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Studies on Prevalence and Sustainable handling of Post-harvest fungal diseases of Mango fruits (*Mangifera indica* L.) in Western U.P.

Dr. Vaibhav Sharma
Department of Botany,
Govt. P.G. College, Khair (Aligarh) (UP) India

(Corresponding author Dr. Vaibhav Sharma)
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ABSTRACT: The investigations were carried out during three consecutive years from 2010 to 2012 in different mango growing districts of western Uttar Pradesh. The survey of post-harvest fungal diseases of mango prevailing during the entire marketing channel from orchard to consumers, revealed that common diseases are *Anthracnose*, *Aspergillus* rot, *Rhizopus* rot, *Alternaria* rot, Scab and Black rot. Among these diseases severely spreading ones are *Aspergillus* rot (3.85%) and Black rot (3.5%) while the scab represent lowest incidence (0.34%). It was also noted that the total fruit loss due to post harvest fungal diseases occurring in the marketing channel was 34.52%.

Reports on the prevention of post harvest fungal diseases showed that coating of freshly harvested fruits with coconut oil was found most effective in preventing Considerable decay of fruits (20.93%). Treatment of freshly harvested mangoes with hot water at ~55°C and water vapours between (46°C-50°C) for 5 to 10 minutes were recorded to be highly promising and result oriented for preventing fungal diseases. Experimentation on packaging designs of harvested fruits have shown that to sustain the life span of mango fruits up to consumers level, use of shallow ventilated slated wooden boxes with newspaper lining and wrapping the individual fruit with tissue paper or newspaper is the best design of packaging.

Key words: Post harvest fungal diseases, sustainable handling, fruit coating, hot water and vapor heat treatment, packaging.

I. INTRODUCTION

Mango (*Mangifera indica* L.) belonging to dicotyledonous family Anacardiaceae, is one of the highly prized tropical fruits of India. It is also called as 'King of fruits' in world market, because of its excellent flavor, attractive fragrance, beautiful shades, delicious taste and healthful value. Mango being popular fruit of summer season also attached with the economy of several fruit traders, invites special attention towards its healthy upkeep. Since it is a perishable fruit, it has high delicacy towards fungal diseases that damage major part of produce during post harvest operations like grading, packing, transportation, storage and marketing till it reaches to the hands of consumers. Mango fruits being climacteric have a short shelf life. Moreover at the time of harvest the warm weather added with vital heat generated due to accelerated rate of fruit respiration and high temperature in transport containers and ripening chambers, fruits become prone to attack by fungal pathogens during the period between harvest and consumption. Post harvest diseases result not only in substantial losses and reduction in mango productions, but also reduces quality of the fruits. To prevent post harvest losses handling of fruits is the most important step. The study of post harvest diseases and their prevention in marketing channel make a significant contribution to increase the production of fruits as an alternative by reducing the post harvest losses as hidden harvest has already been justified (1-3). In our country tropical fruits being perishable commodities are only seasonably available and the marketable period for freshly harvested fruits ranges from a few days to two or three weeks. In this situation if post harvest handling is not proper their exposure to several diseases can be estimated to be between 20 to 30 percent for perishable fruit like mango. In the present study an effort has been made to identify the different fungal diseases occurring in marketing channel after harvesting and to apply sustainable method of fruits handling to prevent post harvest fungal diseases.

II. MATERIAL AND METHODS

A. Disease incidence

A survey of post-harvest diseases of mango fruits in orchards and markets was conducted for three consecutive years from 2010 to 2012 in five prominent mango growing districts of western Uttar Pradesh, viz. Bulandshahr, Ghaziabad, Meerut , Muzaffarnagar and Saharanpur.

To detect incidence of diseases infected mango fruits were collected weekly from orchards and fruit markets of areas under study during the peak maturity months i.e. June and July. All the samples collected were kept in separate sterilized polythene bags to avoid contamination. The district wise samples of diseased fruits were studied to identify the diseases by keen observations of symptoms developed on fruits.

To identify the causal organisms isolation of the pathogens was done from diseased fruit portions. Small bits of infected fruit tissues were transferred aseptically to freshly prepared sterilized PDA media for the culture of fungus. Petridishes of inoculated media were put into incubator at 30°C for 4 to 6 days to stimulate proper growth of fungus. Ten petridishes were maintained for each disease at different dates. To identify the pathogen few strains were isolated from culture and studied under microscope. For confirmation of strain pathogenecity tests were conducted in vitro by artificially inoculating the healthy semiripe fresh mango fruits with the isolated pathogens. The symptoms developed on fruits were recorded [4]. Thus the ultimate disease incidence was recorded from the fruits of different varieties collected from different orchards and market sites.

B. Fruit loss

To study the fruit loss two dimensional observations were taken into consideration one at the harvesting time at orchard level and the other after harvesting at whole seller and retailer level. For experimentation sampling units were selected randomly. On the day of harvest ten samples were taken from the heaps of freshly harvested mangoes in each sample separately. The procedure was repeated in different popular orchards of each district and observations were recorded. Non parasitic and parasitic disorders were also calculated from these samples.

By critical survey of all steps in post harvest handling, the total fruit loss in marketing chain was assessed. Then the data was tabulated and analyzed thoroughly at each level in order to draw the inferences. The aggregate fruit loss at each level was worked out by combining different damage intensities and then the results were pooled to work out the flow of mango fruit from producers to consumers and resulting fruit losses.

C. Post-Harvest Handling

Careful handling of fruits can substantially reduce the intensity of fungal diseases that usually occur after harvesting. (5-6) To avoid use of hazardous fungicides experimentations on sustainable measures like fruit coatings with oils and wax, hot water and vapour heat treatments and disease free packaging were implemented for prevention and minimizing the post harvest fungal diseases.

For each experiment three sets of 15 to 20 freshly harvested healthy fruits of medium size were selected including one set of control. For fruit coatings Mustard oil Refined oil, Coconut oil, Desi Ghee and Natural wax were used to study their antifungal effectivity. The oils as per set were smeared on the surface of the fruit with the help of cotton swab, where as natural wax was first melted and fruits were dipped into it. After coating fruits were air dried and stored at room temperature in perforated brown bags for seven days. After taking extra precautions data pertaining to the number of diseased and healthy fruits in each treatment was recorded after one week of storage and examining each fruit carefully.

Hot water treatment was done as per reported method (7). Three sets of 15-20 diseased fruits were washed with tap water and dried using cotton cloth and then immersed in sterilized hot water contained in thermostat at ~55°C for 5-20 minutes and dried at room temperature . All fruits were stored setwise in perforated polythene bags for one week. Simultaneously control was also kept for comparison. Fruits were weighed twice for recording the percent decay. After one week effectiveness of hot water on fruit diseases was recorded on the basis of disease development.

Three sets of 15-20 fruits were washed in running water, dried and surface sterilized with ethyl alcohol. The fruits were exposed to the high humidity hot air in a closed vessel ranging 46°C to 50°C for 10 minutes . Fruits were dried and stored in perforated brown bags at room temperature for one week and data was recorded.

Experiments were conducted to study the effects of packaging design to minimize the occurrence of diseases (8-9). Since the freshly harvested mango fruits generate heat and gases that can be detrimental in conventional unventilated methods of packaging like use of gunny bags, wooden boxes, card board boxes and pitthoos. I used shallow ventilated' slated wooden boxes with newspaper Lining and wrapping individual fruit in tissue paper or newspaper.

RESULTS AND DISCUSSION

A. Disease incidence

Perusal of average data during three consecutive years 2010-12 reveals that the commonly occurring post harvest fungal diseases of mango in western Uttar Pradesh are *Aspergillus* rot, Anthracnose, Black rot, *Fusarium* rot, *Alternaria* Black spot, Stem end rot, *Rhizopus* rot and Scab Caused by *Aspergillus nigre*, *Colletotrichum gloeosporioides*, *Aspergillus nigre*, *Fusarium equsetti*, *Alternaria alternata*, *Botrydiplodia theobromae*, *Rhizopus stolonifer* and *Alsinoe mangiferae* respectively.

The mean data of disease incidence shows that two diseases *Aspergillus* rot (3.86%) and Black rot (3.5%) are severely spreading diseases of western Uttar Pradesh at post harvest level where as followed by these diseases are Anthracnose (2.33%) *Rhizopus* rot (1.7%) *Alternaria* black spot (1.66%) Stem end rot (1.34%) and *Fusarium* rot (1.34%). The Scab with its minimum incidence (0.34%) causes negligible loss. However cumulative incidence of all post harvest fungal diseases is 16.07% in all (Table 1).

Table 1: Incidence of different Post-Harvest fungal diseases in Western Uttar Pradesh (in %).

S. No.	Diseases	Pathogen	Percentage Disease Incidence			Average (%)
			2010	2011	2012	
1	Stem end rot	*Botryodiplodia theobromae*	2.0	2.0	1.0	1.34
2	Rhizopus rot	*Rhizopus stolonifer*	2.2	1.9	1.2	1.70
3	Scab	*Elsinoe mangiferae*	0.5	0.0	0.5	0.34
4	Aspergillus rot	*Aspergillus niger*	3.2	4.3	4.1	3.86
5	Black rot	Aspergillus niger	3.6	3.2	3.7	3.50
6	Fusarium rot	*Fusarium equasetti*	1.0	2.0	1.0	1.34
7	Anthracnose	*Colletotrichum gloeosporioides*	2.0	3.0	2.0	2.33
8	Alternaria black spot	*Alternaria alternata*	2.0	2.0	1.0	1.66
9	Cumulative incidence					16.07

B. Assessment of Post-Harvest fruit loss

Concerted attempts have been made to assess the post harvest fruit losses due to fungal diseases at different levels of marketing channel. The experimental data reveals that at orchard level usually four fungal diseases viz. Stem end rot, Black rot, *Rhizopus* rot and *Aspergillus* rot commonly occur and cause 1.5%, 1.0%, 1.0% and 0.7% fruit loss respectively (Table 2). At wholesaler level the dominating diseases are Aspergillus rot, Black rot, Anthracnose, Rhizopus rot, Stem end rot, Alternaria rot, Fusarium rot and Scab causing average fruit loss 3.66%, 3.5%, 2.27%, 1.66%, 1.5%, 1.5%, 1.14% and 0.43% respectively (Table 2).

Table 2: Assessment of post harvest fruit loss in mango at various Marketing Channels.

S.No.	Causes of fruit loss	2010	2011	2012	Average fruit loss in percentage (%)
	At Orchard Level				
1	Stem end rot	2.2	1.3	1.0	1.5
2	Black rot	1.2	0.9	0.9	1.0
3	*Rhizopus* rot	1.0	1.5	0.5	1.0
4	*Aspergillus* rot	1.0	0.6	0.5	0.7
	Total loss				4.20
	At Whole Saler Level				
1	Black rot	3.3	3.7	3.5	3.50
2	Stem end rot	2.1	1.2	1.2	1.50
3	*Rhizopus* rot	1.2	1.2	1.3	1.66
4	*Anthracnose*	2.5	2.9	2.4	2.27
5	*Alternaria* rot	1.2	1.3	2.0	1.50
6	Scab	0.5	0.5	0.3	0.43
7	*Fusarium* rot	1.3	1.9	1.2	1.14
8	*Aspergillus* rot	3.2	3.3	2.7	3.66
	Total Loss				15.66
	At Retailer Level				
1	Black rot	2.8	2.2	1.9	2.3
2	Stem end rot	3.5	3.1	3.0	3.2
3	Over Ripening	1.1	2.0	1.4	1.5
4	Rotting	2.2	2.2	1.6	2.0
	Total Loss				9.0

However at retailer level the losses are mainly due to Stem end rot and Black rot Causing 3.21% and 2.3% loss respectively where as over ripening and rotting cause average loss 1.5% and 2.0% respectively. (Table 2). As regards the overall assessment of fruit loss our result, indicates that the total average loss at orchard level is 4.20%, at wholesaler level 15.66% and 9% at retailer level. The results of present study corroborate with the reported findings (10-11).

C. Post-Harvest Handlings

Careful and sustainable handling of the fruits during harvesting, packaging and transportation are the prerequisites to prevent post harvest losses in marketing channel. In our experimentation some ecofriendly cost effective treatments viz. fruit coating with fixed oils and natural wax, hot water treatment, vapour heat treatment and new packaging devices were adopted. After harvesting fruits were coated with Mustard oil, Dalda, Refined oil, Coconut oil, Desi ghee and Natural wax before packaging. The mean values of three replicates of all the three consecutive years indicate that every coating has a significant impact on shelf life and controlling of percent decay of fruits, however Coconut oil is the best preservant showing minimum fruit loss (20.93%) as compared with control (83.34). Whereas next to it are Natural wax (22.89%) and Mustard oil (23.17%). These results of our experimentation are consistent with the reported finding (12-16).

The hot water treatment was conducted at ~55°C for 5, 10, 15 and 20 minutes on freshly harvested diseased mango fruits. The resultant data revealed that Rhizopus rot was reduced to 19.84% as compared to control (76.91%) at 5 minutes hot water exposure. Stem end rot and Fusarium rot were reduced to 22.11% and 22.59% as compared to 83.05% and 83.89% in control respectively at 10 minutes exposure. Scab, Anthracnose, Aspergillus rot and Alternaria rot were reduced to 27.14%, 28.07%, 28.64% and 29.65% as compared to 80.08%, 82.47%, 76.73% and 79.79% in control at 10, 15, 20 and 10 minutes respectively (Table 4). These results are in fair agreement with reported ones (17-19).

Table 3: Effectiveness of Fixed oils and Natural wax in controlling fruit loss by Post harvest Fungal diseases.

Treatments with fixed oils and Natural wax	% Decay / % of fruit loss			
	2010	2011	2012	Pooled/ Average
Mustard oil	23.33	23.59	22.60	23.17
Dalda	31.77	34.54	37.56	34.62
Refined oil	28.59	28.71	34.14	30.48
Coconut oil	20.37	23.57	18.86	20.93
Desi ghee	30.59	32.95	34.74	32.76
Natural wax	23.50	23.98	21.19	22.89
Control	85.79	85.40	78.84	83.34
SEM ±	1.82	1.63	1.29	1.92
CD 0.5%	5.61	5.03	3.99	2.66

Table 4: Effectiveness of hot water treatment on Post harvest fungal diseases.

Average data of Percentage reduction in fungal diseases							
Treatment at 55°C±1°C hot water for	Rhizopus rot	Stem end rot	Fusarium rot	Scab	Anthracnose	Aspergillus rot	Alternaria rot
5 minutes	19.84	23.89	27.20	30.54	30.22	34.05	38.49
10 minutes	36.56	22.11	22.59	27.14	28.56	38.94	29.65
15 minutes	27.62	32.84	23.11	28.82	28.07	37.12	35.30
20 minutes	28.02	24.66	27.77	36.51	39.51	28.64	34.76
Control	76.91	83.05	83.89	80.08	82.47	76.73	79.79
SEM ±	2.41	1.99	0.98	1.86	0.72	3.24	2.12
CD 0.5%	7.03	2.91	2.88	2.50	2.11	9.45	6.18

The mean data of all the three consecutive experimental years reveal that vapour heat treatment in range of 46°C to 50°C is exclusively effective to control the *Fusarium* rot disease, whereas Stem end rot, Rhizopus rot, Anthracnose, Aspergillus rot, Scab and *Alternaria* rot could be controlled only at specific temperatures *viz* 49°C, 50°C, 47°C, 49°C, 46°C and 47°C respectively (Table 5) as reported earlier (20). Different from conventional methods efforts were made to search innovative designs of packaging to reduce the spoilage in transportation and storage. After experimentation it was found that shallow ventilated slated wooden boxes with newspaper lining containing fruits wrapped with tissue paper or newspaper would be an economically acceptable and safe method of packaging against the traditional methods used by orchard men traders and godown keepers.

Fusarium Rot

Scab

Rhizopus Rot

Stem end rot

Alternaria Rot

Anthracnose

Post harvest fungal diseases of Mango

Table 5: Effectiveness of Vapour heat treatment on Post harvest fungal diseases.

Vapour heat Treatment for 10 minutes at the temp.	**Average data of Percentage reduction in fungal diseases**						
	***Fusarium* rot**	**Stem end rot**	***Rhizopus* rot**	**Anthracnose rot**	***Aspergillus* rot**	**Scab**	***Alternaria* rot**
46°C	0.00	25.17	5.01	12.67	4.65	0.00	1.56
47°C	0.78	28.22	7.20	12.05	8.05	0.00	0.93
48°C	0.93	31.16	4.23	15.79	4.63	0.00	1.48
49°C	0.78	22.41	3.05	20.82	3.36	1.30	1.74
50°C	0.00	25.34	1.45	19.97	6.59	1.70	1.28
Control	68.27	84.74	72.42	65.28	69.44	61.31	67.69
SEM ±	0.51	0.60	0.66	0.86	0.80	0.50	0.54
CD 0.5%	1.46	1.73	1.92	2.50	2.30	1.43	1.56

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