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INFLUENCE OF EPIPHYTIC FLUORESCENT *PSEUDOMONAS* ON THE SHELF LIFE & PHYSIOCHEMICAL PROPERTIES OF MANGO (*MANGIFERA INDICIA)* FRUIT STORED AT AMBIENT TEMPERATURE

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Abstract

An evaluation was performed to study the efficacy of postharvest application of epiphytic fluorescent *Pseudomonas* on mango "Safaid Chaunsa' fruit with a view of elevating compositional quality and storage period. In the current study, Mango fruits were at the ripened stage 4. Surface treatment was performed by suspending the selected isolates of epiphytic fluorescent *Pseudomonas* namely HAB-10, HAB-15, and HAB-25 in water to 10^7 CFU/mL. For positive control, treatment with potassium sorbate (K-sorbate) 1 % was performed while treatment with sterilized distilled water acted as negative control. All fruits (treated and non-treated) were kept at 28±3ºC with 63-67% relative humidity for ten days. During study, samples were tested for changes in their physical and chemical composition such as total soluble solids (TSS), physiological loss in weight (PLW), pH, total titratable acidity (TTA), firmness, decay percent and total polyphenol content (TPC) on every fifth day. After nine days of storage, results demonstrated that; lower PLW, higher firmness, lower concentration of TSS and TTA and fluorescent *Pseudomonas* treated fruits showed least decay percent as compared to non-treated fruit set (control). After storage of ten days, higher content of phenols (TPC) was observed in fruits treated with HAB-15 tailed by HAB-25 and HAB-10 treatment. The epiphytic fluorescent *Pseudomonas* treated fruits showed slow rate of metabolic process and caused delay in ripening of fruits, ultimately maintaining better quality as compared to untreated fruits (control sets) during ten days of storage at ambient conditions.

Key words: Epiphytes, Decay, Physiochemical properties, Fluorescent *Pseudomonas*, *Mangifera indicia.*

Introduction

The perishable fruits like Mango have limited shelf life and ripen after 3 to 4 days after reaping at ambient temperature (Amwoka *et al*., 2021). Different varieties of mango fruits ripen at different interval; it depends on the conditions in which it is stored. Usually, Mango ripens within 4 to 8 days at 25-28ºC while 2-3 weeks at 13ºC (Carrillo-Lopez *et al*., 2000). Due to limited shelf life, the long distance transportation of fruits becomes difficult (Mukherjee & Litz, 2009). Green mango takes 9-12 days to ripen after harvesting (Umar, 2021).

Mango fruits are perishable in nature and sensitive to low temperature and decay which has made handling, transportation and storage a difficult task to cope with (Gelaye, 2024). The reduction in shelf life and frequency of postharvest decay due to *Botryodiplodia theobromae* (stem-end rot disease) causes a noteworthy effect in retrieving the quality of mango fruits for export along with widespread losses in native markets. Fruits may be attacked by pathogens in pre and post harvesting conditions as dormant infection. Contrary wise, Mango fruits are not compatible with controlled atmosphere (CA) or modified atmosphere (MA). Even though, studies have reported that extension of shelf-life can be done by CA storage but it is expensive (Singh *et al*., 2010). During storage and packing of fruits, spraying with thiabendazole (TBZ), carbendazim, and imazalil (IMZ) can control pathogens up to some extent (Habiba *et al*., 2021). But due to its possible harmful risks and pathogen resistivity many fungicides have not been used for postharvest treatment.

Alternative methods should be developed to control post-harvest disease because of increasing concern of public for health and environmental safety and demand of fruits free from all toxic residues (Habiba *et al*., 2019; Habiba *et al*., 2017). An alternative method which is growing very rapidly is the application of microbial antagonists as biological control agents individually or as integrated control strategy to decrease the use of fungicide. Besides, the resistance of fungicides against most of the strains of pathogen (Gea *et al.,* 2021) and their environmental hazard. In the recent times, the focus of consumers and industries is to purchase mango fruits free from remnants of chemical pesticides or lethal substance. Thus, it is important to build up an unconventional, ecologically friendly method to control postharvest disease and increase shelf life.

Application of bio-inoculants which shows antimicrobial and shelf-life-increasing activities showed less environmental hazards (Habiba *et al*., 2020). Bacterial inoculant used as bio-inoculant may be responsible for protection of the goods via antibiosis, induction of defense pathway and spatial competition (Manikandan & Raguchander, 2014). Combinations of diverse group of biocontrol agents may help in controlling pathogens up to greater extend (Przyklenk *et al*., 2017). The utilization of mixture of biocontrol agents to control various diseases under different conditions has also been reported. The improved actions of a range of defense-related enzymes and compounds in reaction to infection of pathogen and increased production of defense-related compounds delayed or controlled the postharvest disease of perishable fruits have been reported by application of biocontrol agents such as *Pseudomonas* spp. (Peeran *et al*., 2014) and *Bacillus* spp. (Alvindia & Acda, 2015).

Nowadays, microbial antagonists Aspire, Biosave-100, and Biosave-110 are commercially accessible to control postharvest diseases. In laboratory studies, bacterial and yeast antagonists are used to resist infection of *Botrytis cinerea* and *Penicillium expansum* on different fruits (Peng & Sutton, 1991; Fan & Tian, 2001; Vero *et al*., 2002 ; Mikani *et al*., 2008; Godana *et al*., 2020). The improvement of shelf life and quality parameters of stored tomato fruits by application of epiphytic *Pseudomonas* has been reported in our earlier study findings (Habiba *et al*., 2017) and endophytic fluorescent *Pseudomonas* at pre-harvest stage is also well documented (Noreen *et al*., 2016; Korejo *et al*., 2019; Noreen *et al*., 2019; Noreen *et al*., 2015; Yang *et al*., 2011). However, current study aims to investigate the biocontrol efficacy of epiphytic fluorescent *Pseudomonas* against *B. thoeobrame* with the study of its potential in the management of postharvest quality of mango fruit.

Material and Methods

Biocontrol agent: In recent study, healthy fruits and vegetables were used to enumerate epiphytic fluorescent *Pseudomonas*, their biocontrol potential and molecular identification has been reported (Habiba *et al*., 2017). Selected isolates of epiphytic florescent *Pseudomonas* were maintained at 4°C on Kings B medium before use.

Fruit: Mangos (*Mangifera indica*) fruits at 80% maturity stage were collected from Karachi's supermarkets and fields and were moved to the laboratory. The surface sterilization of fruits was performed by dipping in 2% NaClO for 2 min, washed with sterilized distilled water and air dried at room temperature (28°C).

Dual culture plate assay for antifungal activity of epiphytic *Pseudomonas*: Dual culture plate method was used to determine the antifungal activity of epiphytic f. *Pseudomonas* against *B. theobromae* (Habiba *et al*., 2017). Fungal disc of *B. theobromae* having diameter of 5mm was placed at one end and epiphytic fluorescent *Pseudomonas* were streaked on another end of the petri dishes holding Czapek's Dox agar. After incubation of 7 d at 32ºC the inhibition zones were measured.

Application of epiphytic fluorescent *Pseudomonas* species on the postharvest physiochemical properties of stored Mango fruit: Mango fruits used during experimentation were of uniform size, fresh and free from disease collected at partially ripened stage (stage 4) during 2013-2014. After collection, surface sterilization and air drying of fruits was carried out at ambient conditions prior to application of treatments. The epiphytic fluorescent *Pseudomon*as aqueous suspensions namely HAB-10, HAB-25, and HAB-15 at 10^7 CFU/mL was prepared for dipping fruits for 5 min (Habiba *et al*., 2017), dried and 4 fruits were placed in well aerated baskets. The K-sorbate (1%) aqueous suspension was applied as positive control, while sterile water was applied as negative control. During the period of study, relative humidity ranged between 63-67% and temperature ranged from 28±3 ºC. At room condition, after every five days interval different physiological parameters were recorder.

Effect of epiphytic fluorescent *Pseudomonas* species on physiochemical properties of Mango: Mango fruit's physiochemical properties were calculated during the period of study from 2013 to 2014.

Weight loss: A standard procedure was used to calculate the weight loss of mango fruit (Bates, 1994):

$$\text{Weight loss} = W1\text{-}W2/W1 \times 100$$

where:
W1 = Initial weight of Mango
W2 = Final weight of the Mango fruit on succeeding days of the study

Firmness of fruit: In order to determine fruits firmness, Hand-held penetrometer (PCE-PTR 200) with a cross head of 8 mm was used, readings were taken from two opposing sides at two points on its cheeks (Abbasi *et al*., 2009).

Total soluble solids (TSS): To find out the amount of total soluble solid of mango fruits Hand refractometer (Atago Co., Tokyo, Japan) was used and was measured at Brix % (Rathore *et al*., 2007).

pH: The standard method described and followed by (Singh *et al*., 2007) was used to determine pH of mango fruit by using calibrated pH meter.

Titratable acidity (TA): To measure total tritable acidity in % citric acid, standard method was used (Carrillo-Lopez *et al*., 2000). 5 mL mango juice was titrated against 0.1 N NaOH, using an indicator (phenolphthalein).

$$\% \text{ Citric acid} = V \times N \times Wmeq \times 100/Y$$

where:
V = mL of NaOH solution used for titration,
N = Normality of NaOH solution
Wmeq = Milliequivalent of citric acid (0.064),
Y = sample weight in g or mL

Estimation of total phenol content in mango fruit juice (TPC): The standard method Folin-Ciocalteu method with reference (Chandini *et al*., 2008) was used to determine total phenolic content (TPC) of mango fruit. For fifteen minutes, mango juices were centrifuged (1007×g). The supernatant (10µL) was used and a total volume of 100µL was made with distilled H_2O. 2ml of 2% Na_2CO_3 was poured and incubated for 2min. After the period of incubation, 100µl of Folin-Ciocalteu phenol reagent (50%) was mixed and incubated for 30 min at room temperature in dark condition. Spectrophotometer was used to determine the absorbance of samples at 720nm against blank and presented in mg/g GAE.

Decay/rotting percent: The decay % was determined by visual observations. Calculation was done by formula:

$$\text{Decay percent} = \frac{\text{Number of decayed fruits}}{\text{Total number of fruits}} \times 100$$

Data analysis: The difference between Treatment means and time was determined by using Two-way analysis of variance (ANOVA). To relate treatment means, LSD (least significant difference) at *p=0.05* was used as the follow-up (Gomez & Gomez, 1984).

Results

***In-vitro* antifungal activity of epiphytic fluorescent *Pseudomonas* against *Botryodiplodia theobromae* of mango fruit:** The *In-vitro* inhibition of *Botryodiplodia theobromae* growth was observed in petri-plate having f. *Pseudomonas* namely HAB-30 tailed by HAB-11, HAB-14, HAB-29, HAB-12, HAB-24, HAB-1, HAB-21, HAB-5, HAB-15, HAB-16, HAB-17, and HAB-25. The degradation of fungal mycelium was also observed by effective isolates which has been heighted through asterisk (*) as shown in Table 1, Fig. 1.

Table 1. *In-vitro* antifungal activity of epiphytic fluorescent *Pseudomonas* against *Botryodiplodia theobromae* of mango fruit.

Culture No.	PCR code	Source	Zone of inhibition (mm)
			Botryodiplodia theobromae
HAB-1	Ps-1	Lemon	15*
HAB-2	Ps-2	Lemon	12
HAB-3	-	Lemon	13
HAB-4	-	Lemon	10
HAB-5	Ps-8	Melon	15
HAB-6	-	Tomato	10
HAB-7	-	Tomato	12
HAB-8	Ps-11	Grapefruit	17
HAB-9	Ps-12	Tomato	11.5
HAB-10	-	Orange	10
HAB-11	-	Orange	17
HAB-12	Ps-15	Lemon	16
HAB-13	-	Lemon	12
HAB-14	Ps-4	Lemon	17
HAB-15	Ps-7	Melon	15
HAB-16	-	Lemon	15
HAB-17	-	Melon	15
HAB-18	-	Melon	10
HAB-19	-	Melon	12
HAB-20	-	Melon	12
HAB-21	Ps-9	Melon	15*
HAB-22		Tomato	12
HAB-23	-	Tomato	10
HAB-24	Ps-10	Orange	16
HAB-25	-	Tomato	15
HAB-26	-	Grapefruit	14
HAB-27	-	Lemon	12
HAB-28	-	Grapefruit	12
HAB-29	Ps-13	Melon	17
HAB-30	Ps-14	Lemon	18

* = Lysis of mycelium

Effect of epiphytic fluorescent *Pseudomonas* on the physiochemical properties of mango fruit: In this study, Safaid Chaunsa was used as a test fruit. During ten days of study, the temperature ranged from 28±3ºC while relative humidity was 63-67%. Increase percentage in loss of weight regarding time in mango fruits has been presented in Table 2. In comparison to control set the increment in weight loss in treatment was gradual and small. At the end of storage, treatment HAB-25 (19.36%) showed minimum percentage weight loss tailed by HAB-15 (20.13%) and HAB-10 (20.16%). While higher percent weight loss (23.31%) was witnessed in control set after that 20.23% loss in weight was observed in 1% K-sorbate on tenth day. The storage time decreases the fruit firmness, this drop in firmness was least in treatments in comparison to positive and negative control. Treatment HAB-10 (1.92 N) showed maximum fruit firmness after that HAB-15 (1.51 N) and HAB-25 (1.5 N); control set showed minimum (1.41N) fruit firmness (Table 3). All treatments showed decreasing total soluble solids. On one hand, a steady decrease in TSS was seen in all treatments in comparison to control. The TSS content range between 23.35-27.6 in treated fruits as shown in Table 4. On the other hand, the pH of mango fruit was similar trend both in treated and control fruits. The increment in pH is steady in treatments in comparison to control (Table 5). The gradual decreasing trend of total phenol content and TTA of pulp of mango fruit in comparison to control along with the storage period (0 D–10 D) was observed during this study (Tables 6 and 7). Decay percentage was seen increasing in control comparative to the treatments with the increase in storage time (Fig. 2). After ten days of storage, maximum % of decay was detected in control set (41.66%) while minimum percent decay of 16.65% was seen in treatment HAB-15 and HAB-25 and 24.99% in HAB-10. Figure 3 showed the comparative biocontrol potential of epiphytic fluorescent *Pseudomonas* in comparison to control and positive control.

Table 2. Effect of fluorescent *Pseudomonas* on the percent weight loss in stored mango fruit.

Treatment	0 D	5 D	10 D
Control	0 ± 0	10.24 ± 1.15	23.31 ± 4.12
1% K sorbate	0 ± 0	8.77 ± 0.25	20.23 ± 2.72
HAB-10	0 ± 0	8.75 ± 0.71	20.16 ± 1.68
HAB-25	0 ± 0	9.02 ± 0.96	19.36 ± 1.37
HAB-15	0 ± 0	8.98 ± 0.71	20.13 ± 1.16
$LSD_{0.05}$ = Treatment[1] = 1.236		Days[2] = 0.957	

[1]Mean values in column showing differences greater than LSD values are significantly different at p<0.05

[2]Mean values in rows showing differences greater than LSD values are significantly different at p<0.05

Table 3. Effect of fluorescent *Pseudomonas* on fruit Firmness (N) in stored mango fruit.

Treatment	0 D	5 D	10 D
Control	3.26 ± 0.20	2.12 ± 1.15	1.41 ± 0.06
1% K sorbate	3.26 ± 0.20	2.65 ± 0.05	1.32 ± 0.5
HAB-10	3.26 ± 0.20	2.4 ± 0.34	1.92 ± 0.05
HAB-25	3.26 ± 0.20	2.6 ± 0.14	1.5 ± 0.2
HAB-15	3.26 ± 0.20	2.98 ± 0.08	1.51 ± 0.16
$LSD_{0.05}$ = Treatment[1] = 0.305		Days[2] = 0.236	

[1]Mean values in column showing differences greater than LSD values are significantly different at p<0.05

[2]Mean values in rows showing differences greater than LSD values are significantly different at p<0.05

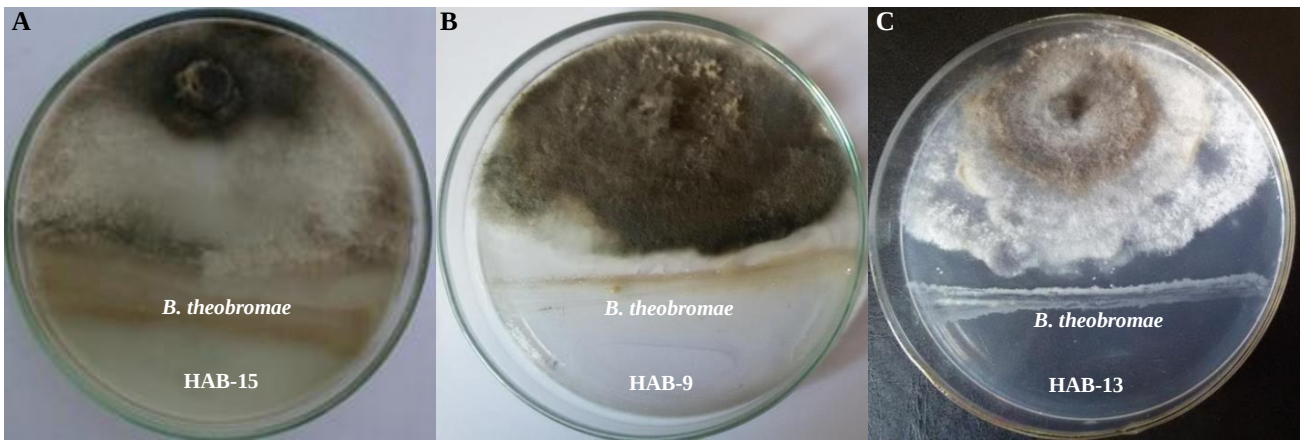

Fig. 1. Inhibition of radial growth of *B. theobromae* (Top of the plates) by epiphytic fluorescent *Pseudomonas* (A, B, C) (bottom of the plates) in dual culture plate assay showing zone of inhibition.
A= HAB- 15, B=HAB- 9, C= HAB- 13
HAB= (fluorescent *Pseudomonas)*
15, 9, 13= Number assigned to the isolates of epiphytic f. *Pseudomonas*

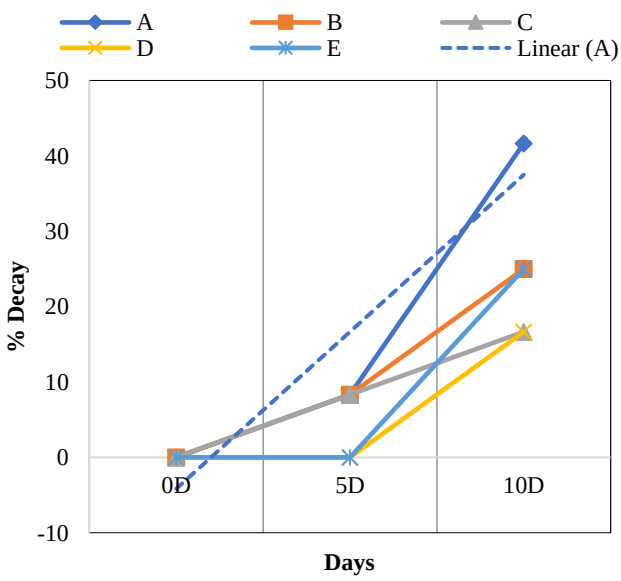

Fig. 2. Effect of epiphytic fluorescent *Pseudomonas* on the percent decay of mango fruit.
A = Control; B = 1 % K-sorbate; C = HAB-10; D = HAB-15; E = HAB-25
LSD0.05 = Treatment[1] = 11.903, Days[2] = 9.220
[1]Mean values of bar in graph for treatment showing differences greater than LSD values are significantly different at p<0.05
[2]Mean values of bar at different days in graph showing differences greater than LSD values are significantly different at p<0.05

Table 4. Effect of fluorescent *Pseudomonas* on Total soluble solids (%) in stored mango fruit.

Treatment	0 D	5 D	10 D
Control	23.35 ± 1.80	22.9 ± 1.36	28.45 ± 1.34
1% K sorbate	23.35 ± 1.80	23.4 ± 1.76	25.57 ± 1.70
HAB-10	23.35 ± 1.80	26.8 ± 1.47	27.65 ± 0.9
HAB-25	23.35 ± 1.80	24.25 ± 1.47	26.6 ± 1.09
HAB-15	23.35 ± 1.80	26 ± 1.72	27.6 ± 3.45
$LSD_{0.05}$ = Treatment[1] = 1.291		Days[2] = 1.000	

[1]Mean values in column showing differences greater than LSD values are significantly different at p<0.05
[2]Mean values in rows showing differences greater than LSD values are significantly different at p<0.05

Table 5. Effect of fluorescent *Pseudomonas* on pH in stored mango fruit.

Treatment	0 D	5 D	10 D
Control	4.68 ± 0.16	5.06 ± 0.42	5.06 ± 0.42
1% K sorbate	4.68 ± 0.16	5.29 ± 0.40	5.29 ± 0.40
HAB-10	4.68 ± 0.16	4.72 ± 0.19	5.4 ± 0.29
HAB-25	4.68 ± 0.16	5.61 ± 0.39	5.51 ± 0.46
HAB-15	4.68 ± 0.16	5.02 ± 0.16	5.75 ± 0.58
$LSD_{0.05}$ = Treatment[1] = 0.276		Days[2] = 0.213	

[1]Mean values in column showing differences greater than LSD values are significantly different at p<0.05
[2]Mean values in rows showing differences greater than LSD values are significantly different at p<0.05

Table 6. Effect of fluorescent *Pseudomonas* on Total Titratable Acidity (% Citric acid) in stored mango fruit.

Treatment	0 D	5 D	10 D
Control	0.91 ± 0.05	0.32 ± 0.05	0.27 ± 0.03
1% K sorbate	0.91 ± 0.05	0.23 ± 0.02	0.23 ± 0.02
HAB-10	0.91 ± 0.05	0.28 ± 0.06	0.21 ± 0.02
HAB-25	0.91 ± 0.05	0.31 ± 0.05	0.26 ± 0.06
HAB-15	0.91 ± 0.05	0.32 ± 0.05	0.25 ± 0.01
$LSD_{0.05}$ = Treatment[1] = 0.037		Days[2] = 0.029	

[1]Mean values in column showing differences greater than LSD values are significantly different at p<0.05
[2]Mean values in rows showing differences greater than LSD values are significantly different at p<0.05

Table 7. Effect of fluorescent *Pseudomonas* on polyphenol content TPC (% mg of Gallic acid) in stored mango fruit.

Treatment	0 D	5 D	10 D
Control	3.21 ± 0.10	2.27 ± 0.25	1.41 ± 0.15
1% K sorbate	3.21 ± 0.10	1.95 ± 0.58	1.42 ± 0.09
HAB-10	3.21 ± 0.10	2.71 ± 0.12	1.47 ± 0.14
HAB-25	3.21 ± 0.10	2.86 ± 0.41	1.76 ± 0.47
HAB-15	3.21 ± 0.10	3.16 ± 0.17	1.80 ± 0.52
$LSD_{0.05}$ = Treatment[1] = 0.233		Days[2] = 0.181	

[1]Mean values in column showing differences greater than LSD values are significantly different at p<0.05
[2]Mean values in rows showing differences greater than LSD values are significantly different at p<0.05

Fig. A. Mangoes on first day of experimentation.

10 D

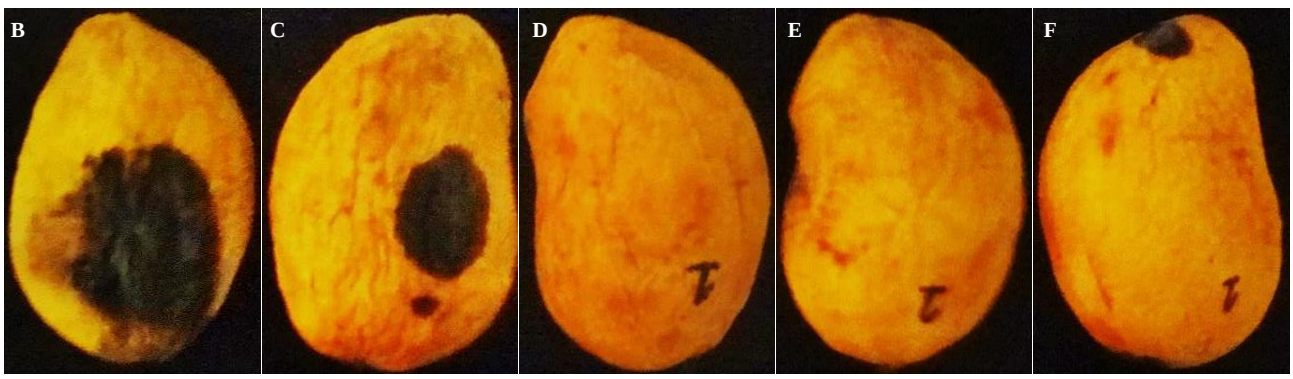

Fig. 3. Effect of epiphytic fluorescent *Pseudomonas* compared with control (Negative) and positive control (1% K-sorbate) on mangoes on 10 d of study.
B = Control (distilled water); **C** = 1% K-sorbate (Food preservative); **D**= HAB-25 (f. *Pseudomonas*); **E**= HAB-10 (f. *Pseudomonas*)
F = HAB-15 (f. *Pseudomonas*)

Discussions

Number of alternative methods has been devised to control post-harvest diseases which have been reported (Bell *et al*. 2021). Among these substitute treatments, the application of antagonistic microorganisms such as yeasts and bacteria on the fruit surface can control pre and post-harvest diseases up to some extent and may reduce deterioration of fruit (Spadaro & Droby, 2016; Carmona-Hernandez *et al*., 2019 ; Noreen *et al*., 2019; Aguirre-Güitrón *et al*., 2022). Number of species of *Pseudomonas* (Peeran *et al*., 2014; Habiba *et al*., 2017) and *Bacillus* (Alvindia & Acda, 2015) has been used as biocontrol agents to mediate defense-related enzymes and suppress the post-harvest diseases of fruit. These biocontrol agents potentially produce lethal compounds and pore forming protein in response to the pathogens. This research investigates the biocontrol effectiveness of epiphytic fluorescent *Pseudomonas* against *Botryodiplodia theobromae,* focusing on its impact on the quality of stored mango fruit at room temperature.

The production of volatile organic compounds and action of defense-related enzymes might have improved the *In-vitro* antifungal activity of fluorescent *Pseudomonas* against the *B. theobromae* (Peeran *et al*., 2014; Wang *et al*., 2021). In this study, treatment with epiphytic fluorescent *Pseudomonas* on Mango fruits showed less weight loss with respect to time in comparison to control and positive control. The process of respiration and transpiration commonly causes the increment in weight loss (Lentzou *et al*., 2021).

The deterioration of cell wall occurs because of cell wall degrading enzymes which cause loss of fruit firmness. Our outcomes are in correspondence with former studies which showed that with the advancement of storage period, firmness of fruit decreases (Adhikary *et al.*, 2022). The increase in TSS might be linked with the changes in hydrolytic enzymes which convert starch to sugar as chief index for ripening process in mango and other seasonal fruits (Ghosh *et al.*, 2023).

In our study, gradual increase in pH in comparison to control has been observed which might be due to the effect of respiration and reduced metabolism (Ghosh *et al.*, 2023). Phenols are widely present in fruit & vegetables and are also known for their role in nutritional quality, contrary to it, they are vulnerable to deprivation in storage (Mgaya-Kilima *et al*., 2015). The type of fruit cultivar, species, climatic and environmental settings throughout its growth phase determine the progress of total phenolics during storage (Medda *et al*.,2022). The decreasing trend in TTA (total titratable acidity) and TPC (total phenol content) in mango fruits with respect to storage time is similar with the

results concluded by different researchers (Abdipour *et al*., 2020). The higher phenol content exhibited by f. *Pseudomonas* treated fruit in comparison to the control fruit and 1% K-sorbate treated fruits, it might be the results of decreased titratable acidity during storage which causes the formation of carbon skeletons for the synthesis of phenolic compounds through inter-conversion with carbohydrates (Kalt *et al*., 1999).

Mango fruit is vulnerable to various postharvest infections, being *B. theobromae* as the main causative agent for majority of postharvest losses thus declining market acceptability. Overall, mangoes treated with f. *Pseudomona*s were more effective in controlling the anthracnose infection on stored mango fruit than control and K sorbate (1%). The least percent decay in biocontrol treated mangoes might be due to greater phenol content in biocontrol treated fruit. Since phenols are known secondary metabolites which help to overcome the oxidative stress by scavenging free radicals (ROS) during postharvest senescence (Valverde *et al*., 2015; Rastegar *et al*., 2020; Jia *et al.*, 2023). The level of anthracnose protection was elevated in fruits treated with f. *Pseudomonas*. This research showed that fluorescent *Pseudomonas* has potential to control the infections by *B. theobromae* in mangoes and percent decay, if treated with the suspension of fluorescent *Pseudomonas* thus production of antibiotics and secondary metabolites by fluorescent *Pseudomonas* maybe the reason behind their biocontrol potential.

Conclusion

In conclusion, the postharvest quality and shelf life of mangoes can be improved by treating them with epiphytic fluorescent *Pseudomonas*. The observed *In-vitro* antifungal potential of epiphytic f. *Pseudomonas* against *B. theobromae* confirms its efficacy against postharvest fungal losses. The gradual and comparatively less decrease in fruit firmness and total phenolic content in *Pseudomonas* treated mango fruit suggests its efficacy in the control of postharvest quality. The least percent decay observed in *Pseudomonas* treated fruits further unlocks its potential against postharvest fungal pathogen. However, additional studies are required to validate the safe use of epiphytic *Pseudomonas* as postharvest biocontrol agent specifically on fresh fruits and vegetables.

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