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Physico-microbial and shelf life analysis of commercially important three mango varieties under different treatments

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ABSTRACT

Every year huge quantity of mangoes is lost due to lack of proper postharvest storage condition. Various treatments are used to minimize postharvest losses and extend shelf life. So, an experiment was carried out at the Laboratories of the Department of Horticulture and Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh during the period from July to October, 2018 to investigate the effect of variety and different postharvest treatments to extend shelf life of mango. The two-factor experiment was laid out in Randomized Complete Block design with three replications. The factors taken for the experiments were (i) three varieties of mango, *viz.*, V_1= Langra, V_2= Fazli and V_3= Ashwina and (ii) six postharvest treatments, *viz.*, T_1 = control; T_2 = perforated low density polythene (LDPE) bag with $KMnO_4$; T_3 = perforated LDPE bag without $KMnO_4$; T_4 = mustard oil coating; T_5 = hot water treatment (50º C) for 5 minutes; T_6 = garlic extracts. Freshly harvested mango was treated with those different treatments. Untreated mango was considered as control. The treated fruits showed significant differences in case of peel color, firmness, total weight loss, disease incidence and severity, and shelf life compared to control fruits. Among the treatments, T_2 perforated LDPE with $KMnO_4$ showed the longest shelf life (12 days), less disease incidence and severity and the lowest weight loss at 9 DAS days after storage. The treatment T5 (hot water treatment @ 50º C for 5 minutes) was also found effective for maintaining postharvest quality of mango stored at ambient conditions.

Introduction

Mango (*Mangifera indica* L.) is a delicious, nutritionally superior and one of the most valuable fruits which is a member of the family Anacardiaceae. Mango, often referred to as the king of tropical fruits, is an important fruit crop cultivated in tropical regions (Boghrma *et al*., 2000). It is the only species that is grown commercially on a large scale. It has a unique position in respect of nutritional quality, taste, consumers' preference, etc. It is one of the most popular and delicious fruits in Bangladesh because of having delicious taste, excellent flavor and high nutritive value especially 100% vitamin C (unripe mango) and 36% Vitamin A. It is commercially grown in more than 40 countries in the world. The main mango producing countries of world are India, Pakistan, Mexico, Brazil, Haiti, the Philippines and Bangladesh. In terms of total production of mango, Bangladesh ranks seventh among the worldwide production (Alam *et al.*, 2017). But in Bangladesh, mango ranks first in terms of production and second in area. Bangladesh has seen a rise in mango production over the last 18 years, according to a report in 2017 by Food and Agriculture Organization. Around 2.4 million tonnes of mangoes were harvested in 2017-18, according to DAE officials (The Daily Star, May 11, 2019). According to Agriculture officials, 152 mango varieties are grown in the districts of Rajshahi, Dinajpur, Rangpur, Kushtia, Satkhira and Jessore. Among them Langra, Fazli, Ashwina, Gopalbhog, Khirsapat are main varieties**.** However, profitable mango production is hampered by several challenges, including inappropriate agronomic practices, inappropriate pest and disease management technologies, poor extension support systems, poor postharvest handling technologies and poor marketing infrastructure as well as lack of appropriate credit support facilities.

Because of mishandling, inadequate storage or lack of postharvest technical knowledge, producers and traders have to face about 27.4% losses of their fresh produce (Hassan, 2010). In this regard, development of postharvest technology related to quality maintenance and extending the postharvest life is essential for expanding export markets for mango fruit (Rodov *et al.*, 1997). Around the world, different post-harvest technologies are used to minimize the losses for extending shelf life.

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Considering this situation, the current study was conducted to evaluate the effectiveness of above treatments in maintaining physico-chemical properties and extending shelf life of mango during postharvest period.

Materials and Methods

Experimental materials

The mature, disease and insect free mangoes were collected through mango grower from their mango orchard from Chapainawabganj district. The post-harvest experiment was performed at the Post Graduate Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from July to October, 2018.

Experimental treatments and design

The experiment consisted of three mango varieties *viz.* Langra (V_1), Fazli (V_2), Ashwina (V_3) and six postharvest treatments *viz.* control (T_1), fruits wrapped in polybag containing $KMnO_4$ (T_2), perforated low-density polythene (LDPE) bags (T_3), edible oil (Mustard oil) coating (T_4), fruits treated with hot water at 50˚ C for 5 minutes (T_5) and fruits treated with garlic extract (T_6) and was laid out in Randomized Complete Block Design (RCBD) having three replications with seven mangoes in each replication.

Application of postharvest treatments

Disease free three hundred and seventy eight mango fruits were selected randomly from the fruit lot collected from Chapainawabganj and were placed on brown paper placed on laboratory table without applying any treatments (control), with wrapping in polybag containing $KMnO_4$, with perforated low-density polythene (LDPE) bags, with edible oil (Mustard oil) coating, treated with hot water at 50˚C for 5 minutes and treated with garlic extract. Each polyethylene bag was characterized by 12.5 cm length and 19 cm width having 12 perforations (each perforation was of 4 mm diameter) for perforated bag. In case of oil treatment and garlic extract, the individual mango was dipped in garlic solution and mustard oil and kept on another place to drain out the excess solution and oil.

Parameters investigated

The following physical parameters *viz.* total weight loss, peel color change, firmness, visual & other characteristics and microbial parameters *viz.* disease incidence and disease severity were investigated.

Methods of studying parameters

Total weight loss

Six out of 7 fruits of each replication of each treatment were weighed individually and kept under different postharvest treatments for data collection. Weight loss was calculated using the following formula:

$$\text{Percent weight loss (\%WL)} = \frac{IW - FW}{IW} \times 100$$

Where, WL = Percent total weight loss
IW = Initial weight of fruits (g)
FW = Final weight of fruits (g)

Peel color change

The changes in color of mango were determined using a numerical rating scale of 1-6, where 1 = green, 2 = Breaker, 3 = Up to 25% yellow, 4 = 25- <50% yellow, 5 = 50- <75% yellow and 6 = 75-100% yellow. Similar method was followed by Hassan (2006).

Firmness

Firmness of mango was determined by hand feeling using a numerical rating scale of 1-5, where, 1= mature hard, 2 = sprung, 3 = between sprung and eating ripe, 4 = eating ripe and 5 = over ripe. This method was mentioned by Hassan (2006).

Disease incidence

Diseases incidence means percentage of fruits infected with disease. This is measured by calculating the percentage of fruits infected in each replication of each treatment. The diseased fruits were identified symptomatically. The disease incidence was calculated as follow:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected fruits in each replication}}{\text{Total number of fruits in each replication}} \times 100$$

Disease severity

Disease severity represents the percent diseased portion of the infected mango fruit. The infected fruit of each replication of each treatment were selected to determine percent fruit area infected, and was measured based on eye estimation.

Visual and other characteristics

The external and internal visual changes noticed in the mango were examined and recorded up to 12 DAS. The flavor developed in unperforated polyethylene bag and oil coated mango was examined by nasal sensation.

Statistical analysis

The statistical analysis was done using MSTAT-C statistical package. The means for the treatments were calculated and the analysis of variances (ANOVA) for the parameters was performed by F-test. The significance of the difference between the pair of means was compared by least significant difference (LSD) test at the 5 and 1% levels of probability.

Results and Discussion

Changes in fruit firmness of mango during storage

The storage condition and postharvest treatments had a highly significant effect on fruit firmness of mango (Table 1 & 3, Plate 1). Ashwina showed the lowest firmness score at 12 DAS whereas Langra possessed the highest (Table 1). The rate of firmness degradation reduced in treatment Fruits wrapping with polythene bag containing $KMnO_4$ and rate of firmness degradation was fastest in control treatment $KMnO_4$ acted as a scavenger for ethylene gas. It reduced the concentration of ethylene gas production and so ripening processes became delay. For combined effects the lowest fruit firmness score showed by cv. Ashwina treated with Fruits wrapping with polythene bag containing $KMnO_4$ whereas highest score showed by cv. Langra treated in controlled condition at 12 DAS. During ripening the pectic substances (protopectin, cellulose, hemicelluloses etc.) are broken down through enzymatic reaction. As a result, the cell wall and the strength of inter cellular bond become weak resulting the softening of the fruit (Mondal, 2000).

Changes in peel color during storage of mango

Statistically significant variation in peel color change was noticed among three varieties postharvest treatments (Table 2 & 3, Plate 1). During the storage period, the color of mango changes from green to yellow. From present study we observed that, longer period was required for Ashwina followed by Fazli and Langra to change the color from green to yellow (Plate 1). Change of peel color during ripening and senescence of fruits involves chlorophyll degradation or qualitative and quantitative alternation of the green pigment into other pigments. In case of effect of treatments, mustard oil coating showed the lowest rate of peel color change, whereas in control treatment, the rate of peel color change was the fastest (Table 2). This was due to inhibition of different chemical changes like chlorophyll breakdown. This was shown by Farooqui *et al.* (1988), reported that the coating has gained importance in reducing the moisture loss and maintaining the firmness & freshness of fruits and vegetables during storage.

Table 1. Effects of variety on firmness, disease incidence and disease severity of mango during storage and ripening

Name of the Varieties	Firmness at different days after storage (DAS)				% Disease incidence at different days after storage (DAS)				% Disease severity at different days after storage (DAS)			
	3	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
Langra (V_1)	1.88	2.96	3.49	4.32	11.11	37.0	68.30	88.89	0.87	10.64	25.56	43.78
Fazli(V_2)	1.80	2.94	3.67	4.29	-	9.26	46.29	70.34	1.30	6.05	16.75	34.75
Ashwina (V_3)	2.04	2.85	3.71	4.23	5.56	18.0	51.85	83.49	0.50	3.67	10.10	25.51
Level of significance	**	*	**	**	-	**	**	**	**	**	**	**

Table 2. Effects of treatments on peel color, disease incidence and disease severity of mango during storage and ripening

Treatments	Peel color at different days after storage (DAS)				% Disease incidence at different days after storage (DAS)				% Disease severity at different days after storage (DAS)			
	3	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
T_1	1.80	4.03	4.78	3.62	3.70	43.38	73.74	90.96	2.22	14.98	31.61	50.03
T_2	1.24	1.83	2.72	3.64	3.70	11.11	36.96	74.07	0.62	6.03	17.43	33.34
T_3	1.62	2.73	4.04	4.91	7.41	29.63	59.25	85.18	0.29	2.62	11.66	29.10
T_4	1.05	1.79	2.24	2.98	3.70	11.11	55.55	85.17	0.92	5.84	15.41	35.47
T_5	1.66	3.73	4.46	5.42	-	11.11	40.74	81.47	1.09	9.10	19.75	41.91
T_6	1.60	3.65	4.41	5.25	3.70	22.22	66.66	92.59	0.18	2.14	8.95	18.21
Sig. level	**	**	**	**	-	**	**	**	**	**	**	**

(T_1 = Control, T_2=Fruits wrapping with polythene bag containing $KMnO_4$, T_3 = Perforated low-density polythene bag, T_4 = Edible oil (mustard oil) coating, T_5= Fruits treated with Hot water treatment at 50˚ C for 5 minutes, T_6=Fruits treated with garlic extract. Color score: 1 = green, 2 = breaker, 3 = < 25 % yellow, 4 = <50 % yellow, 5 = <75 % yellow, and 6 = 75 to 100 % yellow).

Considering the combined effects of peel color degradation was reduced in Ashwina treated with mustard oil and rate of peel color degradation faster in Langra with control conditions. The faster rate of color change of mango under control treatment may be due to the rapid activity of some enzymes that are responsible for the color changes of mango Robinson (1996).

Changes in total weight loss during storage of mango

The variation in terms of total weight loss was highly significant among the three mango varieties and the postharvest treatments (Plate 1, Table 3). The weight loss was greatest in Langra (14.52%) followed by Ashwina and Fazli (12.03%) during 12th day of storage.

This phenomenon is in agreement with the research findings of Yuniarti and Suhardi (1992) who noted that fruits kept in perforated sealed polythene bags containing KMn04 as an ethylene absorbent had delayed ripening. Weight loss occurs due to the respiration loss of stored starch in mango and increase of respiration is positively correlated with the increase of temperature. The total weight loss was found to be the highest (17.60%) in case of control at the 12th day of storage and the lowest (11.22%) was observed in $KMnO_4$ treated fruits at the 12th day of storage.

Table 3. Combined effect of postharvest treatments on total weight loss, peel color change and firmness change of mango at different DAS

Varieties	Treatments	Weight loss at different days after storage (DAS)				peel color at different days after storage (DAS)				Firmness at different days after storage (DAS)			
		3	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
Langra(V_1)	T_1	9.62	12.90	13.94	18.01	1.98	4.47	5.32	ND	2.10	3.20	4.89	0.00
	T_2	3.76	6.70	9.47	10.95	1.35	2.22	2.98	3.96	1.11	1.68	2.12	3.21
	T_3	4.91	6.56	8.12	12.26	1.65	3.10	4.78	5.45	2.40	3.75	4.03	4.84
	T_4	4.11	4.32	6.98	10.90	1.10	1.95	2.19	3.25	1.24	2.12	2.70	3.53
	T_5	8.81	12.45	13.29	14.38	1.80	3.75	4.78	5.76	2.14	3.66	4.12	4.97
	T_6	6.16	6.87	10.33	17.51	1.70	3.70	4.60	5.60	2.31	3.32	4.45	5.03
Fazli(V_2)	T_1	6.00	7.33	9.16	11.88	1.77	3.87	4.89	5.97	2.19	3.33	3.84	4.76
	T_2	5.00	8.50	10.12	10.70	1.21	2.00	2.80	3.80	1.10	1.73	2.11	3.12
	T_3	6.40	8.30	9.55	10.74	1.62	3.10	4.65	5.40	2.03	3.30	4.05	4.64
	T_4	5.53	6.06	9.08	11.41	1.03	1.87	2.16	3.20	1.19	2.32	2.97	3.52
	T_5	5.64	7.00	9.91	10.50	1.65	3.70	4.50	5.70	2.21	3.77	4.59	4.80
	T_6	6.00	9.43	13.49	16.83	1.60	3.60	4.58	5.40	2.06	3.20	4.43	4.91
Ashiwana(V_3)	T_1	5.93	7.86	9.74	13.13	1.65	3.76	4.12	4.89	2.11	3.15	4.09	4.73
	T_2	6.02	8.99	11.90	11.93	1.15	1.28	2.38	3.17	1.14	1.73	2.75	3.10
	T_3	5.91	9.29	11.70	12.11	1.60	2.00	2.68	3.89	2.14	3.29	4.06	4.55
	T_4	5.53	6.72	8.60	11.57	1.00	1.55	2.38	3.10	1.52	2.31	2.88	3.34
	T_5	5.66	8.98	10.92	12.04	1.55	3.75	4.10	4.80	2.31	3.20	4.26	4.71
	T_6	5.63	8.92	13.59	18.46	1.50	3.67	4.06	4.76	3.02	3.43	4.22	4.92
Sig. level		**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

V_1 = Langra, V_2 = Fazli, V_3 = Ashiwana, T_1 = Control, T_2 = Fruits wrapping with polythene bag containing $KMnO_4$, T_3 = Perforated low density polythene bag, T_4 = Edible oil (mustard oil) coating, T_5= Fruits treated with hot water treatment at 50˚C for 5 minutes, T_6 = Fruits treated with garlic extract.

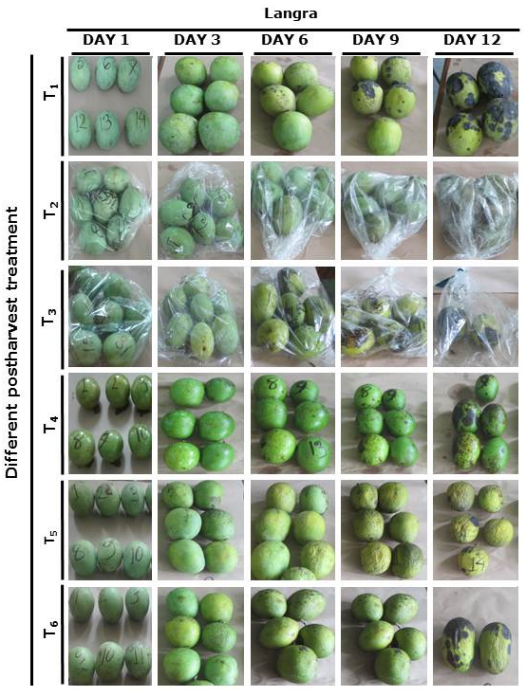

Plate 1: Photographs showing the physical changes of mango var. Langra under different treatments at different days after storage. T_1 = Control, T_2=Fruits wrapping with polythene bag containing $KMnO_4$, T3 = Perforated low-density polythene bag, T_4 = Edible oil (mustard oil) coating, T_5= Fruits treated with hot water at 50˚ C for 5 minutes, T_6 = Fruits treated with garlic extract.

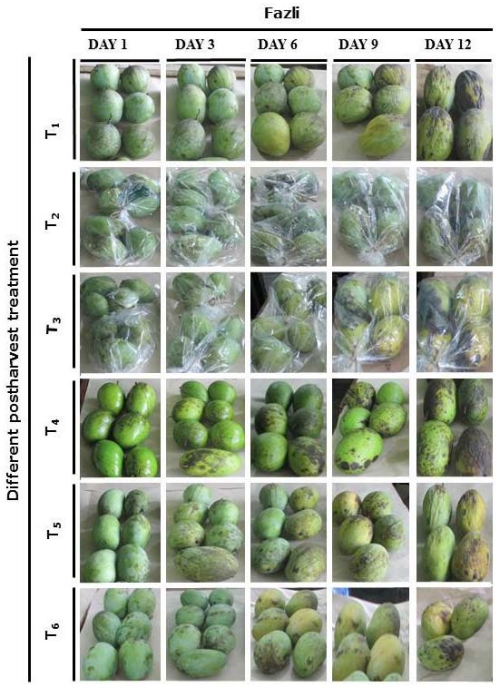

Plate 1 (contd.): Photographs showing the physical changes of mango var. Fazli under different treatments at different days after storage. T_1 = Control, T_2=Fruits wrapping with polythene bag containing $KMnO_4$, T_3 = Perforated low-density polythene bag, T_4 = Edible oil (mustard oil) coating, T_5 = Fruits treated with hot water at 50˚ C for 5 minutes, T_6 = Fruits treated with garlic extract.

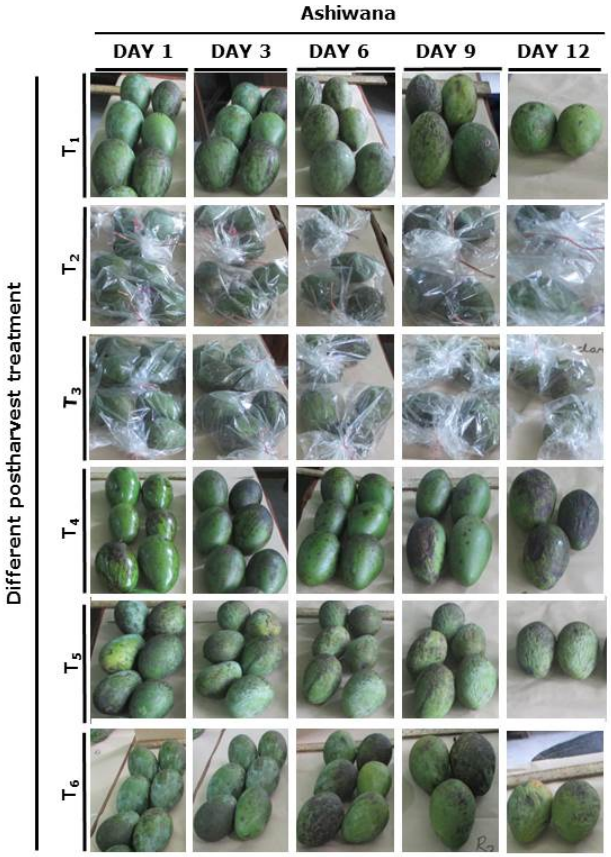

Plate 1 (contd.): Photographs showing the physical changes of mango var. Fazli under different treatments at different days after storage. T_1 = Control, T_2=Fruits wrapping with polythene bag containing $KMnO_4$, T3 = Perforated low-density polythene bag, T_4 = Edible oil (mustard oil) coating, T_5= Fruits treated with hot water at 50˚ C for 5 minutes, T_6 = Fruits treated with garlic extract.

Reddy and Haripriya (2002) reported that mango fruits treated with GA3 and stored in polyethylene bags with ethylene absorbent significantly reduced physiological weight loss. Tefera *et al.* (2007) and Fawaz (2006) also reported the lowest total weight loss in polythene wrapped mangoes. The combined effects showed the highest total weight loss (18.01%) was found in Langra in control condition at 1 DAS while it was the lowest (10.50%) in Fazli treated with $KMnO_4$ containing polythene bag at the 12th day of storage. It is in agreement with the finding of Wavhal, 1989 who reported that Packaging of mango fruit in lots of 10 in polyethylene bags (30 x 40 cm, 10 gauges with 0.2 % perforation) reduced weight loss, prolonged shelf life by 4 to 8 days without deteriorating fruit quality compared with non-wrapped fruits. Ben Yehoshua (2013) also suggested the similar phenomenon that packed fruits showed lower weight loss due to checking of the rate of respiration, transpiration and maintaining higher humidity by poly films.

Changes in disease incidence of mango during storage

The levels of disease severity were significantly influenced by postharvest treatments at the different storage time. It was observed that disease severity status of mango was recorded at 3 days interval from day 3 up to 12 days. The disease incidence was significantly high at ambient temperature and found the highest percentage in Langra variety (88.89%) followed by (83.49%) in Ashiwana variety and (70.33%) in Fazli variety at 12th DAS (Table-1). The disease incidence of mango was significantly influenced by different postharvest treatments at different DAS (Table 2 & 4). At 12th DAS, the highest disease incidence was found in control treatment T_1 (90.96%) compared to others treatment. It is in agreement with the findings of Anwari (2013) who stated lower disease incidence in unperforated polyethylene bag than hot water treatment and control. Again, the findings are similar to Islam (2013) and Molla *et al.* (2011) who found maximum disease incidence in control treatment. In the combine effect we found the highest disease incidence was found the all variety control treatment (Table 4).

At 3-9 DAS, control treatment under ambient condition showed rapid increases disease incidence and we found highest percentage in Langra followed by Ashiwana and Fazli variety but there was lowest rate of disease incidence in the treatments of T_2 and T_5 in Fazli variety compared to the others treatments. At 12th DAS the highest disease incidence was found in the treatment T_6 (98.99%) in Langra variety followed by T_3(98.34%), T_4 (88.85%) compared to Ashwina and Fazli variety. We observed the lowest disease incidence in Fazli variety with the treatment of T_2 (66.66%) and T_5 (66.86%) followed by Langra variety with the treatment of T_2 (77.78%) and T_5 (69.67%) and Ashwina variety with the treatments of T_2(66.66%) and T_5 (67.86%) than others treatments (Table 4)

These fungi can infect mango when mango possesses considerable amount of sugar but cannot infect at the condition of high acidity. Green unripe mango contains high amount of different organic acids (Mondal, 2000). For this reason, the fungi cannot infect green unripe mango containing considerable amount of acids.

Changes in disease severity of mango during storage

The variations in disease severity due to the ambient temperature conditions and postharvest treatments were statistically highly significant. There were less disease severity at treated mango compared to untreated mango at different day of storage. We found the highest disease severity at the 12th DAS in the variety of Langra (88.89%) followed by Ashwina (83.49%) and Fazli variety (70.34%) at ambient temperature of untreated mango sample. We found the highest disease severity in the control treatment compared to the others treatments. In the combined effect initially at 3rd DAS we didn't find any disease severity in Fazli variety with the treatment T_2 and T_5, T_6 followed by Ashwina variety with the treatment T_3, T_5 and T_6 compared to the other varieties and treatments.

Table 4. Combined effect of postharvest treatments on disease incidence and disease severity and shelf-life of mango at different DAS

Variety	Treatments	Disease incidence (%)at different days after storage (DAS)				Disease severity (%) at different days after storage (DAS)				Shelf-life (Days)
		3	**6**	**9**	**12**	**3**	**6**	**9**	**12**	
Langra (V1)	T_1	11.11	88.77	99.00	100.00	1.11	19.22	37.22	55.44	9
	T_2	-	11.11	44.22	77.78	0.77	10.87	29.35	45.22	11
	T_3	-	55.55	88.86	98.34	0.55	3.33	18.88	48.12	9
	T_4	-	22.22	55.55	88.85	1.11	8.94	20.27	50.22	10
	T_5	-	11.11	44.44	86.87	1.15	17.05	29.88	42.33	11
	T_6	-	33.33	77.77	98.99	0.55	4.44	17.77	51.26	9
Fazli (V2)	T_1	11.00	11.11	44.44	83.88	0.55	15.39	29.35	50.12	8
	T_2	-	-	33.33	66.66	-	4.44	16.46	25.26	12
	T_3	-	11.11	55.55	68.64	0.33	2.87	10.33	28.33	12
	T_4	-	-	44.44	75.77	1.11	5.47	18.44	35.23	11
	T_5	-	11.11	33.33	66.86	-	6.70	19.70	23.54	12
	T_6	-	22.22	66.66	77.77	-	1.42	6.22	38.29	10
Ashiwana (V3)	T_1	11.01	30.25	77.77	89.00	1.22	10.33	28.27	53.12	7
	T_2	-	22.22	33.33	66.67	-	2.77	6.47	43.20	12
	T_3	-	22.22	33.33	88.87	0.55	1.67	5.78	46.33	9
	T_4	-	11.11	66.66	88.88	-	3.12	7.53	48.43	11
	T_5	-	11.11	44.44	69.67	0.77	3.54	9.66	40.54	11
	T_6	-	11.11	55.55	98.87	-	0.57	2.87	49.23	9
$LSD_{0.05}$		-	2.40	3.18	1.88	0.195	0.818	0.946	1.90	1.35
$LSD_{0.01}$		-	3.24	4.30	2.54	0.263	1.10	1.28	2.56	1.82
Level of significance		-	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

V_1 = Langra, V_2 = Fazli, V_3 = Ashiwana , T_1 = Control, T_2=Fruits wrapping with polythene bag containing $KMnO_4$, T_3 = Perforated low density polythene bag, T_4 = Edible oil (mustard oil) coating, T_5= Fruits treated with Hot water treatment at 50˚C for 5 minutes, T_6=Fruits treated with garlic extract.

We recorded the highest disease severity in the Langra mango variety with the control treatments T_1 (55.44%) compared to other treatments and lowest disease severity was found in Fazli variety with the treatment T_5 (23.54%) and T_2 (25.26%) compared to Langra and Ashwina variety at 12th DAS. It is in agreement with the statement of Anwari (2013) who stated lower disease severity in unperforated polyethylene bag than hot water treatment and control. Islam (2013) also found highest disease severity in control treatment.

Shelf-life

Shelf life of mango fruits was significantly affected by different postharvest treatments. It was observed that the extension of shelf life of fruits has been one of the most important concerns of the researchers. Results revealed that the longest shelf life (12 days) of mango fruits was recorded in those fruit held at the treatment T_2 and T_5 among the treatments. We found the longest shelf-life of Fazli variety with the acceptable quality. The shortest shelf life of 7 days was observed from the control fruits and and also found 8 days with the treatments T_4, T_3 in the Ashwina and Langra variety compared to Fazli variety. Thin plastic film Alphonso mango fruits increased the shelf life of the mango. Different botanical extracts viz. neem and garlic,and coating like sesame oil influence the shelf life and maintain quality of mango (Rodov *et al.*, 1997).

Conclusion

Postharvest treatments had significant effects on color, firmness, total weight loss disease severity, disease incidence and shelf life of mango. The best visual appearance was observed the fruits subjected to hot water treatments and fruits wrapping in polybag containing $KMnO_4$. Mango remained fresh until day 12 if held in the treatment with hot water. Although Fruits wrapping in polybag containing $KMnO_4$ showed better result in storage until the 12th day of storage. At the 12th day of storage, mango stored at hot water treatment and Fruits wrapping in polybag containing $KMnO_4$ had less disease severity and disease incidence than other treatments. Mango stored in Fruits wrapping in polybag containing $KMnO_4$ reduced weight loss in Fazli variety compared to the variety until the 12th day of storage. The longest shelf life of 12 days was found in Fazli variety with the treatment of hat water and fruits wrapping in polybag containing $KMnO_4$.

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