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Etiology of Post-harvest Rot of Apples in NWFP

Jahangir Khan, Shabir Ahmad* and Sher Hassan**
Agricultural Research Station (North) P.O. Box 22, Saidu Sherif, Swat, NWFP, Pakistan
*Department of Plant Pathology, NWFP Agricultural University, Peshwar, Pakistan
**Faculty of Plant Sciences, NWFP Agricultural University, Peshawar, Pakistan

Abstract
Rotted apples collected from six cold stores and two fruit markets in Peshawar and Swat divisions showed attacks of *Penicillium expansum* (74.2%), *Alternaria alternata* (11.6%) and *Rhizopus* sp. (14.2%). However, *P. expansum* was found to be the most prevalent fungus both in apple stores and markets because of its survival potentiality both at low and high temperatures. These fungi are mostly wound pathogens and require injury for infection. The apple variety Red delicious was more susceptible to the disease than Golden delicious indicating differential reaction of these varieties to apple rot. However, the amount of rotting incited by *Rhizopus* sp. was greater than the other fungi due to its rapid growth and virulence at 20°C.

Introduction
Post-harvest rot of apples is a major disease in most of the apple growing areas of the world (Eckert and Sommer, 1967; Tepper and Yoder, 1982). Economic losses caused by post-harvest diseases are heavier than is generally realized because fresh apples increase severalfold in unit value while passing from the field at harvest time to the consumer. A major portion of these losses is attributed to diseases caused by micro-organisms. Fungi responsible for the disease are *Penicillium expansum*, Botrytis cinerea, *Rhizopus* sp. (Rosenberger *et al*., 1979); *Phomopsis mall* (Rosenberger and Burr, 1982); *Acremonium irnplicatum*, *Nodulosponum hinulium*, *Ceratocystis major* (Vyas *et al*., 1976); *Trichoderma harzianum* (Conway, 1983); *Mucor periformis* (Spotts and Cervantes, 1986) and *Alternaria alternate* (Tak *et al*., 1985).

Unsanitary conditions in apple storage and packing facilities provide an ideal environment for the survival of post-harvest pathogens. In Pakistan, a considerable percentage of apples are wasted every year due to inadequate picking, packing, transportation, marketing and storage facilities. Apple rot in cold stores and fruit markets has gained a tremendous momentum. However, no systematic work has been done so far on the etiology and control of this disease in Pakistan, and particularly in NWFP. Owing to the complex nature of the disease both in apple stores and markets in NWFP, the present study was carried out to identify the causal organisms of the post-harvest rot of apples so that control measures for the disease could be worked out.

Materials and Methods
Collection of diseased specimens: An extensive survey of the main cold stores and fruit markets in Peshawar and Swat divisions was made to collect rotten apples. About 318 samples were collected from 8 different cold stores and fruit markets.

Identification of the pathogens: The rotten apples were surface disinfected with 5 percent ethanol for one minute, washed with several changes of distilled water, and then blot dried. From the margin of the fruit, small pieces were taken aseptically from under the skin and placed on Potato Dextrose Agar (PDA) medium on sterilized petri-plates and incubated at 20°C for seven days. Mycelial colonies of the different fungi were subcultured to obtain pure culture of each fungus. The isolated fungi were identified with the help of keys devised by Barnett (1956), Ellis (1971), Mirza *et al*. (1979) and Pitt (1979).

Pathogenicity test: Healthy fruit of two apple varieties Red delicious and Golden delicious were surface disinfected with 5 percent ethanol for one minute, washed with distilled water and then injured with a sterilized pointed needle 2 mm deep. Each fruit received three injuries at different places. Some of the fruit were left uninjured (check). Both types of fruit, injured and uninjured, were dipped in spore suspension (1.5×10^5 spores/ml) of each of the test fungi. Spore counts in sterile water suspension were determined with the aid of a haemocytometer. Inoculated apples were wrapped in paper bags so that they did not touch one another, and were incubated at 20°C for seven days. Data was recorded on the diameter of the rotten area in different treatments at the end of the incubation period. Factorial design was followed, and the treatments were replicated three times. The fungi were re-isolated from the disease lesions and were identified to be the same as isolated from the original specimens of the rotten fruits.

Results and Discussion
Among the several species of fungi isolated from 318 diseased samples from eight cold stores and fruit markets, *P. expansum*, *A. alternata* and *Rhizopus* sp. were the most abundant with a frequency of 74.2, 11.6 and 14.2 percent respectively (Table 1). However, *P. expansum* was found to be the most prevalent fungus both in apple stores and markets. The rapid development and survival of *P. expansum*, both at high and low temperatures, caused this fungus to be present on apples at a high percentage rate in all the cold stores and fruit markets surveyed. The results coincide with those obtained by Conway (1983) and Roy (1975).

Pathogenicity test of *P. expansum*, *A. alternata* and *Rhizopus* sp. indicated the importance of injured fruit and apple varieties in the causation of rot (Table 2). Wounds on

Table 1: Percentage of the fungi isolated from rotted apple fruit

Name of store/market and locality	Specimens Collected	Percentage of isolated fungi		
		P. expansum	*A. alternata*	*Rhizous* sp.
Azim cold store Peshawar	50	76	8	16
Pakistan cold store Peshawar	50	70	10	20
Saeed cold store Peshawar	32	75	15.6	9.4
Zeeshan cold store Peshawar	40	80	7.5	12.5
Sarhad cold store Peshawar	28	75	10.7	14.3
SSA cold store Mingora, Swat	47	74.4	12.8	12.8
Fruit market Peshawar	32	68.7	15.6	15.7
Fruit market Swat	39	74.4	15.4	10.2
Average	318'	74.19	11.95	13.86

*Total rotten specimens collected from the above eight cold stores and markets

Table 2: Pathogenicity test on two apple varieties of *P. expansum*, *A. alternate* and *Rhizopus* sp. incubated at 20°C for one week

Treatments	Mean* rotting size (cm)		Mean[1]
	Red delicious	Goldendelicious	
P. expansum	4.9b	3.8c	4.35b
A. alternata	3.4c	2.6d	3.00c
Rhizopus sp.	8.4a	8.0a	8.20a
Control	0.0e	0.0e	0.00d
Mean[2]	4.17	5a	3.6b

Mean* is the average of three replications, and figures followed by different letters differ from one another significantly at all levels.

Mean[1] is the average rotting on two varieties, and figures followed by different letters are significantly different from one another at all levels.

Mean[2] is the average rotting of the four treatments, and figures followed by different letters are significantly different from one another at all levels

the fruit provided ideal ports of entry for the fungi and hence rotting occurred, while the uninjured fruit indicated no rotting. Blanpied and Purnasiri (1969) reported similar results. Interaction between the pathogens and the varieties was highly significant at all levels. Rotted lesions were larger on the variety Red delicious than on Golden delicious. The fruit of Golden delicious is firmer and crispier which might have caused less decay in this fruit due to its texture (Conway and Sams, 1984). However, acidity is the main factor that could reduce the incidence of rot. A higher level of acidity could contribute in the reduction of susceptibility, whereas an increase in sugar content resulted in increased susceptibility (Kaul, 1984). The amount of rotting caused by *Rhizopus* sp. was greater than the other fungi due to its rapid growth and virulence at 20°C (Kaul, 1986).

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