causing pathogen is becoming a significant problem (Riemann and Deising, 2002, Dianz *et al*., 2002). Thus public stress on the reduced use of pesticides and demands for alternate and safe strategies to reduce the losses incurred by post harvest decay pathogens and that offer no risk to the human and environment in which they live (Willson and Wisniewski, 1989: Wilson *et al*., 1993: Janisiwicz *et al*., 1994). The biological control of post harvest decay of several fruit by pathogenic fungi has been extensively studied and several examples of successful disease control exist (Janisiewicz, 1988: Janisiewicz and Marchi, 1992: Roberts, 1990: Roberts, 1994)

The use of plant products for the control of post harvest diseases of fruits is an alternate and advantageous strategy than fungicides (Sharma, 1998) because these are biodegradable, non pollutant and posses no residual phytotoxic effects. These natural products can be used as anti-fungal materials, to replace synthetic chemicals, and to control post harvest fungal diseases of citrus and other fruits. The benefit of natural plant products in controlling post harvest pathogens is due to their antimicrobial activity displayed by their essential oils or oil fractions. (Singh *et al*., 1980: Thompson, 1989: Zambonelli *et al*., 1996: Sharma and Tripathi, 2006). There are some in vitro studies on the effect of essential oils on the post harvest pathogens (Bishop and Thornton, 1997) and some of the essential oils have been reported to have inhibitory effect on the development of post harvest fungi (Bishop and Reagon, 1998: Sharma, 1998: Hidalgo *et al*., 2002: Sharma and Verma 2004). Use of the essential oils on the fruits and vegetables enhance their storage and shelf life (Dubay and Kishore, 1998). Spraying and dipping of the fruits and vegetables in the essential oils have been reported to control their post harvest decay (Tiwari *et al.*, 1988 and Dixet *et al.*,1995).
The use of essential oils for the control of post harvest decay offers no health hazards to its consumers, no pollution to the environment and no risk for the resistance development by the post harvest pathogens.

REFERENCE

Agrios, G.N. (1997). *Plant Poahtology*. 5th ed. Academic Press, London.

Bishop, C .D. and J. Reagan (1998). Control of storage pathogens *Botrytis cinerea* in dutch white cabbage (*Brassicae oleracae* var. *capitate*) by essential oils of *Monarada citriodora* var *citriodora* and *Melaleuca alternifolia* on the postharvest pathogens . *J. Essential Oils Research*, 10: 57-60.

Bishop, C .D. and I.B. Thornton (1997). Evaluation of antifungal activity of essential oils of *Monarada citriodora* var *citriodora* and *Melaleuca alternifolia* on the postharvest pathogens . *J. Essential Oils Research*, 9: 77-82.

Ceponis, M. J., R.A. Capplini and G. W. Lighter (1986). Disorders in citrus shipment to New York market. 1972-84. *Plant Dis*., 70: 1162-1165.

Dixit, S.N., H. Chandra, R.Tiwari and V. Dixit (1995). Development of botanical fungicides against blue mold of mandarins. *J. Stored Product Res*., 31:165-172.

Dubey, N. K. and N. Kishore (1988). Exploitation of higher plant products as natural Fumigants. In: *Proc. 5th Int. Conf. on Plant Pathology*, Kyoto, Japan. PP 423 (abst).

Dianz, F., M. Santos, R. Balanco and J.C. Tello (2002). Fungicides resistance in *Botrytis cinerea* isolates from strawberry crops in Huelva (Southern Spain) *Phytoparasitiae*, 30: 529-534.

Hidalgo, P.J., J.L. Qliera, J.A. Santos, F.La Front, C. Castelanos, A. Palmino and M. Romars (2002). Essential oils in *Culamontha sylvatica* in wild and cultivated productions and antifungal activity. *Journal of Essential Oils Research*, 14: 68-71.

Lingk, W. (1991). Health risk evaluation of pesticides contaminations in drinking water. *Gesunde Pflazen*, 43: 21-25.

Janisiewicz, W. J. (1988). Biocontrol of Post Harvest Disease of Apples with Antagonistic Mixtures. *Phylopathology*, 78: 194-198.

Janisiewicz, W. J. and A. Marchi (1992). Control of Storage Rot on Various Pear Cultivars with a Saprophytic Strain of *Pseudomonas syringae. Plant Disease*. 78: 555-560.

Janisiewicz, W. J., D. L. Petterson and R. Bors (1994). Control of Storage Decay of Apples with *Sporoholomyces roseus*. *Plant Dis*., 78: 466-470.

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

Phillips, D. J. (1984). Mycotoxins as a Post Harvest Problems In: *Post Harvest Pathology of Fruits and Vegetables*. Post Harvest Losses in Perishable Crops. Univ. of California Berkelay Publication.

Reimann, S and H.B, Deising (2002). Fungicide: risk of resistance development and Search for New Targets. *Archives of Phytopathology and Plant Protection*, 33: 329-349.

Roberts, R. G. (1990). Post Harvest Biological Control of Grey Mold of Apple by *Cryptococcus laurentii*. *Phytopathology*, 80: 526-530.

Roberts, R. G. (1994). Integrating Biological Control into Post Harvest Disease Management Strategies. *Hortscience*, 29:758-762.

Sharma, N. and A. Tripathi (2006). Fungitoxicity of Essential Oils of *Citrus sinensis* on Post Harvest Pathogens . *World Journal Microbiology and Biotechnology*, 22: 587-593.

Sharma, N. (1998). Control of post harvest diseases with natural plants products. In: *Post harvest diseases of Horticultural Perishables* (N. Sharma and M. M. Alam eds). International Book Distributing Company, Lucknow, India PP. 127.

Sharma, N. and U.K. Verma (2004). Bioactivity of *Hyptis suaveolens* on storage mycoflora, In: *International conference on fumigation and controlled atmosphere. Conrad Jupiters Gold Coast Australia*, PP.55 (Abstract).

Singh, A. K., A. Dikshit, L. M. Sharma and S. N. Dixit (1980). Fungi toxic activity of some Essential Oils. *Economic Botany*, 81: 186-190.

Thompson, D. P. (1989). Fungitoxic Activity of Essential Oil Components on Food Storage Fungi. *Mycologia* 81: 151-153.

Tiwari, R., D. N. Mishra and P. S. Upadhyay (1988). Efficacy of Some Plant Volatiles for Control of Black Mold of Onion Caused by *Aspergillus niger* Van. Tiegh During Storage. *Nat. Acad. Sci. Letters*, 11: 345-347.

Unnikrishnan, V. and B.S. Nath (2002). Hazardous chemicals in food. *Indian J. Dairy Bio. Sci*., 11: 155-158.

Wilson, C. L. and M. E. Wisniewski (1989). Biological control of post harvest diseases of fruits and Vegetables: and Emerging Technology. *Annual Review of Phytopathology*, 27: 245-441.

Wilson, C. L., M. E. Wisniewski., S. Droby and E. Chalutz (1993). A Selection Strategy for Microbial Antagonists to Control Post Harvest Disease of the Fruits and Vegetables. *Sci. Hort*., 53:183-189.

Zambonelli, A., A. Z. Aulerio, A. Bianchi and A. Abasini (1996). Effect of Essential Oils on Phytopathogenic Fungi. *Phytopathology,* 144: 491-494.

(*Accepted for publication February 2008*)